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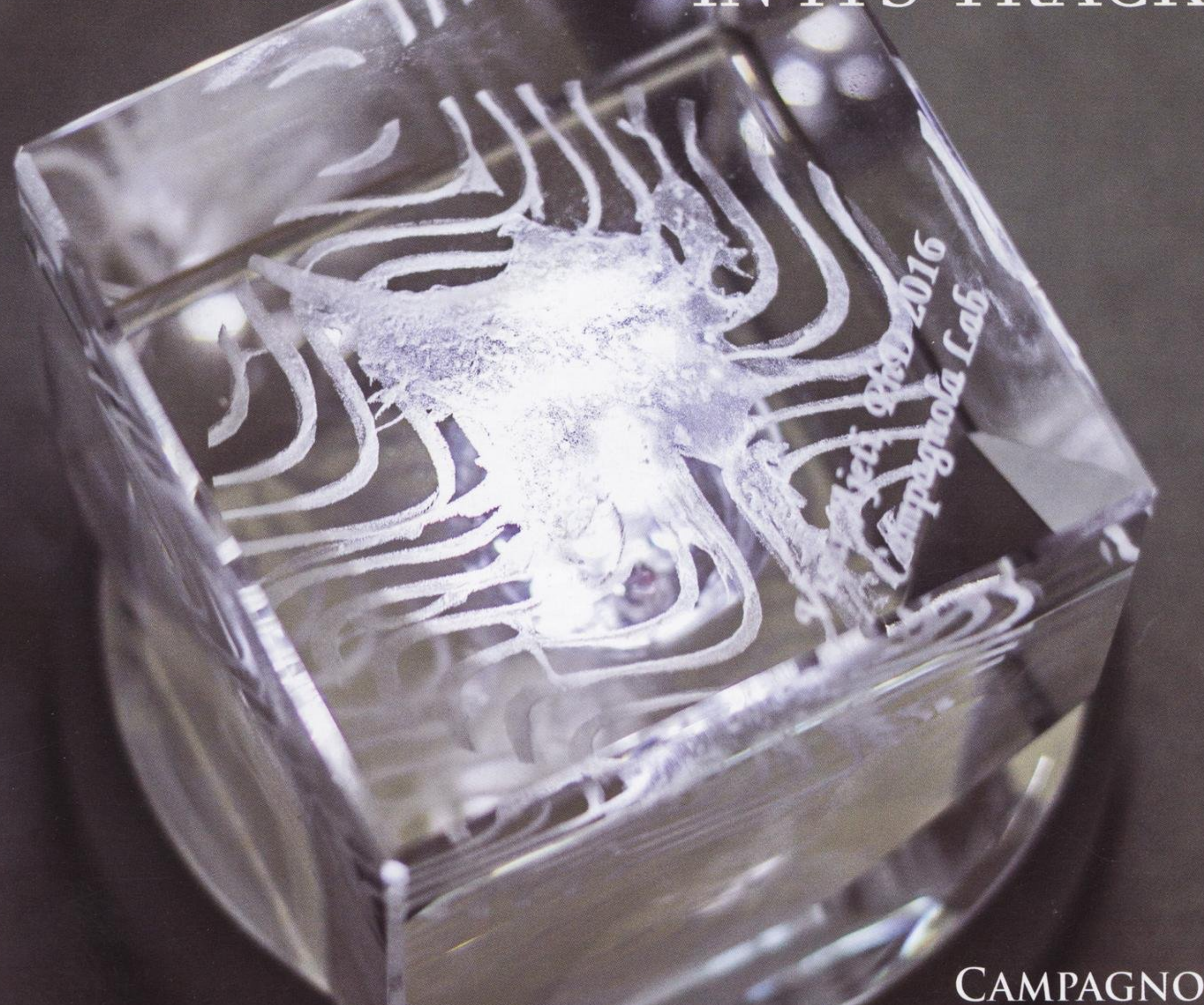
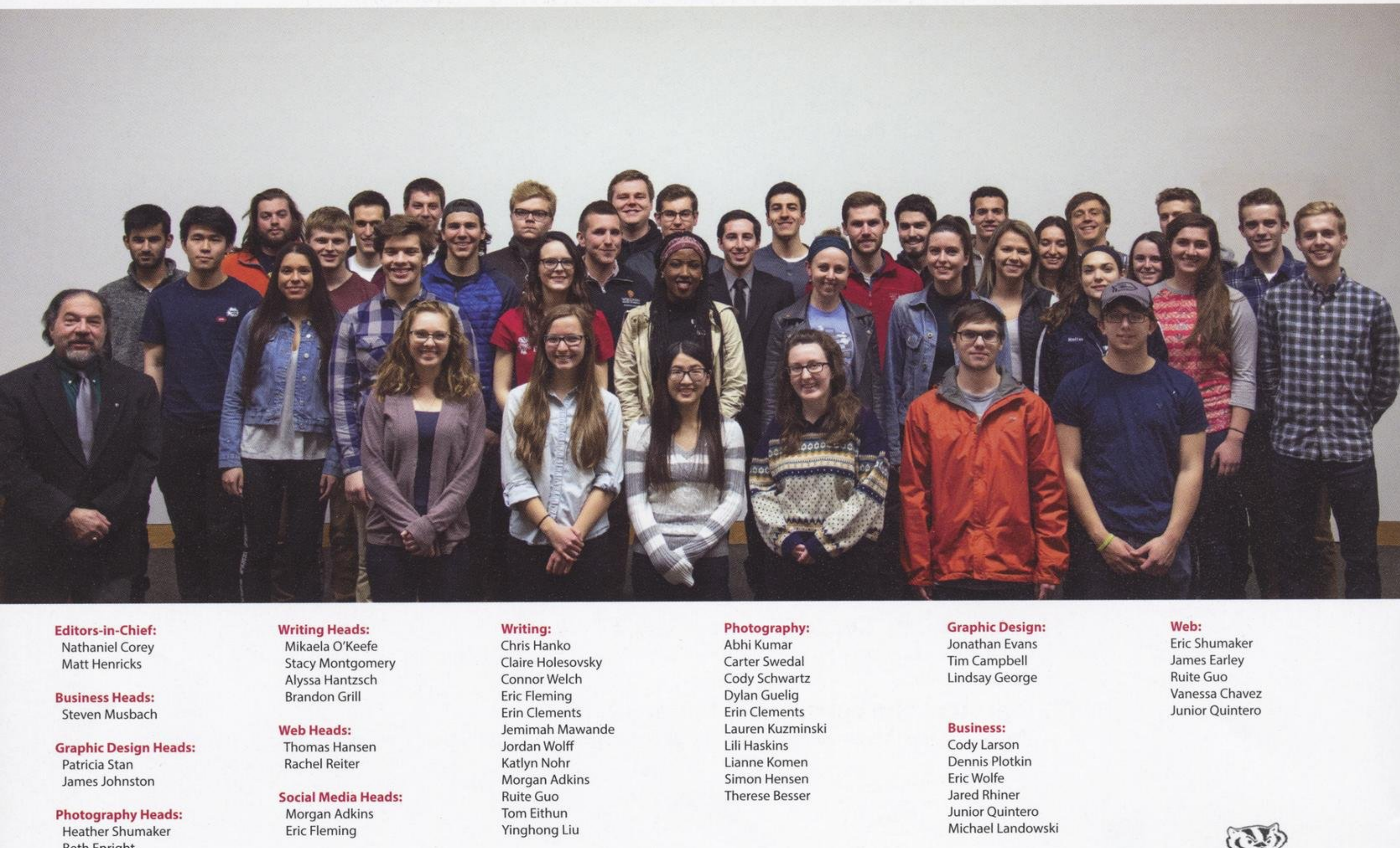
FALL 2017 VOLUME 121, NUMBER 4

STOPPING CANCER IN ITS TRACKS



CAMPAGNOLA LAB BATTLES DISEASE THROUGH IMAGING AND 3D PRINTING



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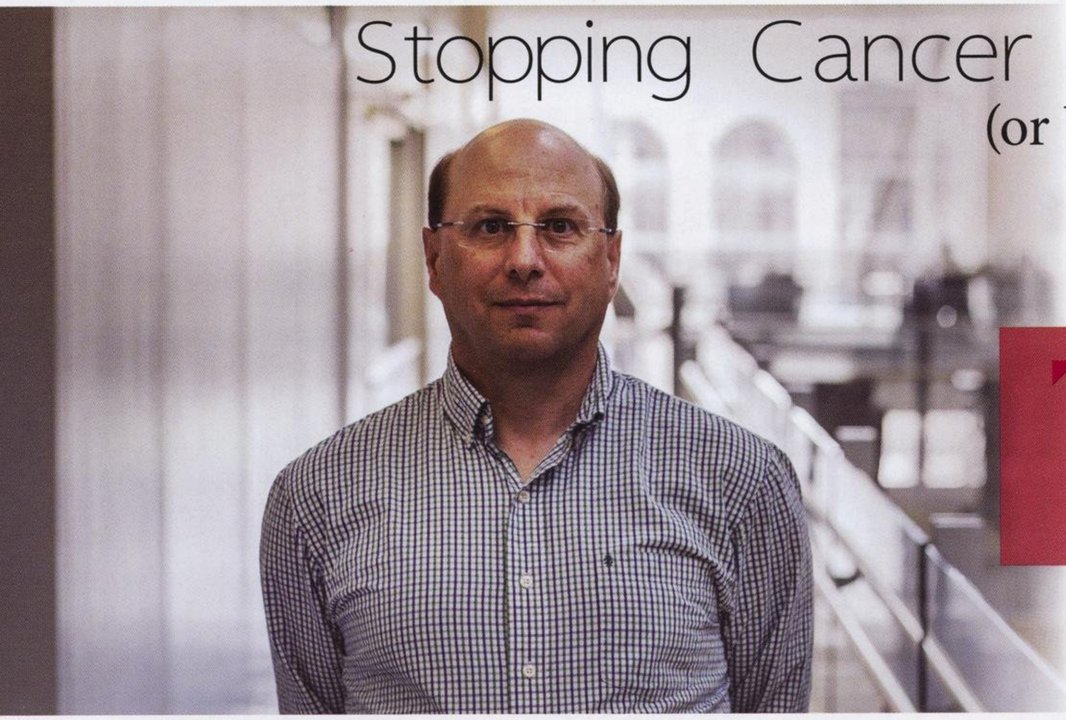
General

Cover photo by Cody Schwartz

Stopping Cancer in its Tracks
(or Visualizing a Solution)



Dr. Paul Campagnola, a professor in the department of Biomedical Engineering.

"Cells in a petri dish don't behave like cells in 3D environments." - Paul Campagnola

Campagnola Lab battles disease through unique cellular imaging and 3D printing.

Cancer is a disease that comes in many different forms and intensities and accounts for roughly a quarter of all deaths in the United States. One of the most lethal types of cancer is ovarian because it is rarely detected before it rapidly spreads throughout the body. UW-Madison Professor and Principal Investigator Paul Campagnola and his associates have studied this disease and developed revolutionary forms of imaging that will contribute to stopping diseases early before they can spread.

The Campagnola Lab has two related components that comprise the research. The first group develops technology for imaging the extracellular matrix (ECM), the network of proteins and other macromolecules surrounding cancerous cells. This technology is called second-harmonic generation microscopy. The second group can then virtually visualize the problematic collagen and tissues and develop accurate 3D models of the tissue. Researchers can then 3D print the models, but instead of using polymers to create the models, they use human proteins that are fabricated with collagen. Campagnola jokes about his lab, saying, "we were 3D printing before it was cool!" The group uses these models to examine how the cancer cells migrate and proliferate. With this knowledge, the researchers can better examine and understand the biology of cancerous cells and attack the disease on a microscopic scale to stop any growth to non-problem areas.

The lab's work with cancer research and new techniques of tissue imaging has earned Campagnola national recognition. In 2016, Campagnola and his associates were awarded a $2 million grant to develop images of ovarian cancer cell collagen in surgical patients. They'll use these images to fabricate biomimetic models of collagen, implanting those models into mice to study how they grow and monitor any further metastasis. In the end, the lab hopes to provide better diagnosis and treatment to improve the outlook for women with ovarian cancer.

Replica of 3D imaged tissue that was printed using a 3D bioprinter.

Campagnola's effort in creating accurate models of the ECM holds great promise for the future of cancer research methods. Conventionally, cancer is studied by observing cells in a lab settings, but Campagnola states, "Cells in a petri dish don't behave like cells in 3D environments." As the research progresses, the lab plans to surgically implant the 3D structures into mice and smaller animals to monitor the tumor development in a mammalian bioenvironment. The future calls for in vitro imaging for cancer and fibrosis in mammals and using the latest imaging techniques including the use of endoscopic probes.

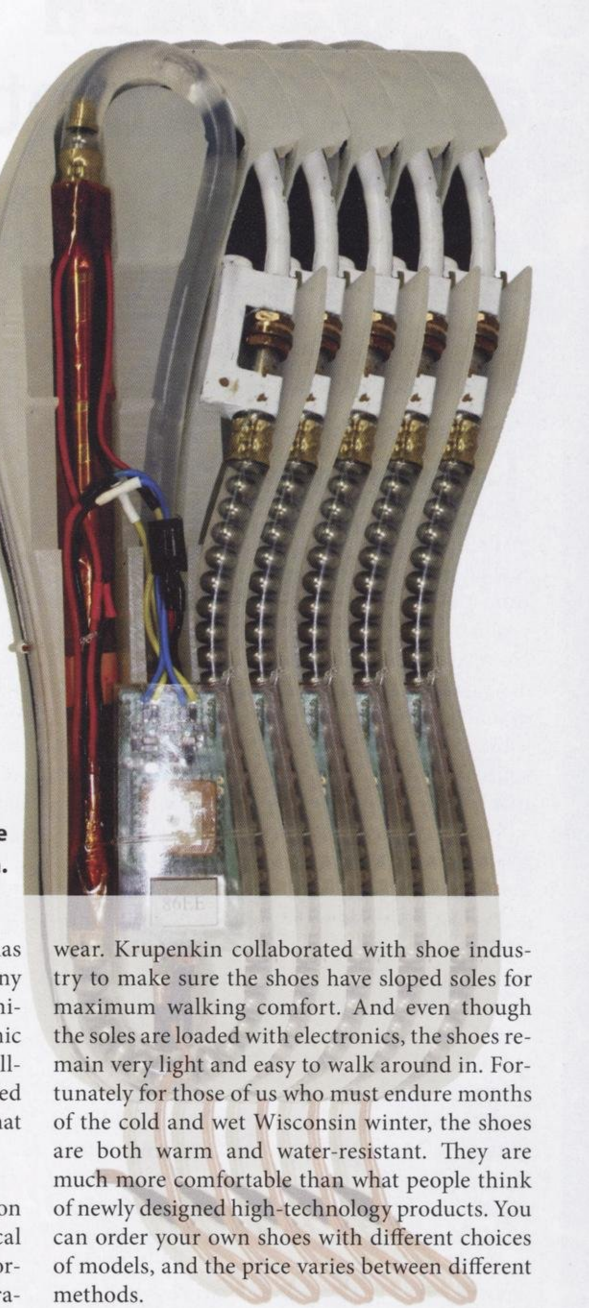
The future applications of Campagnola's medical imaging technology are abundant and can be helpful in studying many diseases and conditions beyond cancer. The lab is currently using the same approach to investigate pulmonary fibrosis, cardiac repair, and decaying cartilage in aging people suffering from arthritis. With this technology, diseases will be easier to detect and the proper diagnosis can be made before any fatal effects arise.

This lab has accomplished some amazing things so far, and with the help of some brilliant minds and sufficient funding, great strides will be taken in the field of cancer and disease diagnostics. Cancer researchers and patients all around the world can benefit from this technology as the Campagnola Lab continues to fight for hope.

Written by: Chris Hanko
Photography by: Cody Schwartz
Design by: Patricia Stan

All in ONE

The idea of a footwear-embedded energy harvester was first proposed in the 20th century. Today, UW-Madison researchers have developed this idea into an operational device.



Inside view of the shoe sole that shows the power generation system.

For the past few years, the wearable technology industry has seen staggering growth, a trend that is projected to continue on a massive scale. Experts at the market analysis company CCS Insight expect that $34 billion in wearable devices will be sold in 2020. As you may expect, wrist-based devices such as fitness trackers and smart watches currently account for the vast majority of wearable device sales. But with new technology being developed at UW-Madison, there may be another contender on the horizon: Shoes.

Tom Krupenkin, a professor of mechanical engineering at UW-Madison, and J. Ashley Taylor, a senior scientist in UW–Madison's Mechanical Engineering Department, are currently developing footwear that has many of the same functions as a cell phone or Apple Watch, such as tracking location. However, unlike your cell phone, these fancy new kicks don't require the use of GPS to do so. "One of the ways to do this is to use accelerometers," Krupenkin says. The science behind this can be explained with Newton's second law. "This law relates the force applied to an object to its acceleration. If you know the force, you know the acceleration," Krupenkin says. "Then, you determine the velocity. If you know your velocity, you can get your position."

According to Krupenkin, a second function of the high-tech shoes "would be having a Wi-Fi hotspot inside the shoe…which means you would have internet access all time." And even better, the energy to power the mobile hotspot is generated within the shoes themselves by the wearer's motion. This energy-harvesting technology has been the focus of Krupenkin's research for many years. Human motion produces a lot of mechanical energy, which can be used to power electronic devices like the tech that Krupenkin is installing in shoes. With this new form of self-powered wearable technology, Krupenkin envisions that "you will never run out of charge."

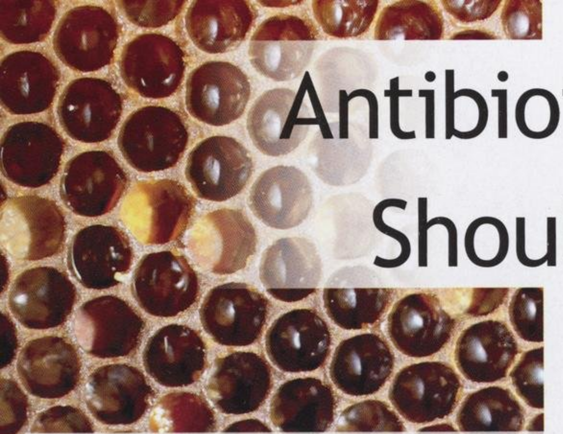
A third, and perhaps most important, application of Krupenkin's footwear is detection of medical emergencies. The foot can provide much information about health conditions; body temperature, pulse, and many other health indices can be detected from the foot. Various devices installed in the shoes can monitor the wearer's body condition, and with the help of the hotspot and the position finder, "the shoes can immediately alert the hospitals" should the person require medical assistance, Krupenkin says. This has the potential to save the lives of many who suffer from cardiovascular diseases, diabetes, and more.

All of this can be achieved within the space of a shoe sole, using only the mechanical energy harvested from footsteps. With Krupenkin's technology, your feet will become powerhouses and your shoes will become energy sinks that will never run dry. "It's just like having your phone in your shoes," Krupenkin says, "but one which is constantly connected to a network, is never off, and is always charged."

In addition to studying the technology behind these multifunctional shoes, Krupenkin has also introduced user-friendly elements into the footwear. Krupenkin collaborated with shoe industry to make sure the shoes have sloped soles for maximum walking comfort. And even though the soles are loaded with electronics, the shoes remain very light and easy to walk around in. Fortunately for those of us who must endure months of the cold and wet Wisconsin winter, the shoes are both warm and water-resistant. They are much more comfortable than what people think of newly designed high-technology products. You can order your own shoes with different choices of models, and the price varies between different methods.

These shoes give us a glimpse at the future of technology. "Most of the electronics that we will be using in the future is not going to be in the form of phone; a lot of the devices will be in things like shoes or other wearable devices," Krupenkin says. More and more sophisticated devices will be integrated with things that we wear every day, making their use simple and convenient. With mechanical energy harvesting technology, our daily movements can be used as a source of energy, allowing us to leave our reliance on chargers behind us. With new innovations happening every day, the wearable technology industry is certainly the one to watch if you're looking to improve your quality of life in a comfortable and stylish way.

Written by: Yinghong Liu
Photography by: Simon Hensen
Design by: James Johnston



Antibiotics From Dragon's Blood: Should We Get Our Hopes Up?

New discovery finds that Komodo dragon blood could give us answers to antibiotic resistance in bacteria.

Bacteria are ancient organisms that are known by many as the first lineage in the origin of life on Earth. Over the course of their existence here on Earth, bacteria have proved their importance to life as we know it, from the decomposition of dead matter to the production of our famous Wisconsin cheeses. However, bacteria are more commonly thought of as harmful organisms that can spread diseases amongst different species. Though capable of spreading deadly illnesses, bacteria are also the sources of antibiotics, providing the medicines that help destroy a variety of bacterial illnesses.

Most of the antibiotics or drugs we use today are derived from microbes found in bacteria on fungi, plants, and even animals. Recently, scientists at George Mason University have reported that they have found antimicrobial protein fragments in Komodo dragon blood that appear to help the animal resist deadly infections. This discovery is potentially a new lead in developing stronger antibiotics that can fight off antibiotic-resistant bacteria. However, after speaking with Professor Cameron Currie from the department of bacteriology at UW-Madison, it seems like this intriguing new find may not be something to get too excited about just yet.

Housed in the Microbial Sciences building, Currie's Lab conducts research that "focuses on symbiotic associations between animals and microbes." Currie and his group screen bacteria from insect systems, focusing on the same type of bacteria found in isolated soil samples. The microbes they screen come from the insects, and the interesting part is the chemistry of the microbes they find are different than what is found in the soil alone. So far, Currie and his colleagues have discovered about 25 new chemical compounds, a few of them prospective leads for antibiotics.

Their screening process involves collecting samples of insects in the field, putting them in a sterile container, and performing a wash. "The more we sample, the more diversity of bacteria we get, and the more bacteria we can screen," Currie says. A bacterial culture of the insect is placed in petri dishes with human pathogens to induce secretion of the chemical compound produced by the bacteria. In warmer weather, they also study microbes found in honey bees. In this situation, they crush up the honey bee into tiny pieces before they isolate the bacteria, a process not unlike that used by high school biology classes to extract DNA from insects.

After isolating the bacteria, it's allowed to grow in response to the pathogen for about a week. If the microbe is not producing antibiotics, growth is seen on the pathogen. If it is, then growth is seen around the petri dish but not on the pathogen. The success of certain antibiotic dosage can be assessed by measuring the zone of inhibition, or the area where the bacteria does not grow; the larger the zone, the more effective the antibiotic is at inhibiting bacterial growth.

"This discovery is potentially a new lead in developing stronger antibiotics that can fight off antibiotic-resistant bacteria."
- Cameron Currie

The main insect system they're recently researching is comprised of leafcutter ants that propagate fungus for food. This process is quite similar to the way humans grow and use crops. The ants take a piece of microscopic fungus from a parent nest, start a new nest, and plant the fungus on rows of leaf material for feeding. These ants have two mutualists, or other organisms they depend on: the fungus they grow for food and the bacteria that live on their skin to produce antibiotics against fungal pests.

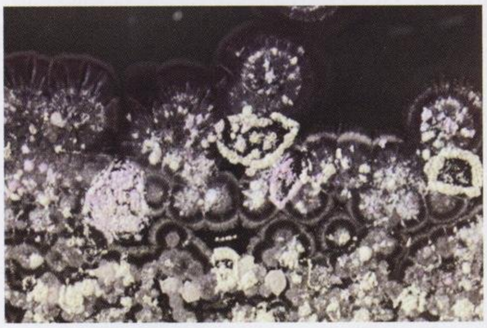
When asked about the possibility of creating antibiotics from Komodo dragon blood, Currie was skeptical given his knowledge of previous bacteria and antibiotic research. Currie explains that, "[It is not hard to] find antimicrobial peptides—all life produces peptides." However, he goes on to say that he has never heard of a drug being developed from a peptide found in animal blood. In addition, the amount of money involved in the research of an antibiotic and the development of a new pharmaceutical drug can cost upwards of hundreds of millions of dollars. It would not be shocking for a 15-year long research on an antibiotic to cost $500 million. "It's a huge undertaking," Currie says. The mere discovery of protein fragments found in Komodo dragon blood is a far way off from obtaining a new antibiotic.

Also, being able to effectively search for any antibiotic-producing microorganisms requires a significant amount of blood from Komodo dragons. The amount of blood needed for the extensive research and clinical trials brings up the issue of animal cruelty, too. An estimated one hundred thousand to one million microbes, or strains, would need to be screened in addition to all the individual cultures of bacteria to develop a pharmaceutically useful antibiotic.

With various research groups finding intriguing new discoveries every day, it's easy to get caught up in emerging possibilities rather than the actual scientific probability that this new finding will truly save lives. The possibility of Komodo dragon blood fighting antibiotic resistance is a fascinating idea, but not one that is very likely to happen anytime in the near future. Because of the expenses involved in the research, as well as the substantial number of microbes to perform a thorough analysis, it isn't feasible with the current technology. So, don't get your hopes up on this dragon's blood. At least, not yet.

Written by: Erin Clements
Photography by: Lauren Kuzminski
Design by: Patricia Stan

Left: Leftover honey deep in the honeycomb of the habitat that housed the hive lead by a queen bee transported from Iowa.
Below: Actino-bacterial isolates cultivated from the honey bee habitat, although found in a similar location, exhibit extremely different characteristics.



Madison: The Gem Of The Midwest

A new understanding of cities may well be the choice between creating a "world of slums" or achieving a sustainable, creative, prosperous, urbanized world expressing the best of the human spirit.

The city has emerged as one of the most complex systems of the 21st century. Cities reveal both the best and the worst aspects of humanity – these systems exhibit mankind's creativity and imagination but also our tendency to discriminate and create waste. A city's infrastructural, economic, and social components interact much like a living organism, which is built upon interdependencies between each subsystem. It therefore becomes quite difficult to understand and appreciate the city by studying each part in isolation. But, in pulling apart the pieces of a successful city, we can begin to understand what makes cities flourish and what separates those that succeed from those that don't.

Madison, Wisconsin, is undoubtedly one of these "successful" cities. Madisonians live in a vibrant hub of culture and diversity. This city is a cultural center of art, music, food, and, of course, beer. Surrounded by festivals year-round, like the Taste of Madison and the Good Neighbor Fest, city locals are never at want for a community event. Being a college town, too, the city and surrounding community are actively supported by over 40,000 students that call this place home. This adds a new layer of experiences to an already intricate place. With thriving suburbs full of families, to a booming downtown full of young professionals and students, Madison is home to a wide variety people. The city's proximity to stunning lakes and trails also attracts avid nature lovers. There are plenty of outdoor activities for all, and it's a naturally picturesque place to be no matter the time of year. It's the most accommodating city for cyclists and one of the "greenest" cities around. Not many cities can compare to Madison, and not a single one can compete in such a variety of areas.

Because of the vast number of places to explore and the diversity of the people who explore it, Madison houses a naturally vibrant and extensive economy. The city is the headquarters for several businesses, the seat of state government, the home to families, and the classroom for students. Housing major institutions like UW-Madison and the state capital leads to greater stability for its population and economy and helps the small to mid-sized city outperform many of its larger counterparts. These institutions bring in talent, research investment, jobs, and a fresh influx of new residents. They create the foundations for scientific development, the arts, and politics-- all the while highlighting the positive effects of diversity through Madison's many different environments.

But what allows Madison to create such an incredible living space? One area, unique to Madison as a college town and government hub, is that people are heavily involved in policy and government. Residents are actively involved in policy making and take advantage of UW-Madison's vast resources to make change. But that isn't the whole picture. It is almost impossible to prescribe a generic "solution" to solve problems different cities face. Policy changes that are effective in one city might fail miserably in another. Similar places have vastly different issues, so we can't always just point to policy and government.

It seems that we have yet to discover exactly what makes a city succeed. Although the likely contenders may be size, culture, and environment, one cannot be sure these are what brings cities like Madison their success due to their aforementioned complexity. Other cities have tried to incorporate many of the successful aspects of Madison without a favorable outcome. There are cities, like Pittsburg or inner-city Milwaukee, filled with beautiful parks that remain untouched and housing developments downtown that fall into disrepair. There are places of similar size that have high levels of concentrated poverty, and places of similar location that don't have any outdoor community activities. There are cities that should, in terms of policy, be much more successful than Madison, but are instead a place of degradation, squalor, and substandard housing.

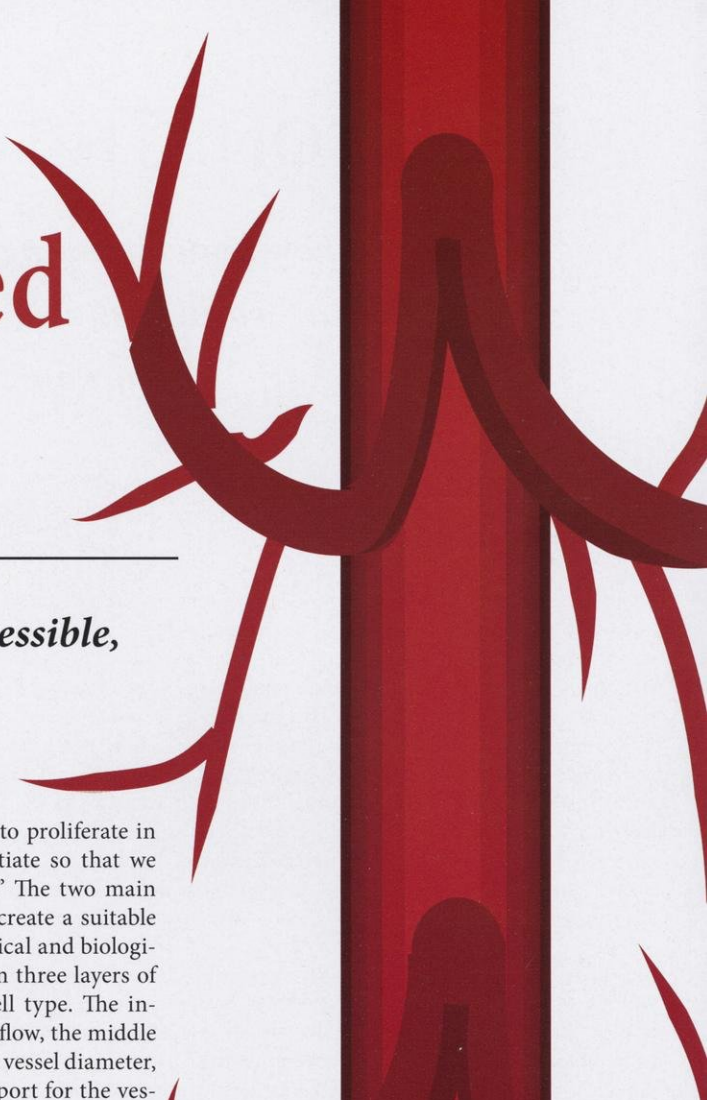
It is my belief that the difference lies in Madison's perspective. It is a well-balanced city filled with many types of people and organizations, and each one is personally invested in different aspects of the city. Each group thinks in terms of differing priorities and time scales. The government thinks in terms of policy and fiscal years; the public in community and decades; businesses in economics and impending deadlines; students in education and the next four years. With each group invested in such different areas, it allows for change and growth across the board and along different time horizons. It builds an interconnected and complex system of people, values, organizations, activities, and infrastructure that are invested and dependent upon the city as a whole.

Madison is more complex than a collection of independent parts – it has emergent properties that surface due to the synergy of its inhabitants. It is a living, breathing organism that survives because of the delicate interdependencies of each system of which it's comprised. It is only through this understanding of the sometimes obscure relationships of the urban system that sustainable growth and prosperity can occur. Although this may not be a formula for policy-makers to follow, a new understanding of cities may well be the choice between creating a "world of slums" or achieving a sustainable, creative, prosperous, urbanized world expressing the best of the human spirit. And that might look a lot like the place we call home.

Written by: Morgan Adkins
Photography by: Carter Swedal
Design by: Patricia Stan

Structures and nature work harmoniously together to make up vibrant cities like Madison, WI.

Tissue Engineered Arteries



Arteries used for bypass could soon be more accessible, more reliable, and grown from stem cells.

Diseases of the heart and arteries remain one of the leading causes of death in the United States; despite vast medical advancements in recent years, about one in four Americans will die from cardiovascular causes. Fortunately, recent times have also seen growth in the biomedical engineering and biomaterials fields. While artificial materials have been developed for replacing large diameter blood vessels, these materials are not as efficient in small diameter vessels. Current solutions to this issue are slow to develop and not able to reach patients quickly. Researchers at UW-Madison are leading an innovative project to design small diameter vessel replacements that are available off the shelf.

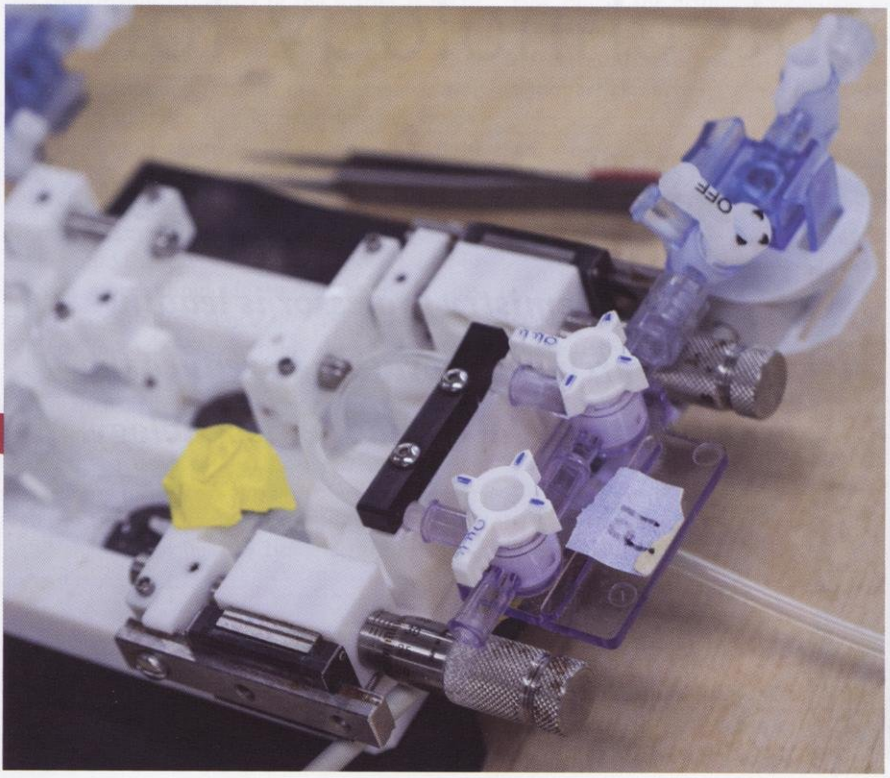
The current treatment method for small blocked arteries is to bypass the section with an artery or vein from the patient, but there are not always enough healthy native vessels available. Researchers funded by the National Institutes of Health working across multiple labs, including the Wisconsin Institute for Discovery and the Morgridge Institute, are looking to change that. "We need small diameter vascular grafts that will not re-occlude when implanted, and that are readily available," UW-Madison Professor of Biomedical Engineering, Naomi Chesler says. In response to this need for a new way to replace malfunctioning small-diameter arteries, a team led by James Thomson, comprised of Chesler, Tom Turng, Sam Poore and other researchers, are developing an artificial biomaterial that will then be seeded with pluripotent stem cells. These cells can differentiate to form a functioning artery replacement.

Chesler states the group's focus is "on the conditions that will direct the cells to proliferate in a scaffold material and differentiate so that we can achieve long term viability." The two main conditions that must be met to create a suitable environment are proper mechanical and biological stimuli. Blood vessels contain three layers of cells, each with a specialized cell type. The innermost layer responds to blood flow, the middle contains muscle cells that change vessel diameter, and the outer layer provides support for the vessel. In engineering an artery replacement, the cells must be directed to specialize in one of these ways. "Our job is to provide the right mechanical and biological stimuli to direct the cells to differentiate in the right way and in the right location to provide artery-like structure and function," Chesler says.

In order to engineer these replacement arteries, Chesler and Assistant Scientist Diana Marcela Tabima Martinez are developing a bioreactor to test various conditions. At the intersection of biology and physics, this bioreactor must allow axial, circumferential, radial, and shear stress in the artery. Exactly how much of these stresses should be imposed and how to time them to induce correct differentiation is still being explored. "The stress conditions that arteries are exposed to in the body are not necessarily the same as those we need to use to differentiate stem cells and grow an artery," Chesler says.

The bioreactor is currently undergoing testing, ensuring that viability of native arteries can be maintained for several months. Before moving forward to testing the stem cell-seeded scaffold material, it is essential that there is a good con-

"We're bridging that gap between the mechanical engineering and the biology"
- Naomi Chesler



Left: Testing the mechanical characteristics of a pig artery. Right: The bioreactor that will be used to grow the vascular tissue.

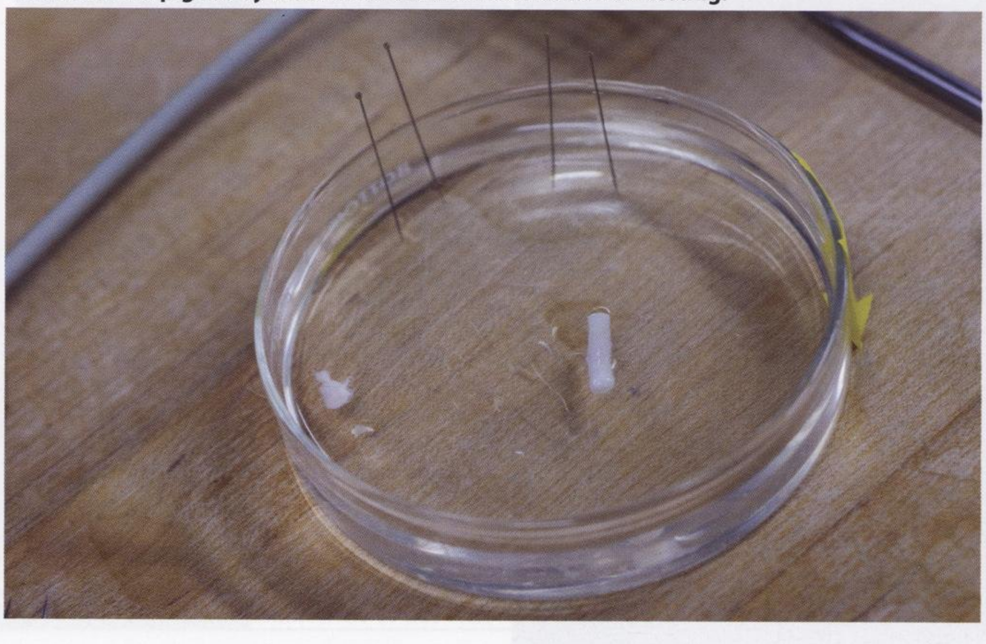
trol over the variables for a mature artery. The next step in the process is to grow, and then increase output of the engineered arteries. This will hopefully increase availability and decrease cost, addressing the previous issue of artificial tissue taking several months to grow while patients are in need.

This research in growing tissue shows promise for application in other surgical procedures and grafts by nullifying the risk of transplant rejection, and hopefully streamlining the process of replacing diseased tissue. "I do think that some of what we learn will be translatable to other tissues, but we shouldn't underestimate the complexity of other tissues," Chesler says. Many of the specifics of the project are unique to the tube structure of blood vessels, but the process of creating tissue that will not be rejected by the body is a substantial medical advancement in itself, which may inspire continued research in this area.

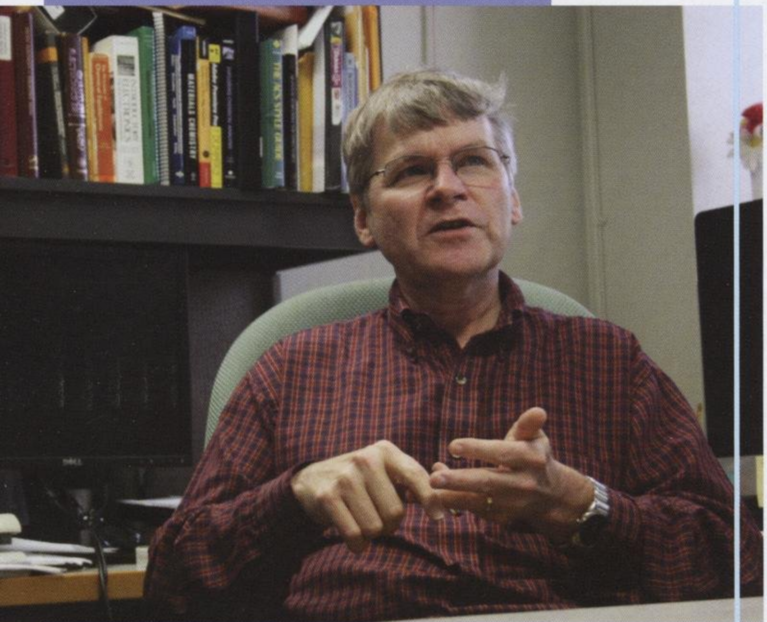
According to Tabima, "One important thing about this project is all the multidisciplinary collaboration… it involves experts from different backgrounds who collaborate to generate a product that incorporates the best ideas from everyone." Chesler and Tabima's work on the bioreactor is part of a larger research team, which includes mechanical engineers, biologists, surgeons, and scientists of other fields. Their team truly reflects the modern research group, which is becoming more interdisciplinary to better address the engineering problems facing our world. "I do feel like we're bridging that gap between the mechanical engineering and the biology," Chesler says. Their work is instrumental in the development of tissue engineering and modernization of the health care field.

Written by: Katlyn Nohr
Photography by: Therese Besser
Design by: Patricia Stan

A section of a pig artery that will be used for biomechanical testing.



Nanotechnology for a Greener Society



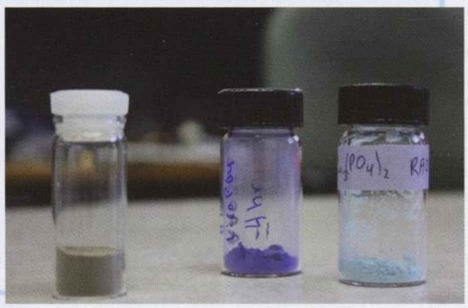
A UW chemistry professor is leading a research collaboration to reduce the environmental damage of technology.

Dr. Bob Hamers has taken a strong leadership position in the Center for Sustainable Nanotechnology and has performed extensive research on nanomaterials.

In the UW-Madison Chemistry Building is the office of Professor Robert Hamers, the director of the Center for Sustainable Nanotechnology. The CSN is a Midwest regional collaboration between scientists from 12 different institutions that conducts cutting-edge research on nanomaterials, which are materials composed of elements processed on a nanometer, or one billionth (1 x 10-9) of a meter, scale. These materials are extremely fine and have a wide range of applications, from consumer technology to agriculture.

Since the field of chemistry is historically very inward-looking and subdivided (into analytical, physical, organic, and inorganic chemistry), Hamers initially had trouble finding a niche for his desired research. "I recognized that the problems I was interested in couldn't be compartmentalized, so I created a fifth division [of chemistry] – materials chemistry," Hamers says. Materials chemistry is the marriage of chemical synthesis and measurement, which are usually considered polarizing skills from the other chemical disciplines – organic chemists will synthesize anything but only use a handful of analytical techniques, and vice versa for the other chemists.

The CSN was founded by Hamers circa 2012. It happened in two phases; the first phase began after Hamers and a few collaborators won a three-year planning grant to focus on developing the organization and forming bonds with other scientists within driving distance from Madison. "The hardest part about building a large center," Hamers says, "is establishing genuine collaborations between people who have never worked together."



Center for Sustainable Nanotechnology labs synthesize a variety of compounds including Lithium Copper Phosphate, Calcium Phosphate, and Nano-Diamond.

When the project moved into phase two, which will last for about eight more years, the CSN grew into the regional organization it is today. Scientists from more diverse backgrounds were recruited, including environmental science, biology, and theory, while even more collaborators were incorporated into the effort via Skype calls. There was no field of study that acted as a magic bullet for nanomaterials research; a lot of synergy was needed to collect all of the required data.

The purpose of the CSN is to develop technologies that are sustainable, hence the name. Nanomaterials can be environmentally harmful or benign when in use, and the synthesis of these materials may produce toxic byproducts or require expensive, dangerous processes. A sustainable nanomaterial should be relatively inert in the environment and should not lead to a lot of wastes. A lot of the electronic waste in the United States, which includes old batteries and cell phone parts, is shipped off to developing countries where it is likely left in a landfill. To combat this, the goal of the CSN is to create more efficient nanotechnology that lasts longer and uses less of our precious metal resources.

There are a handful of metals that are the best catalysts for a wide array of chemical reactions including rhodium, ruthenium, iridium, and platinum. The issue, however, is that these are some of the scarcest elements on Earth. This is where nanotechnology comes into play. By dividing these metals into smaller and smaller pieces, the surface area to volume ratio is maximized. Thus, these catalytic surface reactions can still take place while the expense is also greatly reduced.

One of the major barriers to a greener society is the lack of these precious resources. "If the whole world converted to electric cars, there simply would not be enough cobalt to go around," Hamers says. By developing nanomaterials such as complex oxides for use in batteries and catalysts, this shortage can be alleviated and the pathway to a more eco-friendly planet can be realized. In fact, the Nissan Leaf, a mass-produced electric vehicle, has about 85 pounds of nanometallic oxides forming the cathodes of its lithium ion batteries – indicating that we're already on the right track to managing our resources more efficiently and sustainably. "The fact of the matter is we're going more and more nano," Hamers says.

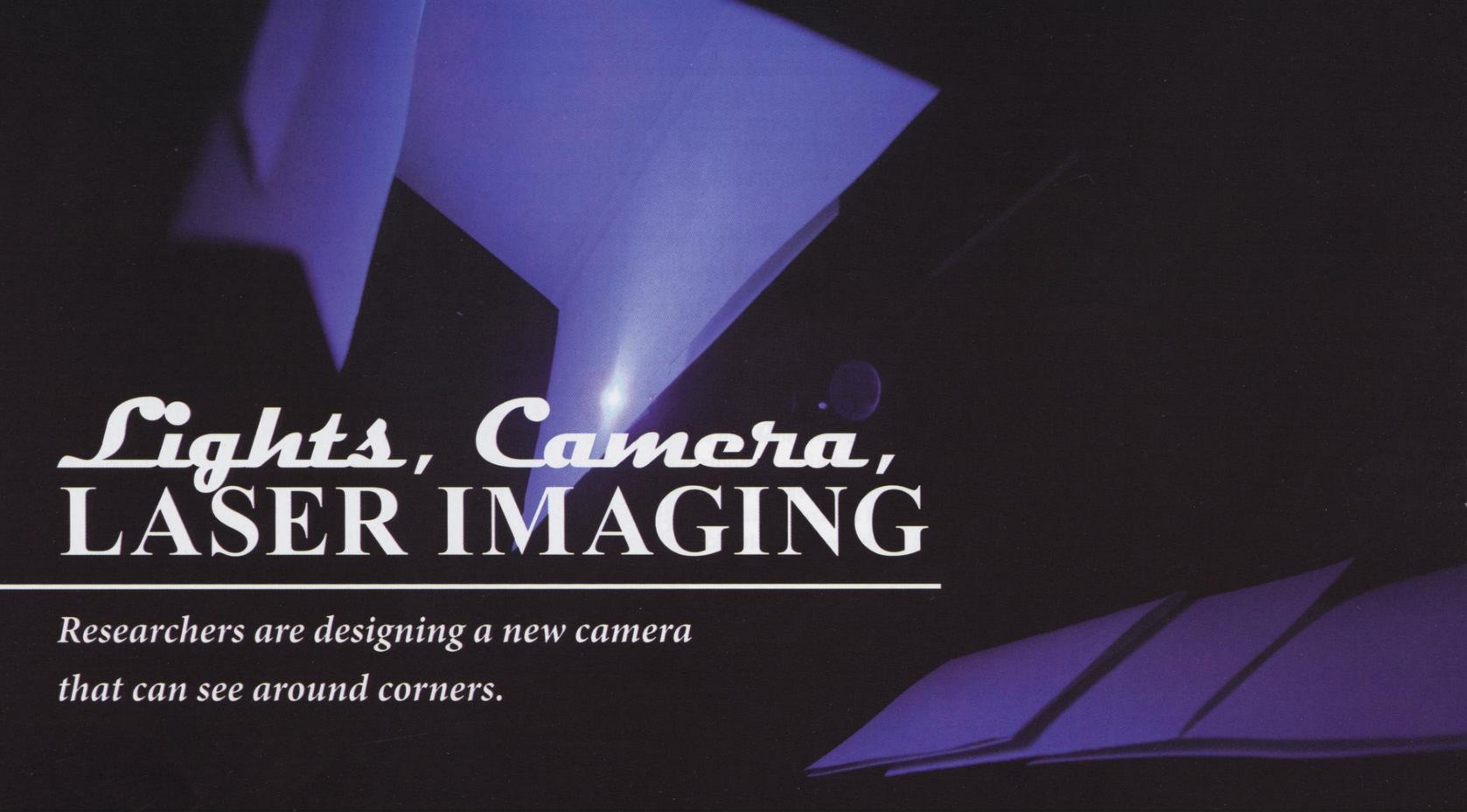
There are other applications of nanomaterials to improve industries like agriculture and medicine. To support a growing population, more food must be produced in a smaller and smaller area of available land. This means crop yields need to be vastly increased. A nanoparticulate spray of copper onto the leaves of crops has been found to act as a superb fungicide, improving yield. This method is nontoxic since the copper nanoparticles do not accumulate inside the plants. More methods like this are being studied by the CSN to ensure there are no environmental side effects. In medicine, nanoparticles of super-paramagnetic iron can be used to specifically target cancerous tumors for microwave heating. Since cancer cells are very sensitive to heat, this helps distinguish them from healthy tissue so they can be destroyed.

While the chemistry labs conducting research for the CSN appear to be ordinary wet-chemical labs, one of the primary challenges for conducting nanomaterials research is in imaging. It can be extraordinarily difficult to track where the nanoparticles are going and how they behave, so special imaging techniques are needed. One of these methods involves nanodiamond, which can be generated by detonating explosives in a chamber with graphite. Nanodiamond particles are essentially bits of pure carbon with a special defect called a nitrogen-vacancy center that allows them to fluoresce. By tracking these fluorescent nanoparticles, it is possible to study where other associated nanoparticles are moving.

"The fact of the matter is we're going more and more nano."
- Robert Hamers

The CSN is largely focused on preventing environmental disasters while still producing technology that improves society. There have been nasty surprises in the past such as freons, CFCs in the atmosphere, and DDT killing bird populations. By recognizing the hazards right away, these types of accidents can be prevented. "If there are risks associated with those materials, we want to know them early on," Hamers says. It is clear that nanomaterial research is having a profound impact on society – in fact, the light from your smartphone is likely being emitted by cadmium selenide nanoparticles. By studying this technology in depth and guaranteeing its safety, the CSN is pushing toward a greener society.

Written by: Edwin Neumann
Photography by: Alexander Fanner
Design by: Patricia Stan



Lights, Camera, LASER IMAGING

Researchers are designing a new camera that can see around corners.

A riddle: How do you take a picture around a corner without moving the camera? Impossible, right? Apparently not. New research from the Massachusetts Institute of Technology and UW-Madison proposes a design for a camera that can do exactly this. The device, dubbed CORNAR (corner + sonar), bends logical thinking through its ingenious design. Assistant Professor Andreas Velten of UW-Madison has been working to perfect the device right here on campus.

Velten first started working on the CORNAR technology at MIT but brought the research to UW-Madison in order to continue his work with the device. Physically, the CORNAR camera is as big as a table, and cannot fit through a door; while cumbersome, the large size is necessary for the camera to contain all the hardware needed to accomplish its impressive task.

The device works by mounting a regular camera on top of a platform, which has different types of hardware connecting to the camera and a computer. A laser attached to the camera emits photons, or particles of light. Upon hitting a surface, the photons bounce around other surfaces. Some of these particles make their way back to the lens of the camera, where, using a method similar to sonar, the software analyzes the time lapse between the light particles colliding with the surface(s) and coming back to the camera lens. This time-lapse information allows the device to map out the area around the corner and display it on the computer screen.

The images that CORNAR produces are low quality but useful in many situations. For example, police can use this device to see if someone is around the corner or if an obstacle is in the way without risking harm to officers. Further applications include rescue missions in which people are trapped under rocks, testing machines to see if all parts are functioning properly, and mapping of hazardous places like volcanoes from a distance.

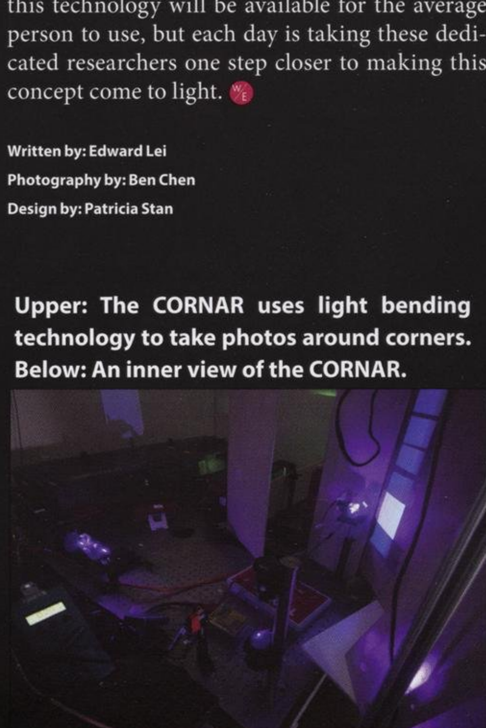
Currently, Velten and his team are simulating how CORNAR would map the layout of moon caves. Their research is evaluating whether a satellite would be able to capture images while constantly moving and how much time it would take to the scan the moon. From early test results, Velten and his team have successfully determined that the motion-capture imaging works; however, the duration to complete a scan could take days or weeks. While the camera itself can generate an image in a matter of seconds, the light particles can take hours to return to the lens. Further issues arise from the possibility of the lens detecting other light particles, which would cause the image to be compromised, another challenge they are working on.

Besides applying CORNAR to the mapping of the moon, Velten and his team are further developing the technology to enable the camera to see around two corners rather than one. The process is the same, but the algorithm needs to account for the extra time it takes for light particles to bounce back from even greater distances, lengthening the process. In situations where there is a long wait time, such as a hostage situation, this would be useful for the police to scout out the general layout, observe if someone is moving, and see where people are located in relation to the doors. This technology could even help them map out a room where there's a possibility of a trap like a bomb or trip wires.

So if you haven't already guessed the answer to the riddle, it is CORNAR and its amazing light-bending technology. It might be some time before this technology will be available for the average person to use, but each day is taking these dedicated researchers one step closer to making this concept come to light.

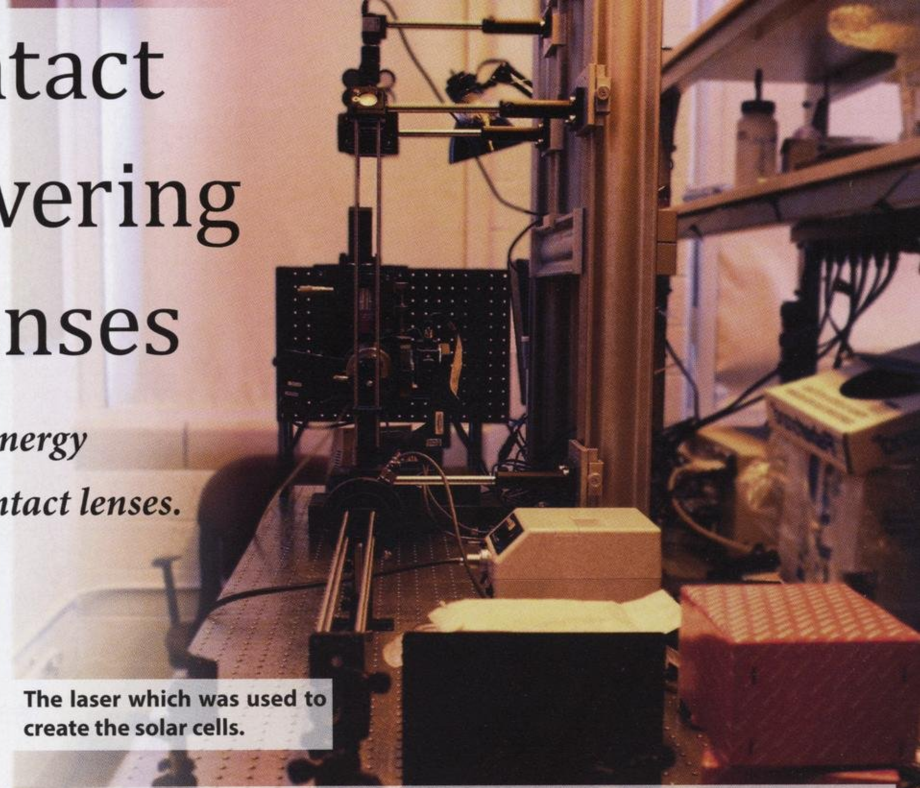
Written by: Edward Lei
Photography by: Ben Chen
Design by: Patricia Stan

Upper: The CORNAR uses light bending technology to take photos around corners. Below: An inner view of the CORNAR.



Making Spy Contact Lenses 101: Powering Your Contact Lenses

Miniature solar cells provide a possible energy source solution for future mechanical contact lenses.



The laser which was used to create the solar cells.

What's the tiniest solar cell you can think of? If your answer is a small chip attached to a watch, forget about it because the record has been beaten. Recently, a group of UW-Madison engineers led by Professor Hongrui Jiang of the department of electrical and computer engineering has developed an extremely tiny solar cell designed to be embedded into contact lenses.

According to Jiang, the idea of embedding a solar cell into contact lenses is motivated by the goal of developing an automatic tunable contact lens for senior citizens whose ciliary muscles have lost the power to adjust the eye lens. The ciliary muscle is a crucial muscle that controls the lens in our eyes. Healthy eyes have ciliary muscle that is strong enough to contract or expand, forcing the lens to change the focal point. Therefore, we can see things from different distances. However, as we age, the ciliary muscle gradually loses its strength, and the focal point of the lens becomes fixed. This is why many seniors require glasses to read but must remove their glasses to look at something farther away.

"The contact lenses we are trying to develop will help seniors to automatically focus on objects, close or distant." Jiang says. "However, the key issue to be resolved first is to develop an energy source that can drive the contact lenses, so we came up with this idea of developing miniature solar cells."

Fabricating a miniscule biocompatible solar cell is no easy task. The solar cell must be able to provide enough of an energy source to drive the integrated circuits implanted in contact lenses. The usual approach to increase the power of an energy source is through selecting high performance material and increasing the surface area as much as possible. However, the material used in fabrication has to be stable enough to prevent degeneration. The limitation on materials makes it very challenging to improve the efficiency of the solar cell.

In addition to material constraints, the biological platform where the solar cell is to be embedded does not allow for a large surface area. "The area for solar cell is extremely limited because we want the transparent part of the contact lenses to be large enough to cover the entire pupil," Jiang says, "so all of the mechanical parts must be placed around the pupil." This limitation in surface area means the solar cell will have very little exposure to sunlight, resulting in a low energy input.

"However, the key issue to be resolved first is to develop an energy source that can drive the contact lenses, so we came up with this idea of developing miniature solar cells."

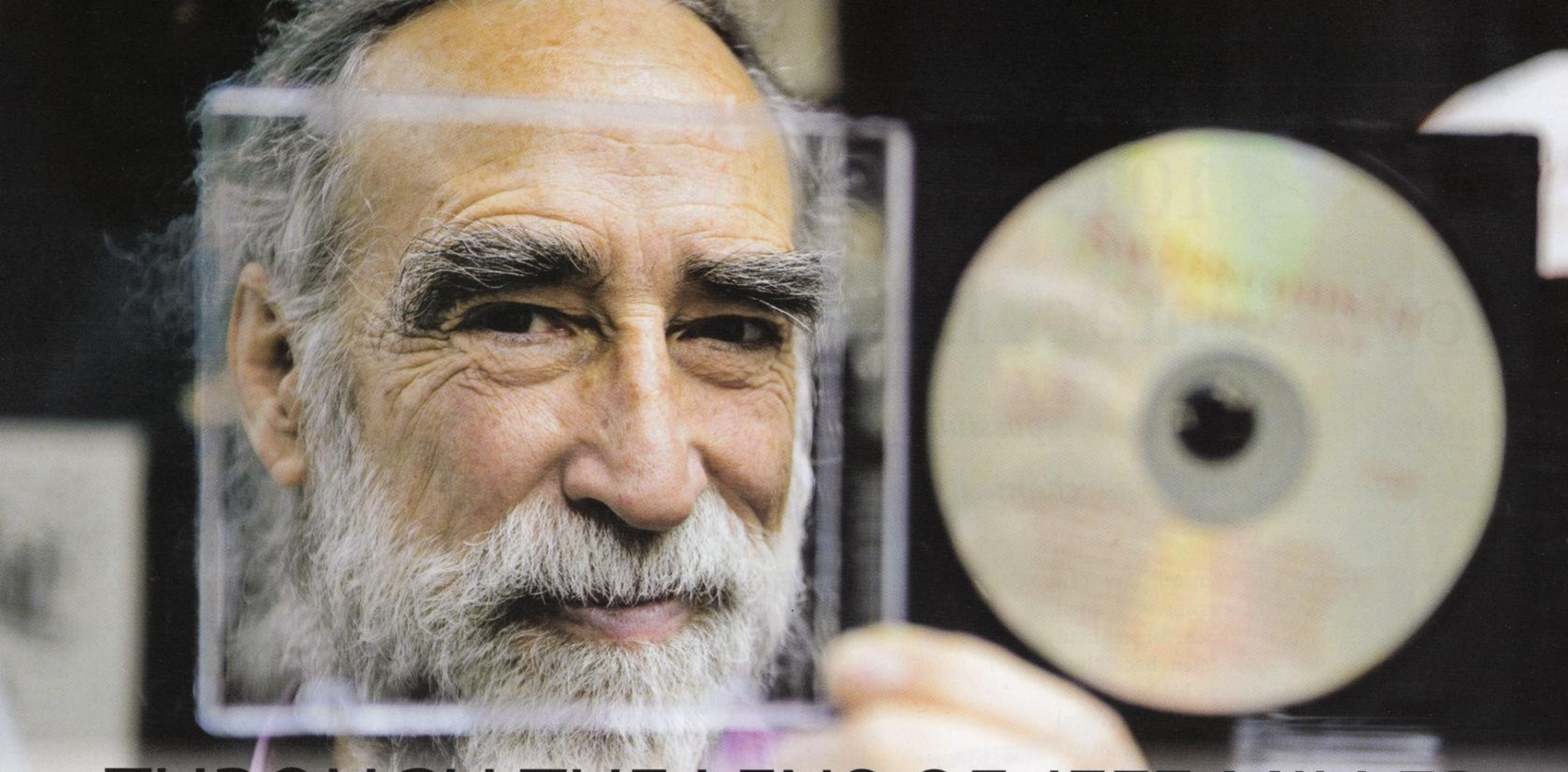
Unable to adopt either of the two most convenient approaches, Jiang and his team tackle this energy efficiency issue by minimizing the energy consumption of the devices, adding an energy storage unit, and adopting the lateral design of the solar circuit. In particular, the importance of adding an energy storage unit is not just improving efficiency. Jiang explains that the other concern is certain situations in which light is unavailable to power the contact lens; the energy storage unit is particularly important to sustain the functionality of the contact lenses. Otherwise, Jiang says, "Imagine you are driving through a tunnel. It would be very dangerous if your contact lenses suddenly died as you lost focusing ability."

In addition to creating the storage unit, Jiang's team also adopted a compact lateral arrangement of the solar cells, which is putting thin solar panels parallel to each other like dominos. The compact lateral design of the circuits used in the lens takes advantage of the full volume and avoids potential waste of space. The increased space will allow more photons, or light, to hit the solar cell, thereby achieving a higher electric current conversion. The result of such a design is very promising. Currently, the front-runner of solar cells with lateral design has a light-to-energy conversion efficiency of around 1.8 percent, but Jiang's group has almost tripled this number, achieving 5.2 percent efficiency.

Another issue of producing the solar cells is the extreme accuracy required for the creation and placement of such miniscule components, so Jiang's group has adopted tools for laser application. "Our laser application has better control over beam size, the laser spot, and the depth of the laser cut, thereby allowing better accuracy," Jiang says.

Completing the design and fabrication of the tiny solar cell is only the first step in the process of developing the final contact lenses product. "From an engineering point of view, we have shown that it is totally feasible to produce such contact lenses," Jang says. "But, we still have a lot of work to do for the product to actually be put into market. Future issues such as the comfort of the product and whether the circuits will cause infections need to be resolved." In the long term, solving the energy source problem for implanted miniature devices has opened the door to a future with much more high-end contact lenses technology. Google glasses might someday become Google contact lenses.

Written by: Ruite Guo
Photography by: Lianne Komen
Design by: Patricia Stan



THROUGH THE LENS OF JEFF MILLER

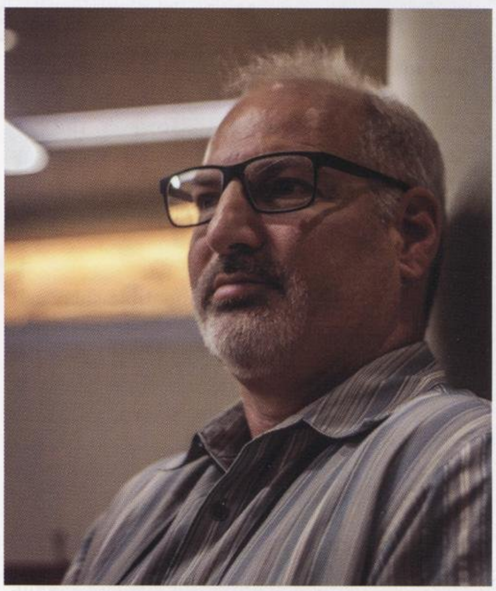
Jeff Miller, UW-Madison's senior photographer shares his 27-year journey capturing the beauty encompassing the campus.

Your UW-Madison story starts at the application to a great institution until the walk on commencement. Your story is typically comprised of frigid but mesmerizing winters, refreshing breezes on Lakes Monona and Mendota, excruciating days in the lab, and the excitement that comes with a weekend out on State Street. Simple moments such as these bloom into memories and are often best captured by the lens of a camera, which with reflection on these images, leaves a permanent a reminder of the pride that comes with being a Badger. Thanks to Jeff Miller, the senior photographer for University Communications at UW-Madison, Badgers have access to captured moments such as these. Recently marking his 27th year working at UW Madison, Jeff Miller shared about his experience.

Miller graduated from the University of Dayton, Ohio in 1986 with a Fine Arts degree in photography. He launched his professional photography career at his alma mater, starting out as a part-time photographer and working his way up into the public relations office. In the summer of 1990, Miller was offered a position at UW-Madison which required him to start from scratch in a city in which he had never set foot. Miller's time and experience carved him a seat at the editorial table of UW Madison's Office of University Communications. His photography can be found on a plethora of sites such as the university social media sites, the news page, the homepage, and online gallery. His photography is distinguished by its ability to tell a story from an institutional rather than specialized viewpoint. For instance, at a Badger athletic event, a photographer from Athletic Communications might be solely interested in capturing the action and technicalities of the game. Instead, Miller's primary focus would be highlighting the enthusiastic spirit from the fans' perspective and capturing candid moments from the stands.

> **"A camera opens the door to a lot of things... and if you respect that privilege it can take you far."**
> **- Jeff Miller**

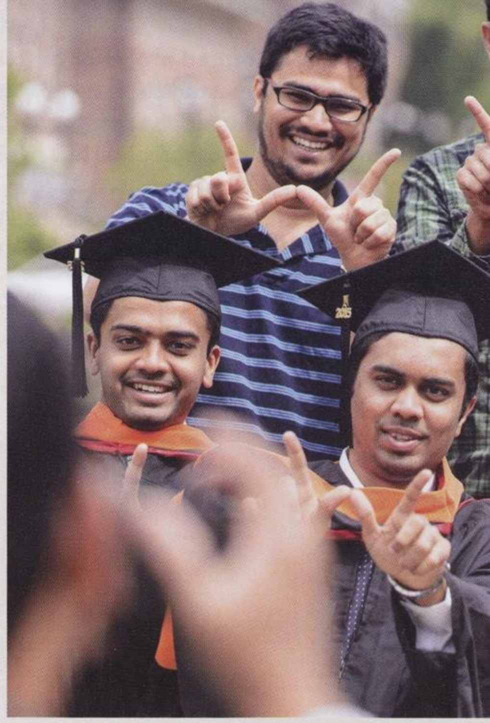
Miller's passion for photography kicked in as early as the seventh grade via extracurricular involvement. The later years in high school were characterized by emotional turmoil due to his parents' divorce. To cope, Miller spent extended amounts of time in the dark room. Miller says that his art teacher was aware of the situation, he says he would rather a student spend time pursuing his passion than finding unhealthy alternatives of coping. His support validated Miller's passion and was thus instrumental in Miller's early success. Photography not only earned Miller early recognition but was also a newfound voice, given his introverted character, and a means to channel his emotion. Initially, Miller's photography was introspective, characterized by shapes and colors.

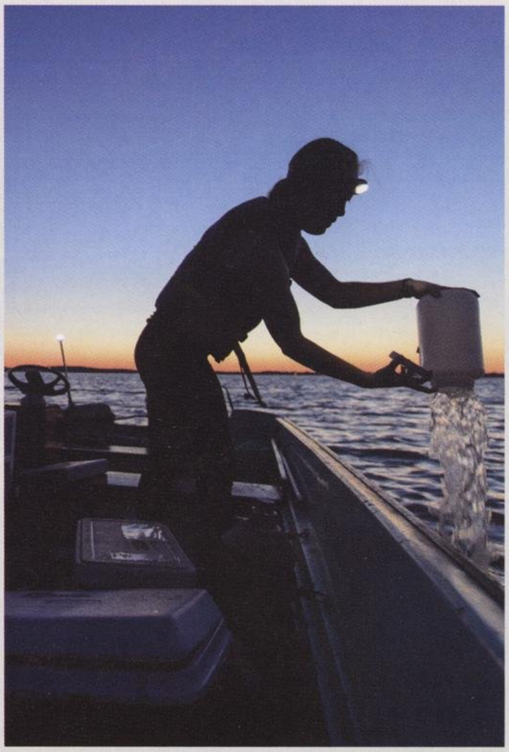


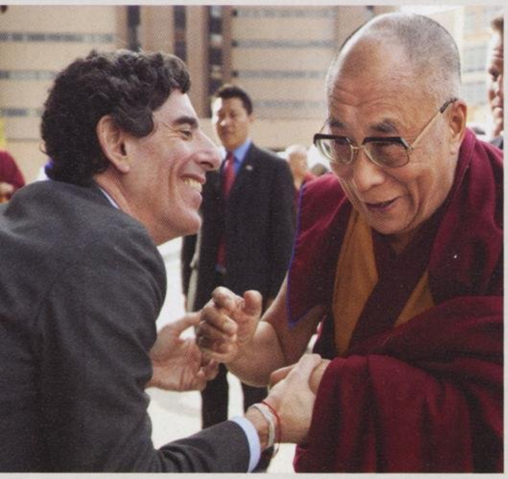
Senior Photographer Jeff Miller taking note of lighting conditions and preparing to put things into frame.

Left: Jim Leary, retired professor of folklore and Scandinavian studies, was nominated for a Grammy Award in the category of "Best Album Notes," as photographed by Jeff Miller. Behind: A sea of red-attired Badger fans cheer as the Wisconsin Badgers football team plays the Miami (Ohio) Redhawks in 2015. Photographed by Jeff Miller.

Photo courtesy of Jeff Miller. For more, visit the online UW-Madison Photo Library at http://go.wisc.edu/photos.







Photos courtesy of Jeff Miller. For more, visit the online UW-Madison Photo Library at http://go.wisc.edu/photos.

Left: An assortment of photos taken by Jeff Miller, which span numerous topics and capute compelling moments at UW.
Behind: A group maintains balance during an Outdoor UW standup paddleboard yoga class led by instructor Sarah Calvert on Lake Mendota, as photographed by Jeff Miller.

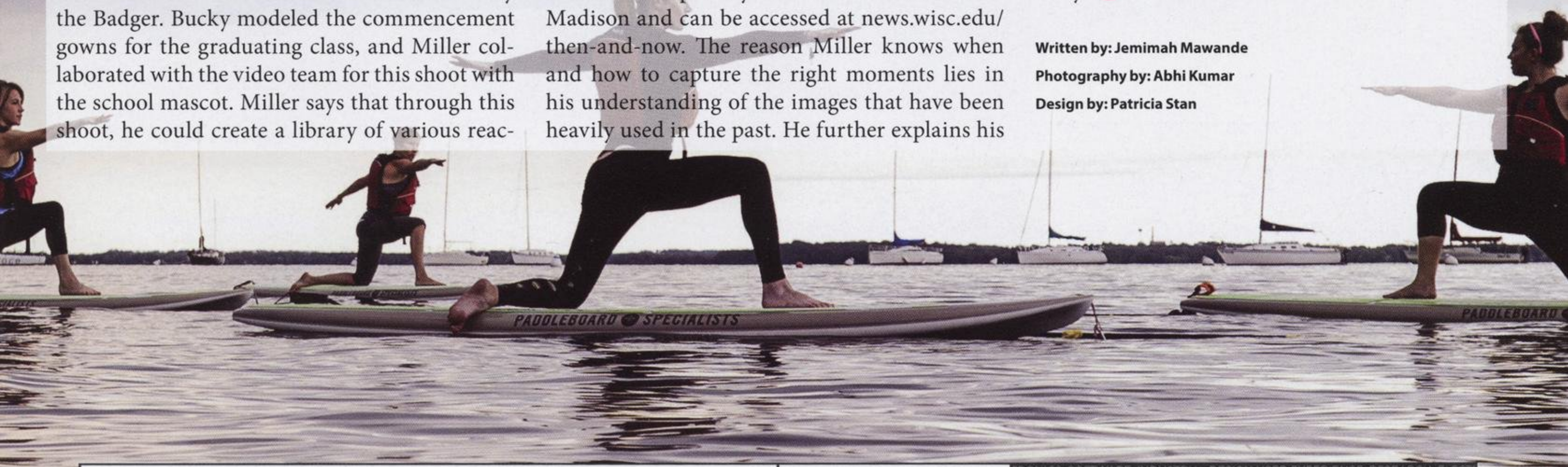
He says his creativity was shaken up by a photojournalism instructor who stated that people and their stories make the world go around, inspiring him to shift his focus to storytelling photography.

At the time of this interview, Jeff Miller was working on a few Badger spirit-related projects, one of which was a collaboration with Bucky the Badger. Bucky modeled the commencement gowns for the graduating class, and Miller collaborated with the video team for this shoot with the school mascot. Miller says that through this shoot, he could create a library of various reaction photos that could later be used by the social media team to create GIFs, which are popular on various social media platforms. Additionally, the aerial photos in the online photo library are noteworthy. When asked how he perfectly encapsulates the isthmus from a bird's eye view, Miller says that helicopters are chartered for this purpose. Miller and his colleague Bryce Richter sit harnessed in an open-door helicopter and demonstrate their artistic prowess .

Miller voluntarily embarked on and finalized a comparative photography project juxtaposing certain aspects of UW-Madison in 1990 and in the 2015-2016 school year. Besides the notable transition from black and white to multi-chromatic print, this "Then and Now" series was significant in its portrayal of the evolution of UW-Madison and can be accessed at news.wisc.edu/then-and-now. The reason Miller knows when and how to capture the right moments lies in his understanding of the images that have been heavily used in the past. He further explains his interest in capturing storytelling photos: "One has to decide whether they want to take a photo that captures a moment or if they are simply taking stock photography in the anticipation of the picture being taken from the library for future use."

A perk of the job includes meeting celebrities as they visit for their distinguished series, though Miller says he is "not one to be star struck." Though honored for these high profile opportunities, Miller says that his most memorable experiences arose from his interaction with the UW-Madison community and relaying their stories through his photography. Humbly, Jeff Miller has pursued his career with passion, dedication, and creativity to effectively capture our colorful story.

Written by: Jemimah Mawande
Photography by: Abhi Kumar
Design by: Patricia Stan



The Shocking Truth Behind Hammers

Common hammers, like those shown here, can lead to strain on tendons in the elbow through repeated use.

UW-Madison professor seeks to prevent injury in the workplace by testing a new hammer design.

The hammer's origins predate modern civilization, and its design has drastically changed over the course of history. From a rock tied to a piece of wood to the hundreds of hammer designs today, improvements are continuously being made. One could even say that modern civilization is measured by the incremental improvements to the hammer – a score sheet for society. Many professionals such as gardeners, carpenters, and doctors use hammers as part of their daily work. Because of this constant use, these persons may develop an injury. Keeping that in mind to propel society forward, Fiskars, a tooling company from the surrounding Wisconsin area, is developing a hammer that reduces the shock when the hammer hits a nail, and UW-Madison researchers have tested this hammer to make sure that it reduces injury for those who use it.

UW-Madison Biomedical Engineering Professor Robert Radwin leads research focusing on preventing injuries in the workplace from tools, machines, or any other hazardous environment to which a worker would be exposed. The overall goal of the laboratory is to see how different tools injure people and to develop solutions to keep accidents from happening. "It's important we understand how to prevent people from having excessive loading in their body," Radwin says. Radwin's lab tested the Fiskars hammer to see if it reduced strain on the elbow compared to conventional hammers.

Through repeated use, metal or wooden-tipped hammers could strain tendons in a person's elbow, but with this shock-reducing hammer, the injury risk is reduced significantly. "Swinging a hammer is not that much different than swinging a tennis racquet," Radwin says. Swinging a hammer can lead to a similar tendinitis in the elbow like that seen in "tennis elbow." To test the shock-reducing hammer, Radwin and his lab compared

"It's important we understand how to prevent people from having excessive loading in their body," - Professor Robert Radwin

muscle contraction, edema (presence of fluid in muscle tissue), and other factors between three types of hammer handles. A group of volunteers hammered 20 nails using different material handles. Results that showed more edema correlated with more strain on tendons in the elbow. After Radwin and the team hammered out the details, they concluded that the shock-reducing hammer indeed did prevent this edema from forming to the extent of the wooden or steel hammer.

What exactly does this hammer do that the others don't? During the experiment, many confounding variables were accounted for including hammer weight, handle girth, and hammer-using experience, so it was a property of the hammer itself that allowed it to withstand the impact of the nails. As opposed to the other hammers tested, when the Fiskars hammer hit a nail, there was very little vibration and thus a smaller backlash to the person's elbow. This hammer can be very beneficial in the long run for those who constantly use hammers in their work. One day, Radwin believes that he could make "smart tools" that can self-adjust to further prevent injury.

People often do not think of getting tennis elbow from using a hammer because it is a simple and common tool. "[We] are still concerned today after thousands of years of use of hammers over the design," Radwin says. Through occasional use, hammers will not cause too much harm, but they can cause lasting damage in a person's elbow through extended use. This new hammer is one step closer to creating a safer workplace without injury.

Written by: Jordan Wolff
Photography by: Matt Henricks
Design by: Patricia Stan

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Photo taken for "Madison: The Gem of the Midwest" (p. 5). Photo by Beth Enright.