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wisconsin engineer

MARCH 2016 VOLUME 120, NUMBER 2

CELEBRATING 120 YEARS

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Correspondence: *Wisconsin Engineer* Magazine; 1550 Engineering Drive; Madison, WI 53706 **Phone:** (608) 262-3494 **email:** wiscengrmagazine@gmail.com

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Wisconsin engineer

Celebrating 120 years of continuous publication

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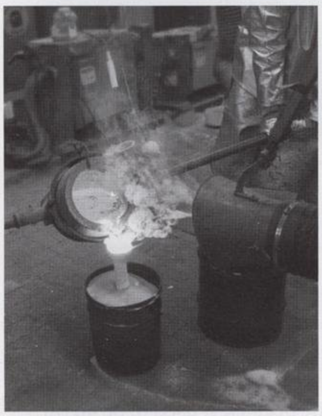
General



Cover: UW-Madison Foundry provides knowledge of the metal casting process to students in the College of Engineering

Photo by: Robin Ritchey

Metric on Markets

Not everyone has the luxury of hearing a Wisconsin cheese curd squeak as their teeth sink in. Or letting the aroma of huge loaves of spicy cheese bread invade their senses. For almost four years now, Alfonso Morales, associate professor in the department of urban and regional planning at UW-Madison (and former street market vendor), has studied the impacts of farmers markets on their communities. Morales' goal for markets is to make it possible for more than produce and other goods to be exchanged – he wants to exchange data from market to market.

Farmers' markets caught the interest of Morales in his early twenties when he frequented the Maxwell Street Market in Chicago looking to buy goods on his college budget. He was intrigued by the diversity of the customers, the vendors and the merchandise they were selling. From local Jewish families advertising homemade challah, to Polish immigrants showing handcrafted furniture, locals and tourists alike were lured and lost in the chaos of that street market. Morales was drawn so far in that he has spent twenty-five years learning about every aspect of street markets.

Morales' team, in partnership with the Farmers Market Coalition, is currently assessing four different impacts of nine markets in six states: environmental, health, social and economic. Farmers' markets are widely known for being healthy and environmentally friendly, but this project gets more in depth. From these nine markets, the project measures which farmers use low tillage to conserve soil; which cultivate different crops to improve soil nutrient levels; and which use fertilizers low in phosphorous to minimize polluted runoff. The locality of the food is also gauged in the miles each vendor commutes.

Certain aspects of the market quantify the impact on health, such as whether cooking demonstrations are offered or not. "Many people today don't know how to cook or what to make with the produce sold at street markets." If the vendor is selling a vegetable like bok choy, for example, and has a demonstration making stir-fried bok choy and provides a recipe handout, this healthy vegetable is now much more accessible to the common consumer. Another way to make open air markets more accessible is to add an entertainment component, which is tallied under social impacts of the project. Many markets have kid activities where children can learn how to plant seeds and bulbs or play corn hole with Hacky Sacks filled with dried corn from the vendor's farm. Others choose to employ a local fiddler to accompany the chaos with a fast-paced tune. The economic impacts are measured in the earnings of each vendor, or whether the market as a whole increases tourism.

The end result that Morales hopes to achieve is to increase farmers' markets' organizational capacity and to better understand how the four impacts described affect the community over time. He notes, "We want to increase the ability of farmers' market managers to collect, analyze and report data to important partners in their communities." Morales has seen a successful network of markets at work before. He references Barcelona's open air market when he admiringly elaborates, "Their markets are woven into the fabric of everyday life because it used to be an important way to get food and to develop a healthy community. Our markets are not always located in the best places for the people who want to use them and are not always supported by local governments." His response is to work with five markets in the Wisconsin "Main Street Program" to begin to understand market impacts at larger social and organizational scales. He concludes, "It teaches us about the multi-functionality of markets and how we can intentionally fit markets into our everyday lives."

Even with all of these metrics reporting how socially and environmentally friendly farmers' markets are, they don't measure the enjoyment that vendors and customers get from a street market. Morales says that there isn't one vegetable or fruit he looks forward to when market season comes around; he simply looks forward to the experience. WE

Written by: Madison Knobloch
Photography by: Eowyn Liu
Design by: Jason Wan

A Foundry Feature

Since the dawn of the Bronze Age over 5000 years ago, humans have been extracting metal from the earth and manipulating it to fit our needs. From tools and weapons to engine blocks and coins, it is almost impossible to look around and not observe some sort of metal creation today. Unfortunately, you can't mine all of these final products straight from the ground. The final products are created from the raw metal taken out of the earth through a process called casting. Casting describes the creation of metal shapes using molds into which liquid metal is poured and solidified. This procedure is carried out in a factory designed specifically for casting, called a foundry. UW-Madison happens to have one right on campus.

Located in the Materials Science and Engineering building, the current foundry has been operating at UW-Madison since 1992. Mainly funded by prominent members of the Wisconsin casting industry, this foundry pushed UW-Madison to the forefront of metallurgy and casting research and development. Today, the foundry still fosters a sense of creativity and provides knowledge of the casting process to students. Various classes are offered that teach undergraduates the basics of casting and how to navigate their way around the foundry.

The foundry classes offered on campus vary from semester to semester. In the fall 2015 semester, a class titled Advanced Metal Castings was offered. This class focused on different aspects of the casting process including mold design, casting properties, casting alloys and casting design. Featuring a very small class size of around 8-10 students, this lab met in the foundry once per week and gave students hands-on experience in the foundry. This course was offered due to popular demand by engineering students, and demonstrates that students have the power to influence what foundry classes are available for future semesters.

In addition, students not enrolled in a casting class can also participate in foundry activities, thanks to the American Foundry Society (AFS) UW-Madison student chapter. AFS is a national professional organization dedicated exclusively to promoting interest in foundry work and technology. The chapter here on campus provides interested students the chance to get hands-on foundry experience. Led by their president, senior Greg Johnson, this organization hosts many opportunities to learn about the foundry, today's casting processes, and to keep in touch with the latest news and developments from the casting industry.

One of the main events facilitated by the AFS UW-Madison chapter is the yearly foundry exhibition held during the UW-Madison Engineering Expo, which draws visitors of all ages. This demonstration is one of the most talked about and well-liked demos at the expo. Titled "Thermodynamics of Fire," it is used to demonstrate basic thermodynamic and casting concepts to visitors through a variety of interactive activities. Activities include casting of various metal shapes and a few other crowd favorites. "We take butane and run it through soapy water to make bubbles, which you can put on your hand and light on fire – so you get this big ball of flames in your hand," Johnson says. "Kids love that one." Since participants' hands are wet, they aren't at risk of getting burnt due to the high heat capacity of water. These events are so successful that the foundry exhibit won second place for people's choice of favorite exhibit, and AFS hopes to continue this trend in future years.

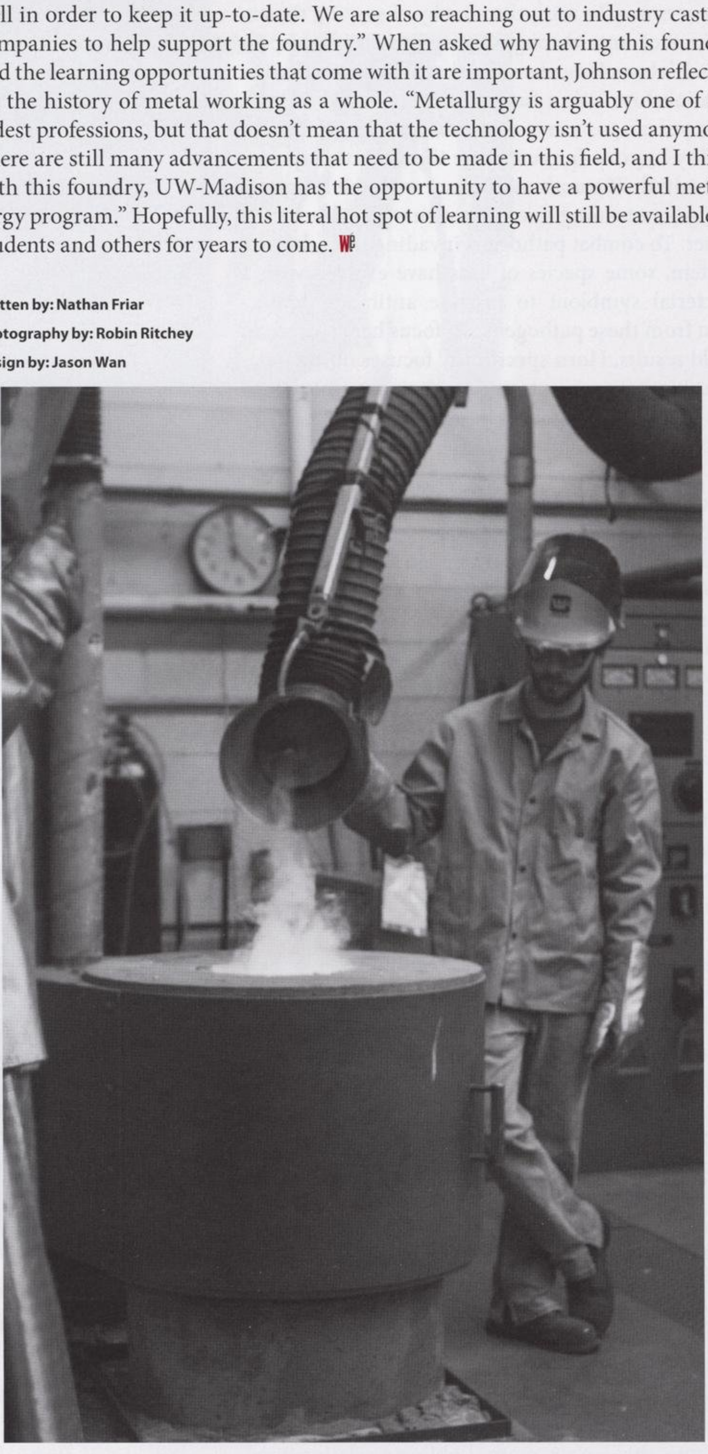
Additionally, AFS hosts Foundry Fun Nights a few times per semester. Foundry Fun Nights are opportunities for students and their friends to visit the foundry and actually take part in casting processes. "Green-sand casting is one of the most common activities," explains Johnson. "It uses a sand and clay mixture that you pack around a pattern, which when removed, leaves a mold with a hollow cavity in the shape of the pattern. After taking out the pattern, you pour liquid metal into this mold, and when it cools, out comes your final product." At their most recent Foundry Fun Night, visitors got to make and keep their own medallions with the AFS logo featured on the front. "These demonstrations are a great way to learn and get a lot of people some hands-on experience with casting, and have a lot of fun at the same time," says Johnson. Certainly, these events go a long way towards promoting interest in casting and the foundry itself.

Looking forward, the future of the foundry is unclear. Although it is still used for classes, demonstrations, and other events, it is used less frequently than it was upon its initial completion. The reallocation of the foundry space to other uses is being considered. "It's a very real concern, and we're taking it seriously," states Johnson. "We want to show that we are using it, and illustrate that not only should the foundry be kept, but that we hope to see some renewed investment into it as well in order to keep it up-to-date. We are also reaching out to industry casting companies to help support the foundry." When asked why having this foundry and the learning opportunities that come with it are important, Johnson reflected on the history of metal working as a whole. "Metallurgy is arguably one of the oldest professions, but that doesn't mean that the technology isn't used anymore. There are still many advancements that need to be made in this field, and I think with this foundry, UW-Madison has the opportunity to have a powerful metallurgy program." Hopefully, this literal hot spot of learning will still be available to students and others for years to come. WE

Written by: Nathan Friar

Photography by: Robin Ritchey

Design by: Jason Wan



Quest for ANTibiotics

As antibacterial-resistant disease prevalence and seriousness increase, scientists are desperately searching for new antibiotics. Traditionally, researchers look into bacteria-rich soil for the antibiotics; however, continuing with this strategy has yielded little novelty. In the Currie Lab at UW-Madison, researchers like graduate student Heidi Horn have focused on a different, unique niche to find new antibiotic bacteria: ants.

These scientists came to the conclusion that the answers may lie with the ants by observing the existence of ants through an evolutionary perspective. It's been long observed that ants have a mutual relationship with a fungus. An estimated 50 million years ago, some ants evolved an agricultural ability to grow fungus. Since then, the two species coevolved. The ant's mutualism with the fungus is obligate, meaning one cannot survive without the other. To combat pathogens invading their delicate system, some species of ants have evolved with a bacterial symbiont to provide antibiotic protection from these pathogens. To focus her research to yield results, Horn specifically focuses on the relationship between ants and bacteria by asking how the relationship evolved in the first place and how it is maintained.

In order to study the ants, the Currie lab has sent scientists like Horn out into the world to find ants with specific qualities such as agricultural fungus farming adaption and bacterial coating. Several ants partake in such agricultural behavior, but the leaf cutter ants that the Currie lab has curated are mainly from Panama and South America, while only a few species are found in North America. Their nests are typically subterraneous, but some are in dead logs; some even grow their fungus on the underside of leaves. To find these ants, the scientist simply scours the grounds looking for the specific ant and then, once the ant is spotted, follows the ant all the way home to its nest (which can sometimes take hours).

The birth of these colonies begins with a new Queen, who takes a bit of the fungus from her parents (an inoculum, in scientific terminology). She then starts her own colony, where the worker ants continue to culture the fungus by feeding it bits of plants, dead vegetative material, or even bits of insects. Then the Queen and the larvae take up residence within this large mass of fungus and survive by eating it. Interestingly, the ants found inside the mass of fungus are covered in a fuzzy white coating, which is the visible bacteria, while the adult worker ants only have this coating under their heads since they are not always in contact with the fungus.

"What's really good about this system and why it's a good model is that you can actually isolate the components and grow bacteria cultures on plates because this isn't a mutual obligate relationship," Horn says. Being able to disassemble the system

Fungus created from leaf-cutter ants in Currie lab grows in laboratory dishes.

have shown that the bacteria differs between ant populations. Therefore, if the bacteria are different, it's possible that the resulting antibiotics are different. As genome sequencing is becoming more affordable, researchers may begin to focus more on genes called secondary metabolite clusters, which are responsible for antibiotic production. Horn explains, "An interesting result from sequencing the genome shows that the bacteria are capable of creating a lot more secondary metabolites than we can see. So one of the big questions is: what causes them to produce this difference in metabolites?"

Horn explains that in theory, different metabolite cluster expressions are probably a result of different environmental stimulations. One might wonder whether the ants would pick up additional antibiotic bacteria from the environment. Horn clarifies, "It might make sense that they could exchange bacteria with the environment. A lot of bacteria in the soil have useable antibacterial properties, but experiments on the ants haven't shown them picking up any additional bacteria and putting it to use." A key point to consider is that the only predator to the ants' fungal food source is called escovopsis, which is a fungus only found in this system. Because of this, the bacteria found on the ant is very specifically adapted to killing the pathogens in escovopsis (further supporting the idea that the bacteria, ant, and fungi coevolved).

Regardless, new antibiotic properties are right there in the ants. The process of developing a new antibiotic, from discovery to human use, is time consuming and take anywhere from 15 to 20 years. "The first test of these antibiotics is a fungal pathogen test, in which the activity is measured," Horn explains. "With good results you can move on to identifying what the bacteria really is and what dosage you would use for fungal pathogens. Then it goes on to mouse models, which is still a long ways away from human trials."

This interesting relationship between ants, fungi and bacteria is just one of the many complex systems found on this planet from which humans can extract something useful to our health. The research being done at the Currie Labs is a great example of the importance of continuing to research fundamental science. The answers are out there, and now just have to be found (probably with a microscope). WE

Written by: Stacy Montgomery

Photography by: Simon Hensen

Design by: Jason Wan

Professor Profile: Steven Zwickel

The Wisconsin Engineer Magazine has been in publication for 119 years and throughout its lifespan has been run and written entirely by UW-Madison students. The past 20 years, however, have been especially pivotal in the history of the magazine. The age of mass communication through the internet has changed the entire field of journalism, and the Wisconsin Engineer is no exception. Fortunately, with all the changes in staffing, production and distribution in the last 20 years (with the exception of a 5 year hiatus), we have had a faculty adviser who has kept the magazine in focus. Professor Zwickel is the most dedicated friend of the magazine to date, and without his mentorship and continuing support, the Wisconsin Engineer would not enjoy as much of a success as it does today.

Professor Zwickel has a diverse academic history including a law degree and a degree in social work, but it's his Graphic Arts and Printing diploma that first got him involved with The Wisconsin Engineer Magazine. He was offered the faculty adviser role back in 1995, and he accepted it as part of his faculty requirements. In his first days as adviser, Zwickel was faced with the task of turning around a $12,000 debt the magazine had accrued. Facing threats of a shutdown of the magazine, which was in its 99th year, Professor Zwickel got together a group of dedicated students and organized an overhaul of the magazine's publication process. He helped to implement the "story team" structure that the magazine still uses today, which greatly improved the quality and synchronization of writing, photography and layout. Shortly after implementing these changes, The Wisconsin Engineer Magazine won four consecutive awards for overall best magazine from the Engineering Colleges Magazine Associated (ECMA). Over time, the magazine was able to pay off its debt and become solvent. Professor Zwickel's record of being an asset to the magazine, however, had just begun. As technology changed, Professor Zwickel was never content with being left behind. He became an expert in various skills including Adobe Photoshop, magazine photography and journalistic interviewing. He very much enjoys being useful as an adviser to the magazine.

An additional challenge that Professor Zwickel faced was keeping the magazine focused on its goal of being a non-profit business. While The Wisconsin Engineer Magazine is a student organization, no money is accepted from the College of Engineering; solely ads and subscriptions are used to fund printing. In order to remind students that they're part of something more than just a student organization, Professor Zwickel has opened up all business-related meetings to all magazine staff members and implemented top-down and bottom-up performance reviews to better the magazine. He believes that the department heads have done a good job keeping things going, but jokingly laments that they can't hold the threat of employment termination over the heads of staffers.

Professor Zwickel has seen many changes in the magazine over his time, and has grown attached to both the magazine and the people involved. Unfortunately, ECMA and many student-run magazines have encountered problems with their funding and no longer exist. He's extremely proud to be a part of a magazine that has survived the trend of going online, and hopes to help The Wisconsin Engineer Magazine stay relevant. He often keeps in touch with former staffers and is happy to learn of their lives and how they all attribute certain skills to their tenure on the magazine. Professor Zwickel loves the diversity in the magazine in terms of gender, major, origin and career trajectory, and lauds the magazine's ability to attract students of all backgrounds. Most importantly, Professor Zwickel describes himself by saying, "I'm the collective memory of the magazine." While student staffers must graduate and leave the magazine after four years, he makes sure that mistakes aren't repeated and that the new staffers are always on task. Professor Zwickel is excited to see what the future holds for The Wisconsin Engineer Magazine and proudly claims that, "the magazine's future is bright and in the hands of very competent people."

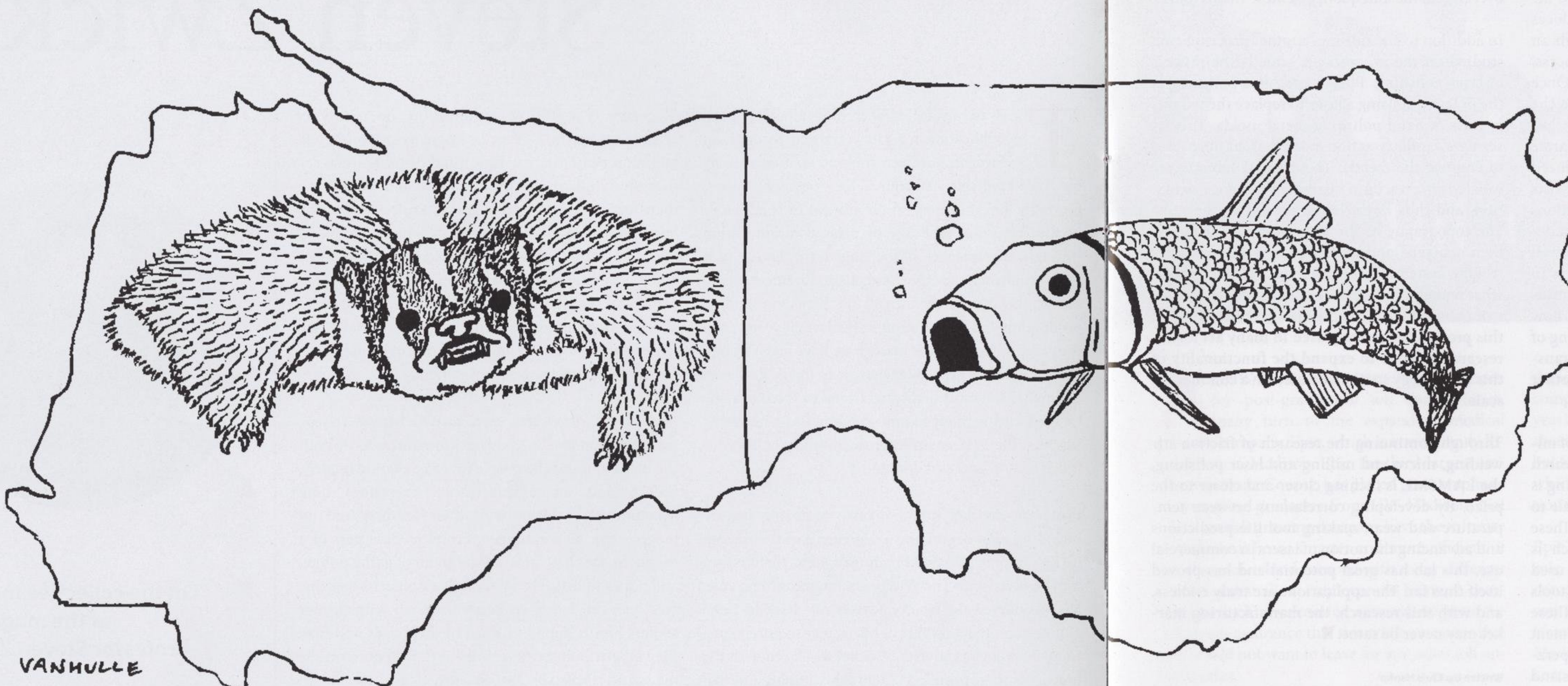
The magazine is always looking for new members to continue the proud tradition of publishing quality articles. We meet every other Wednesday from 7-8pm in Tong Auditorium in the Engineering Centers Building. Come meet the fantastic staff and become a part of one of the oldest student organizations on campus! WE

Written by: Brandon Grill
Photography by: Caitie Qi
Design by: Jason Wan

"I'm the collective memory of the magazine."
-Professor Steven Zwickel

One Thing 'Lead' To Another:

The history of mining in Wisconsin



During childhood, just about everyone received an unfortunate nickname or two that they are quite glad to have left firmly in the past; and fortunately, time does have a certain knack for erasing things from memory. Today most people know Illinois as the Prairie State and Wisconsin as the Badger State. But Illinois developed another nickname that few people remember today. This is the story of how Wisconsin came to be known as the Badger State and how our good neighbor Illinois acquired the less illustrious nickname, the Sucker State.

The story behind these nicknames began in the 1820s before Wisconsin even existed as a state. At the time, it was just the northwestern frontier of the United States. Southern settlers of the frontier regarded the area as a cold, barren wasteland with winters that were inhospitable for settlers. However, this attitude changed abruptly in 1825 when lead was discovered in present-day northern Illinois and southwestern Wisconsin. Suddenly, Wisconsin became the land of opportunity, and thousands of prospectors flocked to its acclaimed lead reserves for the chance of striking it rich on the 'grey gold.' The ensuing influx of people was actually quite similar to the 1848 California gold rush, except perhaps a bit colder and a tad more barren.

The first folks to make their way up to the rolling prairies of modern-day southwest Wisconsin were from Illinois, Kentucky and Tennessee. They were prospectors, not settlers, and they had no intention of staying permanently through the bitter winter in a foreign land. These were adventurous people who were just looking to pull lead from the ground, get rich and get out. They were motivated mainly by money and had evidently not invested much time considering the particulars of mining lead. In fact, most all of these early prospectors had no experience mining and lacked the necessary knowledge and tools. Nevertheless, they proceeded in large numbers, armed with shovels and rifles, to the promised lead reserves to start digging holes.

And digging holes is exactly what they did. The best method the early prospectors had for locating lead was to burrow into the ground at random until they hit bedrock or struck a vein of lead. These exploratory holes were later found littering the landscape with some as far north as the Baraboo hills, an area that doesn't contain any lead. One miner from the time described prospecting as "a good deal like a lottery - a hundred chances to lose where there was not one to win." Few prospectors in the region mined enough lead to make money, and like a lottery, the few that did succeed reinvigorated the efforts of the rest. Each spring, crews of men could be seen trekking north through Illinois to play the original Wisconsin lottery.

In addition to their assessment of the land being rather cold and barren, there was another reason these prospectors did not plan to stay in Wisconsin. Technically, they were trespassing on Ho-Chunk land. The Ho-Chunk had been mining the lead reserves for many years and they did not appreciate the prospectors' invasion of their land. Tensions erupted in a brief conflict, later called the Winnebago War. It began and ended so quickly that some prospectors ignored it completely and continued on mining. At its conclusion, the United States agreed to investigate the Ho-Chunks' grievances regarding the trespassing lead miners. However, it was not enforced and thousands more miners came to the area after the war ended.

This renewed influx of prospectors consisted of not only adventurers from the south; there was a new type of miner with different motives that began to settle in Wisconsin. They were primarily from the east coast of the U.S. and Cornwall, England. In contrast to the early prospectors, they planned to settle permanently in Wisconsin. The Cornish in particular were experienced miners and brought with them tools that allowed them to dig deeper and extract massive quantities of lead from areas abandoned by the early prospectors. This wave of permanent settlers marked a notable change for Wisconsin: it was no longer only a land for prospecting but also a place that held promise for settlers.

Thus, two distinct groups emerged in the lead mining lands – those who stayed through the winter and those who returned to the south. This primarily divided the get-rich-fast prospectors from the south and the more pragmatic, experienced miners from England and the east coast. From this division came the well-known nickname for Wisconsin, the Badger State, and and less familiar one for Illinois, the Sucker State.

The origin of the badger nickname has at least two possible explanations. One story is that the more experienced miners gave the name to the southern prospectors because of their haphazard method of searching for lead. Since the method had a low likelihood of success, prospectors did not waste effort constructing a permanent home, but instead used their holes as temporary shelters. Other settlers considered the digging of these holes to be rather foolish. They heckled the prospectors, calling them 'badgers' and their temporary homes 'badger holes,' due to the similarity of their living arrangements to the animal. This rendition of the story has the interesting implication that the original badgers were actually from Illinois.

Another explanation asserts that the southern prospectors called the permanent settlers 'badgers' because they remained up north in Wisconsin through the winter. The southerners chose the nickname 'badger' because they were not accustomed to the animal in the south and so they associated it with Wisconsin.

The unfortunate nickname that befell Illinois came about in a similar way. Permanent settlers noted that the return of miners from the south to Wisconsin each spring coincided with the northern migration of a fish known as the suckerfish. The transient southerners thus became known as 'suckers'. Some accounts also assert that the exploratory holes dug by prospectors were called 'sucker' holes, not 'badger' holes. This would offer an interesting explanation for why the word 'sucker' is now used to mean gullible.

Thus, when miners gathered during the winter in Wisconsin and someone asked the whereabouts of another miner, the response would often be, "He's gone south, but he'll be up with the suckers in the spring." Similarly, when the southern miners returned north in the spring they would tell others, "We are headed up among the badgers."

Over time, Wisconsin became known as the Badger State, and Illinois as the Sucker State. Evidently, Illinoisans did not embrace their nickname with the same vigor as Wisconsinites, but history still bares the truth. In the ongoing rivalry between our states, it is obvious that Wisconsin came out on top in the battle of nicknames at least. WE

Written by: Mark Bodnar
Illustration by: Alexander VanHulle
Design by: Jason Wan

Laser-Aided Machining: The Future of Manufacturing

There is definitely no shortage of groundbreaking research being done at UW-Madison, and the next breakthrough could happen in the heart of Mechanical Engineering. In Associate Professor Frank Pfefforkorn's Laser-Assisted Multi-Scale Manufacturing Lab, major research is being done in the fields of material science, manufacturing, welding and many others to ultimately grow laser-aided machines from an art form into a commercial-based technology. Through the help of some extraordinary minds, extravagant machinery and the constant ambition of discovery, this lab is on the brink of something great.

The Laser-Assisted Multi-Scale Manufacturing Lab, or LAMSML for short, is based out of the first floor of the Mechanical Engineering building on campus. Professor Pfefforkorn, as well as several graduate and undergraduate students working in the lab, do research in many fields of focus and are funded through the University and the National Science Foundation. The research pertains to the fields of friction stir welding, micro end milling and pulsed laser micro polishing.

The first field of study is focused on the process of friction stir welding. Friction stir welding is the practice of joining two solid-state facing metals using a third body tool but without physically melting any of the materials. The LAMSML specifically focuses on detecting flaws, or voids, as well as studying the temperature effects on the process using two impressive (and expensive) machines.

The first machine is called the Mori Seiki 5-Axis Mill Turn Center and it essentially acts as a 3D printer, but for metals. This machine produces the physical friction stir weld piece through an additive and subtractive machining process, making it customizable to the researchers. Once the part is produced, it is then passed on to the next part of the journey, the HAAS 3-Axis CNC Mill. This mechanism is used to join to separate face metals with the stir welding part produced in the 5-Axis Turn Center. This machine assists in studying the presence of voids or deformations in the metals. This study is critical because it determines the overall quality of the weld, as well as the strength of the materials. Researchers in the LAMSML lab are coming close to determining what causes voids in stir welding, and how to replicate the essentially perfect stir welding of metals. This technology can be applied to transportation, engineering, casting and many other interdisciplinary uses.

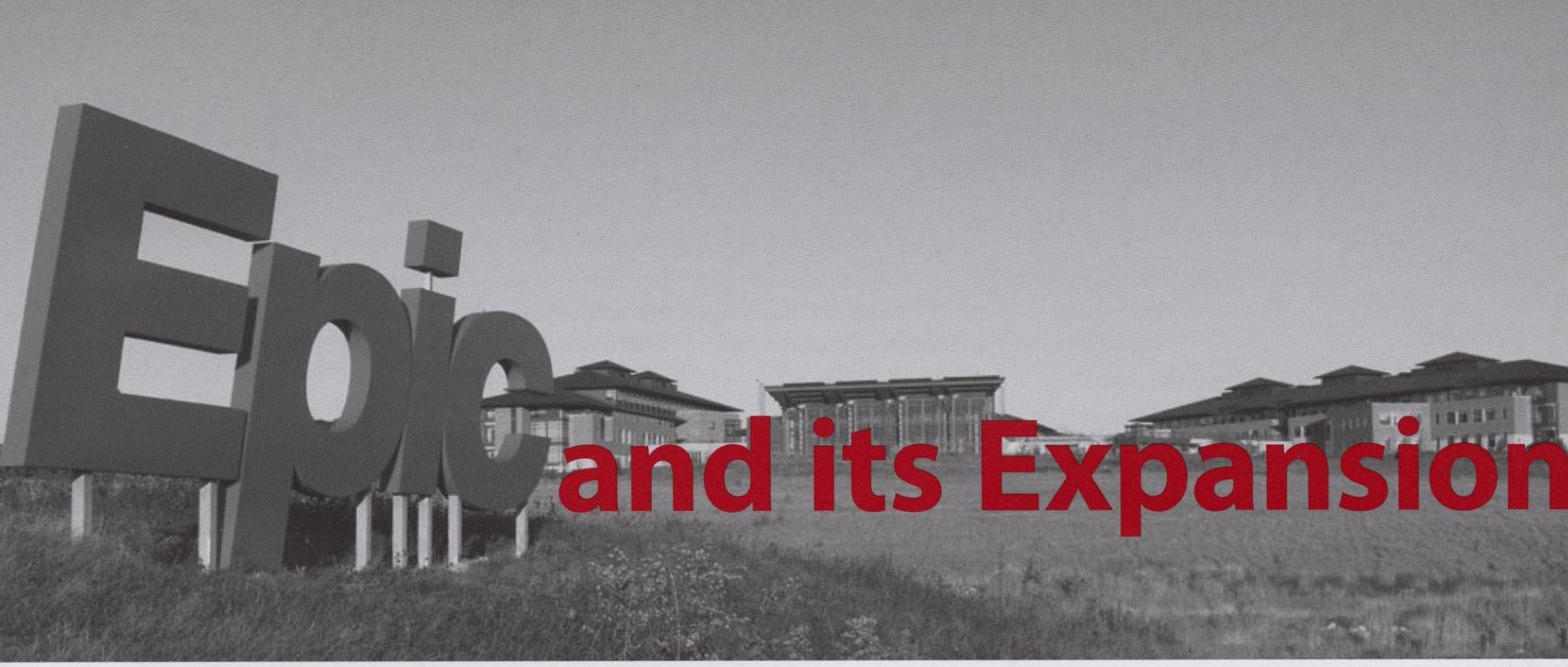
Outside of friction stir welding is the study of micro end milling, another major topic of research being conducted in the lab. Micro end milling is basically milling metals on a very small scale to produce very finite and precise incisions. These tools are about 300μm in diameter, which is smaller than a human hair. The CNC Mill is used to study the wear patterns of these micro tools and develop a tool life prediction for each. These tests are performed in a cryogenic environment to increase speed and reduce cutting temperatures. The correlation between wear patterns and tool life is extremely valuable since no such accurate prediction currently exists. Once this correlation is made, it can be applied to increasing the overall tool life and quality of these micro tools.

In addition to end milling, another process being studied on the microscopic scale is the process of laser polishing. Pulsed end laser polishing is the practice of using a laser to replace the tedious process of hand polishing metal molds. This laser uses capillary action and a pulsed fiber laser to engrave the metals. These metal subjects are isolated in a vacuum chamber to reduce oxidation, and thus improve the quality of the tests. The topography of the laser-polished surface is then analyzed and measured by an optical metrology system. These tests will help determine what makes a good laser polish, and how to control the quality of the finished product. Though this process is currently used in many art forms, researchers hope to expand the functionality of this technology so it can be used on a commercial scale.

Through continuing the research of friction stir welding, micro end milling and laser polishing, the LAMSML is inching closer and closer to the prize. By developing correlations between temperature and wear, making tool life predictions and advancing the notion of lasers in commercial use, this lab has great potential and has proved itself thus far. The applications are truly endless, and with this research, the manufacturing market may never be same. WE

Written by: Chris Hanko
Photography by: Brandon Moe
Design by: Jason Wan

Researchers at UW-Madison are close to perfecting the art of Laser-Aided Machining, which aides in the manufacturing of precision built parts like the turbine blades above.



Epic and its Expansion

As UW-Madison students begin to search for post-graduation job opportunities, many turn to the expanding medical software company, Epic, which is conveniently located here in Madison. Epic, the third-largest employer in Dane County, has placed great emphasis on recruiting graduates from UW-Madison. Not only does this growing company have the software to make healthcare smarter and more efficient, it has a one-of-a-kind campus with many different amenities that allow employees to be more comfortable. Such a welcoming atmosphere gives the employees assurance that this will be a career that they would not want to leave for any other job opportunities.

Dhara Patel, a network operations technician, is one of the thousands of employees who enjoys the many benefits of working for Epic. "The Epic campus is massive, which makes for a great work environment since we all get to work in offices instead of cubicles," says Patel. "No matter what building you're in, you will always find such interesting and somewhat strange art that's intended to inspire creative thinking." The eccentric campus at Epic is only a small part of the company's effort to create an enjoyable work environment. The company organizes numerous activities that encourage employees to get outdoors and away from working inside for long hours. Activities like soccer in the summer, cross country skiing or ice-skating in the winter, and the famous Epicnic, a celebration held by the company for their employees, all contribute to a great work culture at Epic.

Certainly, the Epic campus and company atmosphere has made quite the impression on current and prospective employees, but that's not the only factor bringing attention to the tech company. Epic's expansion over the past several years has been extraordinary. "Not only has the sheer number of employees and buildings risen, but Epic's international footprint is also growing, which enables Epic to also expand the international offices," says Patel.

Epic's continued growth has played a significant role in supporting Madison's economy. "The company has also had a huge effect on the Madison area," says Patel. "For events such as Epic's User Group Meeting, the hotels in the entire Madison area are sold out!" Epic, as the huge corporation it is, brings growth to the Madison economy and is part of the reason for such rapid building of new apartment buildings, stores, and restaurants all across the city. "I'd like to think that some of this has to do with the exponential growth of the company," says Patel. "Epic plays a huge hand in Madison's economy. Some folks refer to this growth in Madison's economy as the 'Epiconomy', denoting Epic's major helping hand to the city of Madison.

"Some folks refer to this growth in Madison's economy as the 'Epiconomy.'"
- Dhara Patel

As Epic works with healthcare organizations to improve care and reduce costs, the company is making itself a crucial player in the world of medicine. Epic's software has the ability to increase patient satisfaction by improving the overall hospital experience. Epic can share data quickly and provides a backdrop for fostering more innovation for the better. This company has, and always will be a crucial part in the city of Madison. As Epic grows larger, it will continue to leave its mark on the people of Madison as well as healthcare institutions and patients everywhere. WE

Written by: Krishna Patel
Photography by: Simon Hensen
Design by: Brent Grimm

Where Should I Study Today?

All the study spots that engineering students should know!

As the home turf of more than 8,000 engineering students, the engineering campus could be one of the toughest places to find a good study spot when midterm season comes around. Although Wendt library, the only engineering library, offers a variety of resources from tutoring to a writing center, it is infamous for its limited study space. Many students believe that Engineering Campus is full of lecture halls but not enough study spaces for students. So when Wendt is full, most students are forced to study at their own homes or somewhere far away. Contrary to popular belief, however, the engineering campus actually offers a lot of study spaces. They may be hidden or may seem to be unavailable but they are there! Here are five study spots in engineering campus of which you might not have known before:

1. Engineering Hall

Most students know that they can study at the Engineering Hall lounge on the first floor. However, what many people don't know is that the empty lecture halls and classrooms are waiting to be occupied by students after all the lectures are done. Although the building closes relatively early, it only locks from the outside. So if you make sure to be in the building on time, you can study as long as you can in an isolated and quiet setting!

2. Mechanical Engineering

The Mechanical Engineering building has so many lecture halls that it doesn't seem like it has much space for studying. However, there are hidden tables and chairs throughout the whole building. Also, just like Engineering Hall, you can occupy any empty lecture rooms and computer labs when no classes are being held.

3. Engineering Center Building (ECB)

ECB is the building that has the most to offer in the engineering campus. However, not many students utilize the space and resources that can be found there. ECB not only has study tables in each floor, but also has CAE computer labs hidden throughout the first and second floors that are nearly empty most of the time.

4. Union South

Union South is a beautiful place that is favored by many students of various majors. It's a great spot for engineering students to take advantage of because the location is right across the street from the engineering campus. Apart from boasting a plethora of tables and study spaces, Union South also is home to multiple grand pianos that anyone is welcome to play.

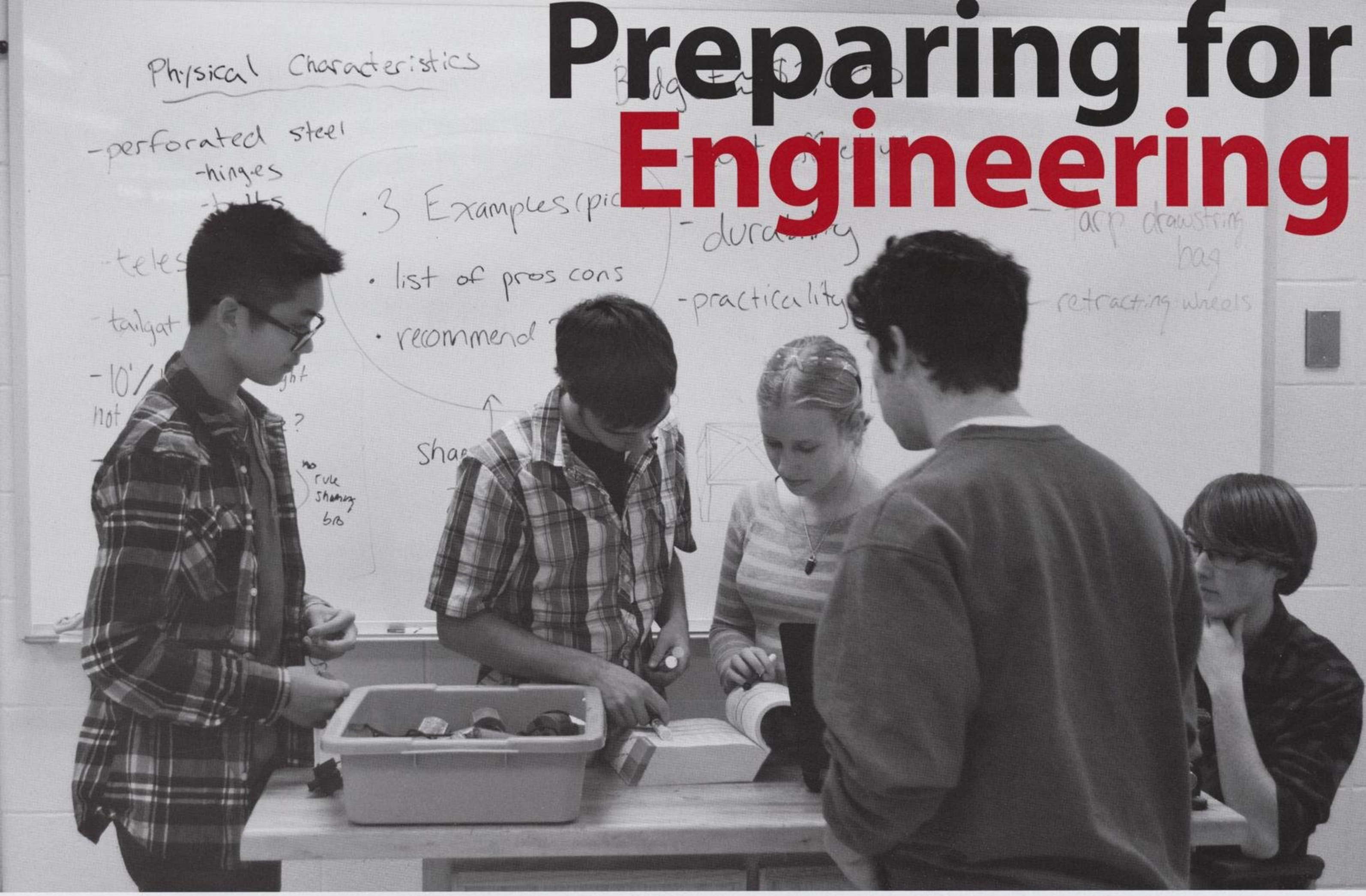
5. Wisconsin Institute of Discovery (WID)

WID is arguably the most beautiful building on the whole UW campus. It is very convenient that this building is adjacent to the engineering campus just like Union South. WID doesn't offer much seating space, but once you get a seat, WID offers one of the best studying atmospheres. The interior is decorated with trees and vegetation, and pleasant back ground sounds emanate from water fountains and chimes.

These five spots are favored by many different students. However, these are not the only study spaces in Engineering Campus other than Wendt library. In order to succeed in college, it is important to know what classes to take or professors that fit you. But it is also important to know where to study and that you have options to choose from different places. WE

Written by: Hanwook Chung
Photography by: Kyle Pedersen
Design by: Brent Grimm

Preparing for Engineering



Project Lead the Way helps students learn to collaborate and solve multidisciplinary engineering problems (Photo by: Benjamin Moncrieff)

Across the United States, students are underexposed to science, technology, engineering and mathematics (STEM) fields, but Project Lead the Way is trying to fix that. Project Lead the Way is a nationwide organization consisting of six different programs, starting with grade school students and moving through high school. Within these programs, a series of courses are offered in elementary, middle, and high schools, where students learn through hands-on experiences instead of from textbooks. The goal is to expose students to STEM at a young age and to encourage the idea of careers and post-secondary education in these fields.

Before college, many students do not know what it means to have a career in engineering. "[Project Lead the Way] shows students what engineering looks like," explains Judy Weiss, a Project Lead the Way instructor at Whitefish Bay High School. The courses touch on many different engineering fields. Through the hands-on, discovery style classes, students work to solve real-life problems. "Instead of having science and math be discrete topics, Project Lead the Way incorporates those things together to solve a problem or answer a question," Weiss says. By teaching math and science skills together in group project work, students are better prepared to work in groups and are more prepared for their introductory level classes in college.

Another goal of Project Lead the Way is to encourage underrepresented students to pursue STEM careers. By exposing all students to the different aspects of STEM, they gain the understanding that a career in a STEM field is possible for anyone. Younger students often do not realize how diverse the field of engineering is because of how it has traditionally been portrayed in the media. "There is a perception that engineering is only for those boys that tinkered with their cars growing up," Weiss says. "We have such a need in STEM fields, but half of the student population doesn't get on the radar screen." There are many different types of engineering that can appeal to a wide variety of people, and Project Lead the Way is hoping to demonstrate that to students starting at the elementary level.

Project Lead the Way courses are different from standard education because they do not use textbooks. "Hands-on is the mechanism for learning," Weiss says. The Project Lead the Way curriculum is developed on a national level which differs from the district-to-district development of curriculum in standard education. At the core of this curriculum is the goal to develop a student's problem-solving skills by having students collaborate in groups to solve problems and answer questions. Project Lead the Way courses are not only useful for students who ultimately decide to go into STEM fields, but also for students who decide to pursue different careers. "To be productive in any field, problem solving is key," Weiss says.

The 21st century skills gained from these courses are what employers are looking for when hiring. Whether or not a student decides to pursue a STEM career, STEM education is an important part of a student's education because all jobs are directly or indirectly related to STEM. Students who take these classes gain skills that not only benefit their education, but also their lives as they move into either industry or post-secondary education. As students move out into the world, their experience with Project Lead the Way gives them a competitive edge. WE

Written by: Emily Morzewski
Photography by: Ryan Yan
Design by: Brent Grimm

Nuclear Fusion: Not Just Science Fiction

Key challenges surrounding nuclear fusion are being met by researchers at UW-Madison.

Energy is everything. Without energy, Earth would be a frozen hunk of rock meandering through space. Without energy, society would cease to exist as we know it today. Humans use water, the oil in the earth, the wind, the sun, and many other methods to generate this energy. Some methods harm our world while others are still quite inefficient. More exotic methods exist that show immense potential to solve both these problems. One in particular is the plasma fusion reactor. The pursuit of the plasma fusion reactor is one of the most complex endeavors ever undertaken by humans. By attempting to harness the power of nuclear fusion, we are attempting to generate energy in a method identical to our sun. Here at UW-Madison and across the world, researchers are working to make fusion energy a reality.

In order to truly appreciate the challenges involved and benefits to be gained from fusion energy, we need to take it slow. First, it's necessary to clarify the difference between nuclear fission and nuclear fusion. Nuclear physics tells us that elements with very low atomic numbers such as hydrogen and very high atomic numbers such as uranium release the most energy when they undergo a nuclear reaction. However, the ways we extract energy from heavy and light elements are fundamentally different. Heavy atoms such as uranium can be cleaved into smaller pieces either by natural decay of the atom or by ramming the atoms with neutrons. This process is known as nuclear fission, which has held widespread popularity in our world for the last 70 years in both peaceful (power plants and medical isotope production) and proliferative (nuclear weapon stockpiling) positions. In short, nuclear fission splits an atom into smaller pieces.

Directly opposite to nuclear fission is nuclear fusion. Nuclear fusion is the process of melding atoms together. While nuclear fission uses heavy elements, nuclear fusion uses light elements. Energy is extracted when the fusing atoms change mass as dictated by the famous E=mc2 equation. The core concept behind nuclear fusion is to have atoms bump into and fuse with each other. For this to be accomplished, two forces need to be taken into account: electric repulsion, which pushes atoms away from each other, and the strong nuclear force, which holds the atom together. The strong nuclear force is much stronger than electric repulsion but only when the atoms are at very short distances from each other. For nuclear fusion to begin, electric repulsion must be overcome. The most common way to overcome electric repulsion is to heat the atoms to increase their kinetic energy past a specific threshold. However, the temperatures required range to millions of degrees, which makes this problem significantly more difficult; no material in existence can hold matter of such temperature extremes.

Heating particles to such high temperatures shifts the particles to the fourth state of matter known as plasma. Plasma is formed after heating a gas to very high temperatures. A key property of plasma is that it feels forces in electromagnetic fields. With this property in mind, researchers developed a nuclear fusion technique that shoots plasma around in a magnetically-confined ring. A device that uses this confinement technique is the donut-shaped tokamak. The tokamak, whose name comes from a Russian acronym, is the most developed fusion-confinement approach to date and is widely used for its good confinement properties and simple design. Yet, the design of the tokamak has some limiting aspects. To understand why, imagine taking a Slinky and putting the two ends of it together. The formed shape is a donut made of helical lines. This is the required magnetic field structure for a tokamak. However, creating this structure requires two separate magnetic fields: one to produce the field going around the donut, and one to twist the field in a spiral. The tokamak requires an electric current to be driven through the plasma to produce this twisting field. As a result, this approach is inherently unstable and has a higher potential for the plasma to lose confinement. If the plasma escapes the magnetically-confined ring through this instability, the immense energy contained would lash outward, potentially destroying the fusion reactor.

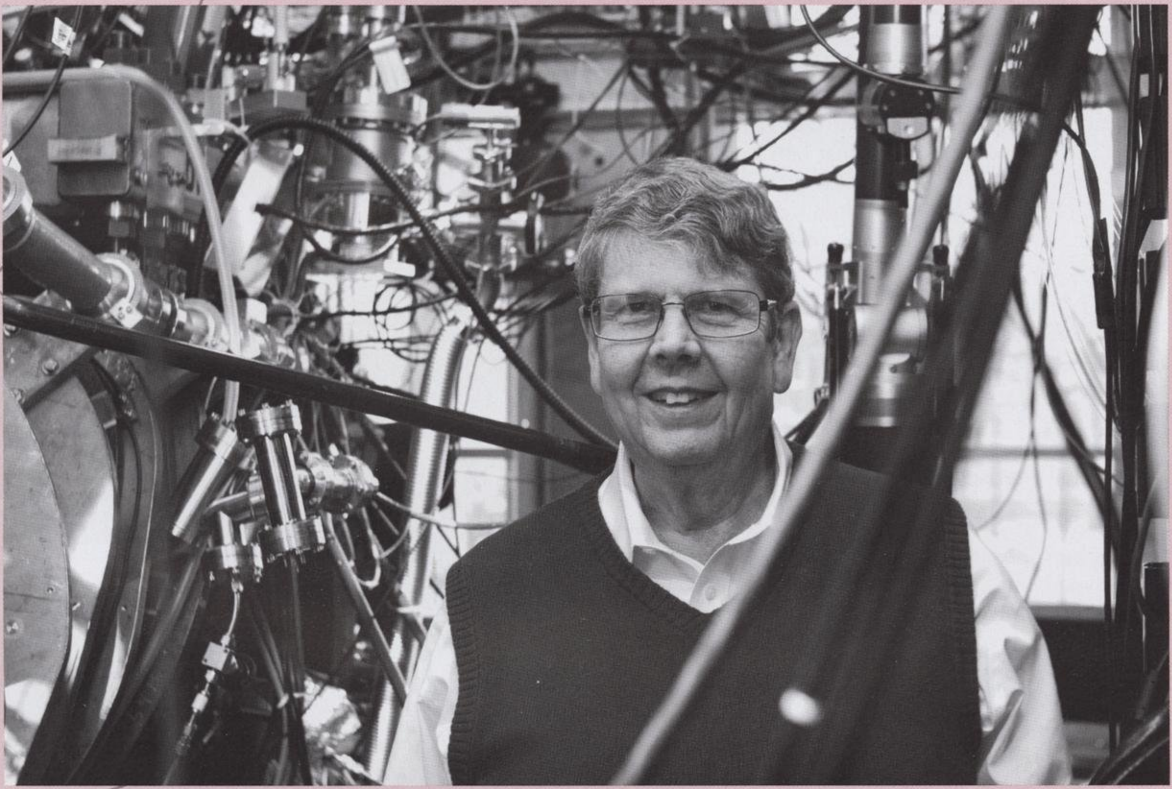
To counteract these problems with the tokamak, a more advanced type of fusion reactor was developed. This reactor, known as a stellarator, uses unconventional configurations of magnets to achieve plasma confinement similar to the tokamak while eliminating the need to drive current through the plasma. This reduces the instability problems of tokamaks and allows for a more efficient confinement device. However, the stellarator introduces a new problem. The tokamak, with its symmetric donut shape, has symmetric magnetic fields, which are desirable. The classical stellarator, with its unconventional magnets, produces asymmetric magnetic fields, which introduces a whole host of new confinement problems.

It is this asymmetry problem that UW-Madison ECE Professor David Anderson has set out to solve. After receiving his PhD from UW-Madison, he continued to work as a plasma researcher at the university, where he proposed the Helically Symmetric eXperiment (HSX) in 1992. HSX is a plasma fusion reactor using the stellarator design. However, this experiment utilizes supercomputer-optimized magnets to trick the plasma into thinking symmetric magnetic fields like those in a tokamak exist, a concept known as quasi-symmetry. HSX was "the first stellarator in the world that [gave] us confinement like a tokamak with the good engineering advantage of the stellarator", Professor Anderson says, with the engineering advantage stemming from the elimination of the tokamak's driven current. Construction began in 1993 and took six years to complete because of the complexities involved.

HSX was the first fully-optimized stellarator to test whether or not quasi-symmetry would work. Thanks to Professor Anderson and all those working on HSX, it has since provided significant scientific contributions to the designs of future stellarators. In essence, it proved that quasi-symmetric stellarators provide equivalent if not better particle confinement over tokamaks across multiple metrics. HSX was able to take a theoretical confinement technique and successfully demonstrate its effectiveness in practice.

With a key confinement problem solved, the next problem to solve is how to design more resilient reactors. "The biggest challenges facing fusion right now are materials. We have to deal with materials under extreme conditions," Professor Anderson says. One of the reasons reactors would degrade is because of the current type of fusion reaction envisioned in the majority of fusion reactors around the world. This fusion reaction uses deuterium and tritium, two heavier isotopes of hydrogen. When these particles are fused, the output is a high-energy helium particle and, crucially, a high-energy neutron. Because neutrons are neutrally-charged particles and have no interaction with the reactor's magnetic fields, neutrons formed in the reaction shoot out and can embed themselves into the wall of the reactor. Over time, this will cause the lining of the wall to degrade and exhibit some radioactivity. Even though the material would only be radioactive for a manageable 50-100 years—which is insignificant compared to the 10,000-year radioactivity of nuclear fission waste—it's in the best interest of fusion researchers to figure out how to mitigate this high-energy neutron problem.

In Germany, a new experiment is beginning operation to test the viability of the stellarator as a reactor candidate. Wendelstein-7X (W7-X) is also a highly-optimized stellerator like HSX, but it will operate at larger energy levels and for longer time periods. Whereas HSX measures its operational timescales in milliseconds, W7-X will attempt to operate for thirty minutes continuously. Laurie Stephey, a graduate researcher with HSX capturing pictures of plasma and neutral particles to study their behavior, has seen the impressive nature of W7-X first-hand. In a complement to her work on HSX, she implemented particle imaging systems on W7-X to determine particle confinement durations. A core research goal of W7-X is the testing of a new type of device to sweep up the high-energy escaping plasma. This will allow W7-X to run for extremely long periods of time, which is critical to develop a grid-scale fusion reactor. "If W7-X is successful in this endeavor, it will make the stellarator a very attractive candidate for a future power plant," Stephey says.



Professor David Anderson stands in front of his creation, the HSX stellarator.

Energy generation is the ultimate goal of these two incredibly impressive research experiments. Nuclear fusion is truly the holy grail of energy production. To their credit, fission reactors can produce outstanding amounts of clean energy. However, fission reactors have highly radioactive waste and have the potential for creating large-scale disasters such as Chernobyl and Fukushima (it should be noted that modern fission reactor designs are significantly safer than those that melted down). Fusion reactors do not suffer from these radioactivity problems and do not have the potential to create a widespread nuclear disaster. As mentioned two paragraphs above, the most common fusion reaction uses deuterium and tritium. The fuel for this fusion reaction is abundant; one gallon of sea water contains enough deuterium fuel to match the energy output of at least 300 gallons of petroleum, and shooting the expelled neutrons from the fusion reaction into the element lithium produces more tritium. In contrast, the uranium for fission reactions must be excavated from mines and put through intensive purification processes. The heat from the fusion reaction will be used to boil water to spin a turbine to generate electricity, meaning the fusion reaction is carbon-neutral like nuclear fission. With readily-available fuel and an extremely clean reaction, it's now up to our scientists to perfect the fusion reactor. This undertaking has been identified by the National Academy of Engineering as one of the Grand Challenges for the 21st Century.

Humanity has been researching fusion reactions for almost as long as we've been researching fission reactions. While it's been a long-fought battle, we have never been closer to realizing widespread fusion energy generation. The implications will be far-reaching; the already-successful fission reaction can be replaced by a reaction that eliminates hazardous waste and is significantly safer to operate. Humans will cage miniature suns for our own benefit. Thanks to the fantastic work of David Anderson, Laurie Stephey and all those associated with HSX and the many other fusion experiments at UW-Madison and beyond, we are that much closer to realizing this reality. WE

Written by: Stephen Eick
Photography by: Ben Chen
Design by: Brent Grimm

A Closer Look at Optics

Learn about Professor Mikhail Kats's research in the field of optics.

On campus, professors are doing many different types of research. Some of these topics are consistent with what one thinks of when hearing the word "research": mixing chemicals in test tubes or observing bacteria cells under a microscope. On the other hand, some professors are delving into topics that may baffle a casual observer. Professor Mikhail Kats' research in various topics in the field of optics falls into the second category.

When optics is traditionally brought up, thoughts of lenses and ray diagrams are normally considered. However, Kats' research is significantly different than just lenses and rays. Kats has only been on campus for about 10 months, having recently completed his PhD at Harvard and working as a post-doctoral scholar for another year. Professor Kats has several fields of interest within the field of optics upon which he focuses his research.

The first topic that Kats specializes in is thermal radiation. Thermal radiation is essentially light that is emitted from an object because of its elevated temperature. This radiation can be at different wavelengths depending on the temperature and material. For most common materials, the amount of emitted power increases as the temperature increases. However, Kats developed a material combination for which the amount of emitted power can decrease as the temperature increases. This discovery could be useful for a few practical applications. Firstly, it could be used to cloak a person's presence from thermal cameras, which has obvious practical military applications. Secondly, it can be used in temperature regulation. A satellite coated with this material would start to be very emissive and radiate more waves when it gets too hot, and then become less emissive after it cools itself down. This method of cooling is very advantageous because it eliminates the need for complicated circuitry.

The second topic that Kats researches is a relatively new topic in optics called plasmonics. Plasmonics is essentially the guiding and controlling of light using metals. Normally in optics, metals cannot be used as optical components because they are opaque. They are traditionally only used for reflecting light. However, light can be trapped along the surface of a metal as long as the surface is patterned in a specific way; from there, the light can be manipulated. This field is called plasmonics because the free electrons within the metal act as a plasma. One application of plasmonics is to confine light at visible frequencies into nanoscale volumes. This increases the intensity of the light, which in turn increases the efficiency of various optical processes. In turn, unfavorable processes that are difficult to observe naturally become more favorable. A practical example of this is the solar cell. Normally a solar cell requires a relatively thick layer of semiconductor material to absorb all of the light that falls on it. However, using plasmonics, resonant structures can be built into the solar cell, which enhances the absorption even with very thin layers of material. Plasmonics, despite being a new field, has many practical uses, many of which are being researched by Kats.

Kats does other research in different fields of optics beyond what has been highlighted. He grew to be interested in optics for many reasons. When he was in college, Kats took a class in optics. "I learned things that I thought were science fiction," Kats says. For example, one optical process traps and moves particles using light, which to Kats sounded exactly like a tractor beam. He found optics to be very interesting and practical, which drew him to the field.

Although light is very well understood and has been for well over a century, new discoveries in optics are still being made to this day. "Optics touches everything and has applications in almost every field," Kats says. Despite this, he has been able to carve out his own niche. "Even though the laws [of optics] were written down over 150 years ago, they describe an almost impossibly large range of phenomena and potential technologies that we are still inventing and discovering to this day, and will be for a very long time," Kats says. "And that is very exciting."

Written by: Alex Chay
Photography by: Martin Johnson
Design by: Jason Wan

Professor Mikhail Kats in his new lab on campus

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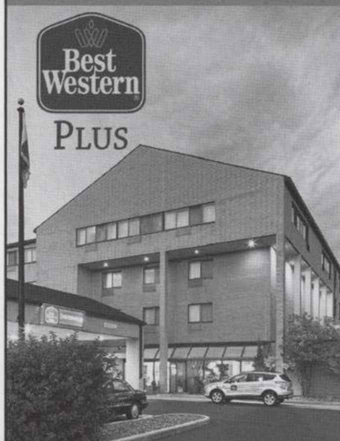

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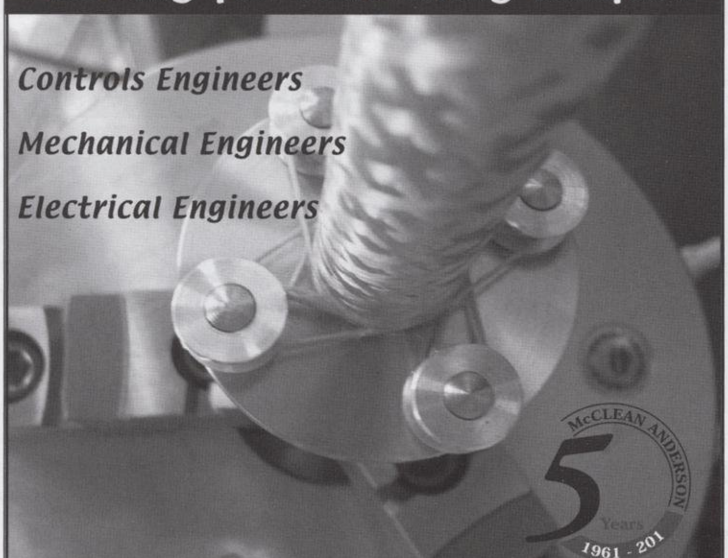

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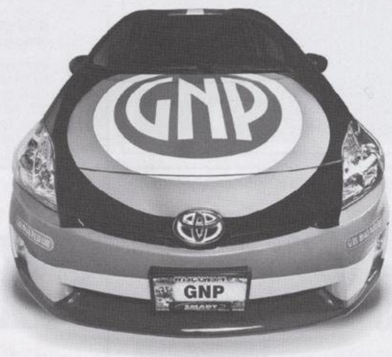

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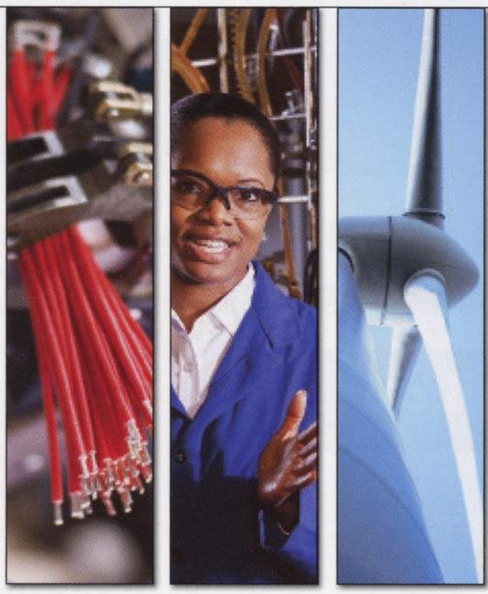

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