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wisconsin engineer

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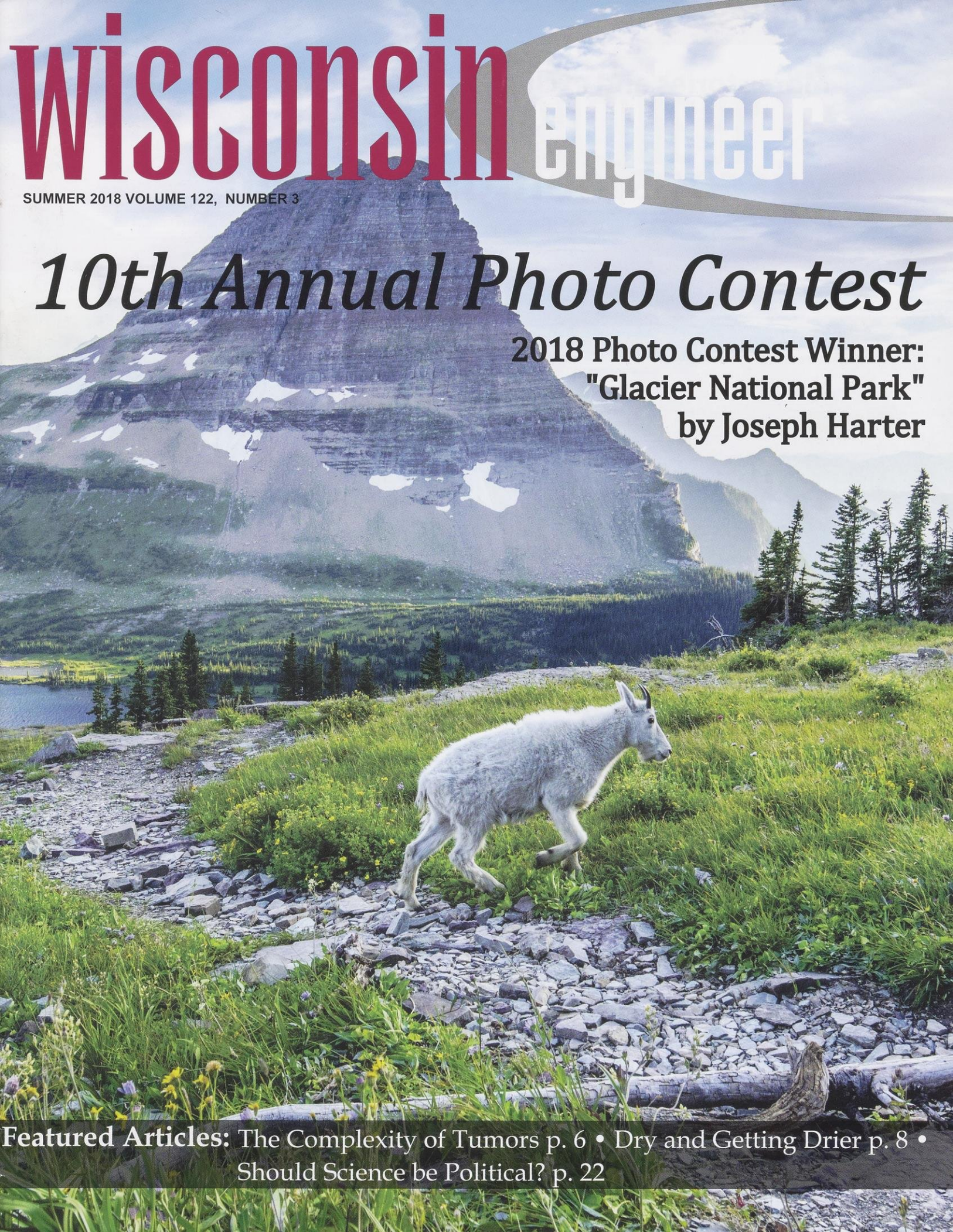
10th Annual Photo Contest

2018 Photo Contest Winner: "Glacier National Park" by Joseph Harter



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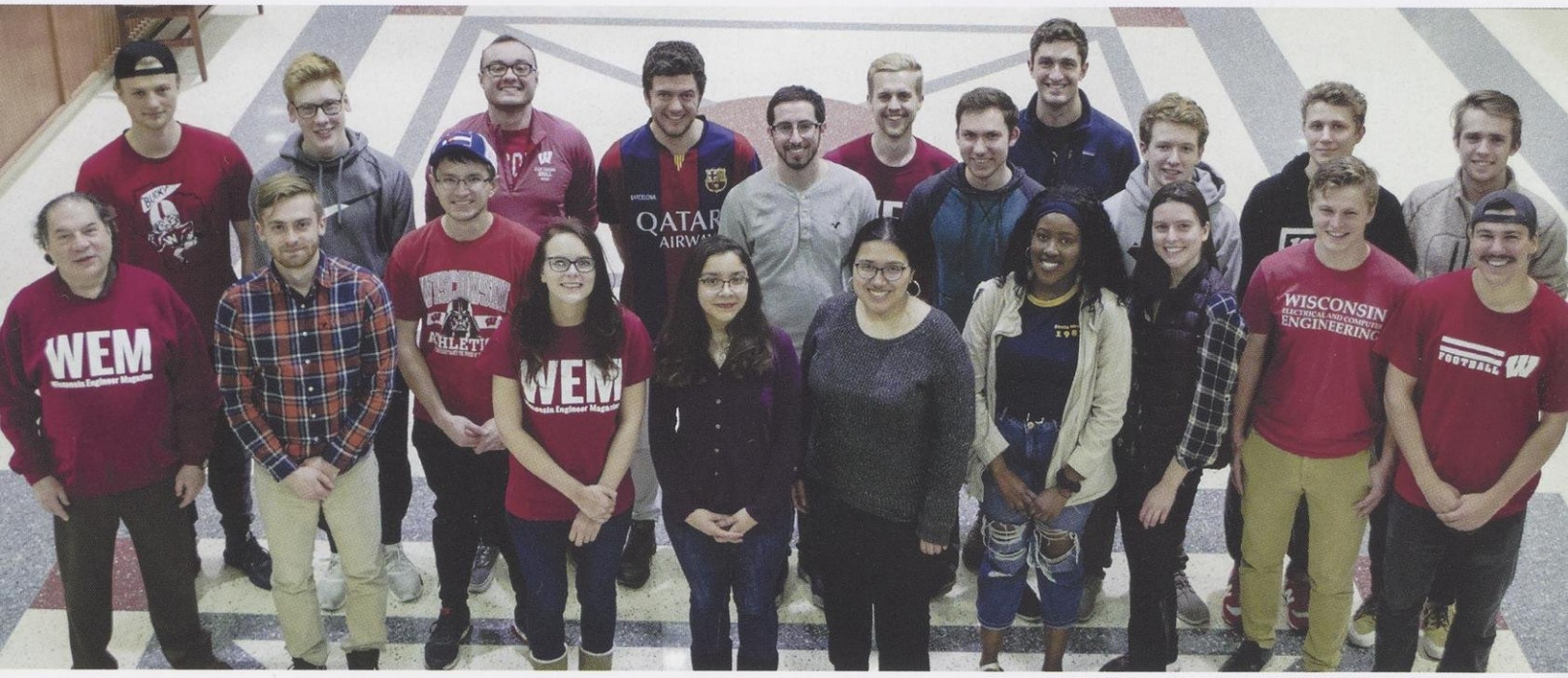

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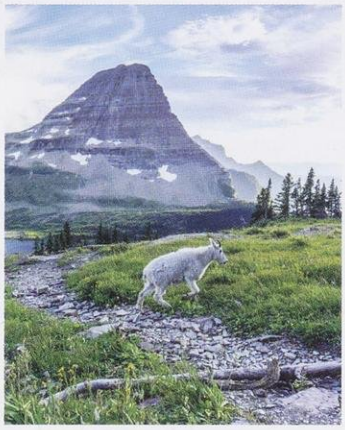
General



Cover photo:
10th Annual Photo Contest Winner,
"Glacier National Park"
Joseph Harter

Shaking Up The Future of Health Care

Whether it's Amazon in health care or big data, the healthcare system of today will change.

There are many aspects of life that remain a mystery. Some of the most difficult parts to grapple are thermodynamics, how the men's basketball team didn't make it into the March Madness tournament, and above all, health care. Despite the importance of health care in people's lives, most in the United States know little other than the fact that it is expensive and the topic of many political debates. To shake things up in the world of health care, three major companies, Amazon, JP Morgan, and Berkshire Hathaway—who, combined, have over a million employees— decided to jump into the spiderweb of health care. These three industry giants could impact the health care system through efficiency of scale and bargaining, but Dr. Oguzhan Alagoz, a professor in the industrial engineering department at UW-Madison, believes the true future of health care is in data.

Amazon, JP Morgan and Berkshire Hathaway announced mid-February that they aim to make health care less expensive for their employees; the details of their plan are mostly left to speculation. The new company they plan to establish together will not seek to profit off of health care unlike the industry's leading for-profit insurers, drug makers, and many health care providers. Though lacking in specifics, they certainly have the power to make a significant impact in the health care realm with the same techniques they have used to conquer other markets, such as a deep understanding of consumer behavior. These super giants could use this understanding to a find better way for their employees to get medicine and lead healthier lives. They might look to expanding telemedicine technology, seek out areas where automated equipment and artificial intelligence could deliver savings, or cut out the middleman in drug sales and open an online pharmacy to handle drug distribution. It is speculated that these three companies could also use their market power to negotiate with pharmaceutical companies for better prices on prescriptions.

Although aims are high, many are skeptical about the companies' entrance into the health care sector, and some believe they will have no impact at all. Whatever changes will be made will only majorly affect the one million people who are employed by the large three firms, and it is unlikely that in the short run the public will see much, if any, difference. With two of the world's three richest people leading the charge—Amazon CEO Jeff Bezos and Berkshire CEO Warren Buffett—it will at least be interesting to see what they can come up with.

"The difference between health care of the future and health care of the past is tremendous amounts of data."
-Oguzhan Alagoz

Health care isn't just trending in the national news; it is a very hot topic in Madison as well. Surrounded by three major health centers (UW-Health, Unity Point Meriter, and St. Mary's), our campus is a hub for health care innovation. We are at the forefront of cutting-edge medical research, and, though not widely known, our industrial engineering department plays a crucial role in that. Alagoz, an industrial engineer, researches health care, technology, and medical decision making. He is all about using simulation, modeling, and data—industrial engineering principles—to transform health care.

Engineering wasn't always at the forefront of well-being. He elaborates, "I think engineers touch everything in the world...and [health care] is an industry where we did little." Alagoz sees the many inefficiencies with the health care system as problems that engineers will be able to think through and solve. To fix these problems, engineers need a variety of tools. One of the best tools to make the health care system more efficient is data. "The difference between health care of the future and health care of the past is tremendous amounts of data on procedures, surgeries, speed of appointments, workflows, and much more," Alagoz says. There is so much data that some companies don't have the capacity to handle it and seek the top minds of universities across the country to analyze it, find inefficiencies, and create solutions to make a visit to the hospital more effective.

Alagoz can see a future where software aids doctors and helps them give more accurate diagnoses. However, he explains, "I don't see this as a replacement but a decision support system." To get this idea into practice, a system must be implemented that patients are comfortable with and doctors find easy to use.

What a visit to the doctor will look like in 50 years remains a mystery, although part of the health care experience might be supplemented by software or machines. Adding Amazon, Berkshire Hathaway, and JP Morgan to the mix creates even more uncertainty in what future health care might entail. The attempts to transform our current health care system, whether through data or privately providing a system for employees, have the same noble goal of helping people live the happiest, healthiest lives.

Written by: Ben Hayes
Photography by: Alex Lape
Design by: Edwin Neumann

Detecting Long-Term Child Anxiety from Monkey Brain Scans

Through imaging studies of children and primates, Dr. Ned Kalin works to find information correlating brain activity and anxiety. His work focuses on developing a basis of early intervention for children at risk of developing long-term anxiety.

Over 20 percent of Americans will suffer from a diagnosed mental illness in their lifetime, the most common being mood and anxiety disorders. Dr. Ned Kalin, chair of the department of psychiatry at UW-Madison has spent the last 30 years researching anxiety and its physical effects on the brain. The work of scientists such as Kalin has led to the realization that anxiety is a lifelong trait characterized by a unique signature in the brain which may be genetically inheritable. Currently, Kalin works with children and young rhesus monkeys born in the UW-Madison primate research colony to begin developing a basis of early interventions to treat humans at risk of long-term anxiety.

Everyone experiences anxiety in their daily life; it's completely normal and expected. Anxiety is the feeling of worry or the uneasy feeling that comes when you don't know the outcome of your actions. This feeling evolved as a means to signal danger. However, continuous feelings of anxiety that manifest in a far more severe and continual form are classified as anxiety disorders. When anxiety disrupts a person's ability to lead a normal life, or when a person feels intensely anxious at a time when it should be minimal, this may be a sign of having an anxiety disorder.

It is because of the severe increase in diagnosed anxiety disorders in young adults that researchers such as Dr. Kalin have focused their attention on how long-term anxiety is developed in the brain. For the past eight years, Dr. Kalin's lab has conducted magnetic resonance imaging (MRI) scans of young children and primates to find correlations between their brain activity and the presence of anxiety. Primates share similarities with humans in behavior, social interaction, and brain function that are not present in other species. Due to this relatedness with humans, studies of non-human primate brains offer the best chance to identify treatments for human psychiatric disorders. Currently, both human and primate brains are under analysis. From this, the research team can take what they learn from one group and apply it to the other, which has allowed research to build upon itself more quickly.

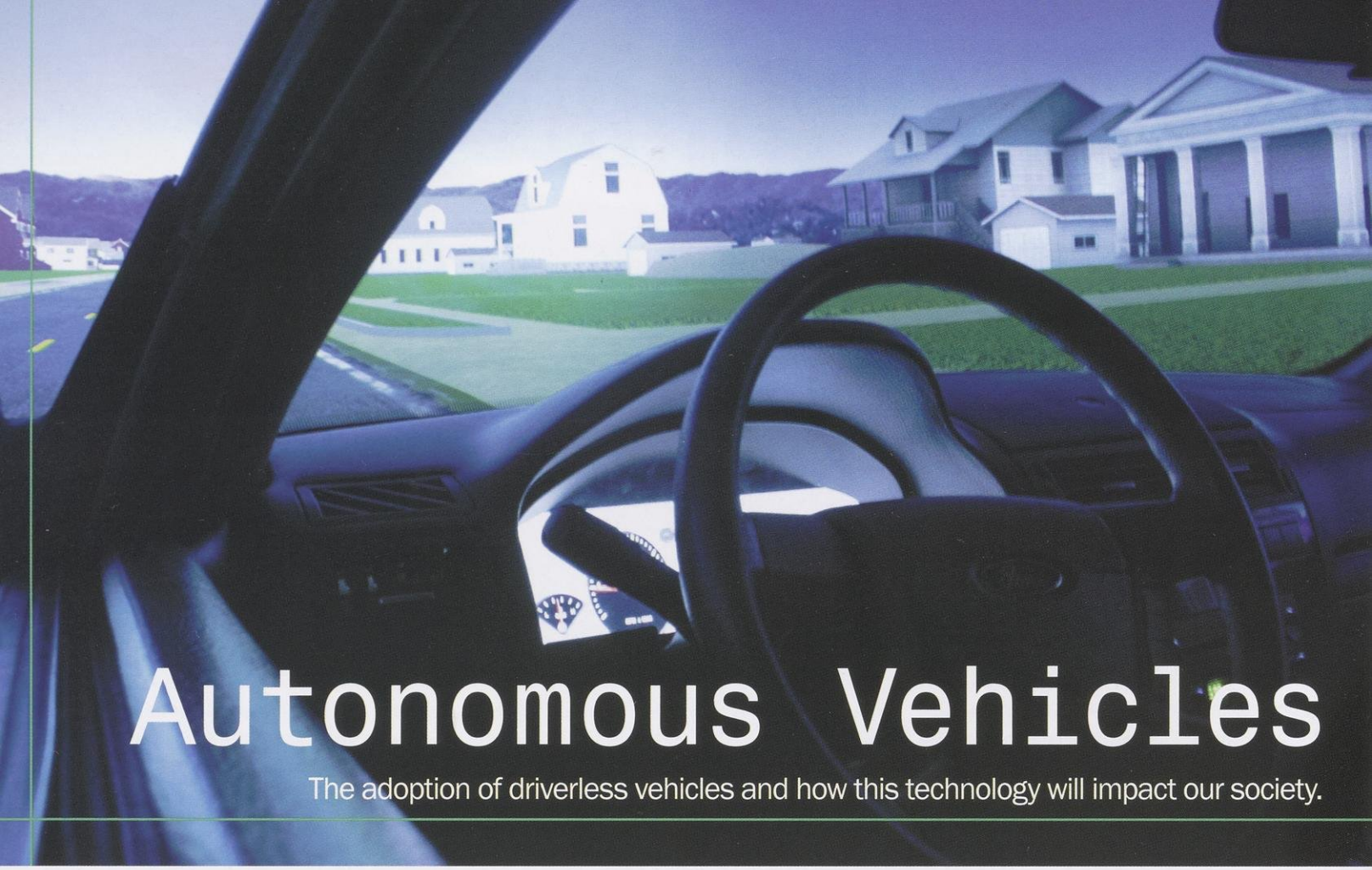
To assess anxiety in primates, Dr. Kalin sets up an experiment in which an individual monkey is presented with an unknown stimulus, usually a person they don't know. Instinctively, the primate gauges the threat potential of the situation—they are very sensitive to eye contact. A researcher can look at a brain scan of the monkey and find correlations between the actions that were observed and the monkey's brain activity before, during, and after the event. It is from these studies that experts have been able to identify and understand brain changes caused by anxiety. Progressing forward, Dr. Kalin's lab has begun to work with genetic therapies. They can take the monkey's brain scans and compare what is in their DNA, trying to determine how anxiety relates as a genetic characteristic. At this point in time, the lab has begun manipulating genes they believe relate to long-term anxiety development and are conducting research on the effects of these manipulations.

The study of human anxiety is very different from the study with the primates. Dr. Kalin's lab has focuses on girls ages 9-12 because this age is associated with increased hormone levels which, in combination with brain chemistry, have been shown to increase anxiety. The children are placed in an MRI system so that their brain may be monitored as various stimuli are presented to them. Images are presented to the children via a screen in the MRI. In some instances, the children are warned that what they may see is scary, but in other instances they are not warned. In both cases, their responses are recorded and then compared to find correlations between their brain activity and what stimuli they were presented with. Using knowledge from the primate studies, the researchers can look at specific areas of a brain scan where anxiety has been found to present itself.

From these studies, Dr. Kalin hopes to develop a better model of how anxiety progresses throughout a life and find interventions that can prevent or reverse the long-term psychological consequences of anxiety in children. Being able to better understand how anxiety presents itself in the brain from the primate scans has vastly increased the ability to understand the scans of children. With continuous research into these brain scans and our susceptibility to anxiety in DNA, research will continue to find new treatments to alleviate the stress and worry of life for people suffering from these disorders.

Written by: Makenna Hall

Design by: Suzanne Kukec



Autonomous Vehicles

The adoption of driverless vehicles and how this technology will impact our society.

The automotive industry has completely transformed the world into the modern marvel it is today. Thanks to vehicles, the cadence of our everyday lives is beating faster with each passing day. Over time, however, our attention and awareness has shifted from driving to distractions, which has been the root cause of many horrific car accidents. While new smart features have evolved to help combat these problems, many of them fall short of addressing all of the threats a modern car poses. One response of technological development has created vehicles that completely eliminate the need for human control, allowing drivers to relinquish all responsibility for their transportation needs. Called autonomous vehicles (AVs), this technology might have the power to completely change how we view transportation in the near future.

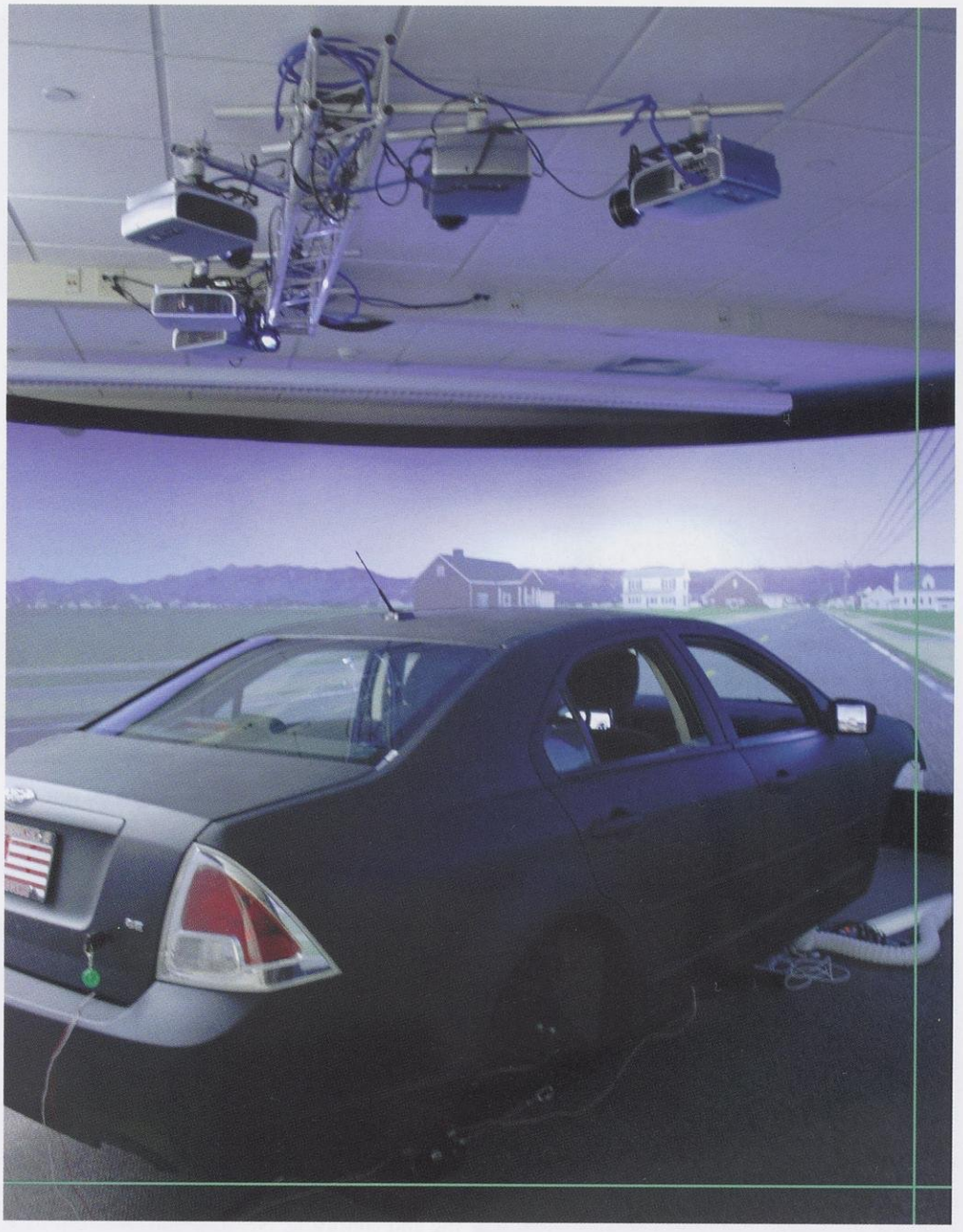
The top priority of the WiscAV lab is to test and promote the capabilities of driverless vehicles according to WiscAV researchers John Riehl and Peter Rafferty. As over one million people die in road crashes worldwide each year, it is crucial to note the cause is often human error. "[Crashes] are getting worse as people become more distracted with personal devices," Riehl says. According to a survey conducted in 2015 by the National Highway Traffic Safety Administration (NHTSA), distracted driving claimed 3,477 lives in the United States. Another key benefit to having access to driverless vehicles, according to Riehl, is access to transportation for those who could not drive before, such as the disabled or hospital patients. "It would definitely help make things easier on hospitals if they didn't have to arrange transportation for their patients," Riehl says. In addition, this technology reduces congestion on roadways.

Imagine a car that can be summoned to your location and drive you to any location you desire, all without needing to control it.

The first thing to understand about autonomous vehicle functionality is the varying degrees of autonomy and how the underlying technology affects what driverless vehicles can and cannot do. Today, an average smart vehicle usually contains features that take over some driving control of small tasks, such as collision warning/brakes or parallel parking. The more advanced systems allow cars to take advantage of features like adaptive cruise control, which gives the vehicle the power to change lanes in response to its environment as well as to speed up or slow down. There are even more advanced AVs in the development process that will be able to take over vehicle control for the majority of the driving but will transfer control to the driver in cases when the car does not know how to respond. True AVs lie in the realm where at least the majority of vehicle control is held by a computer rather than a human driver. These kinds of vehicles will be able to outperform their human counterparts through a complex array of sensors and a powerful computer that is constantly measuring the environment the vehicle is in, instantaneously making decisions and learning how to respond to new challenges.

The key to the success of autonomous vehicles lies in the diversity of the technology. These cars implement a more advanced version of GPS called Global Navigation Satellite System (GNSS), to locate the vehicle and assist in steering. AVs also make very heavy use of cameras. Pointed in every direction from the vehicle, they locate street signs, traffic lights, traffic cones, and other objects. In addition, proximity measurements are taken from various directions with the use of radar systems. Light Detection and Ranging (LiDAR) is a core component of advanced Avs, due to its ability to accurately calculate distances to objects with laser radar and use this information to construct a virtual grid of the environment through which the vehicle is being driven.

UW-Madison is heavily involved in the development of AV technology. The WiscAV lab has spearheaded cross-industry partnerships to advance the testing of AVs. Currently focused on promoting and testing AVs in Wisconsin, Rafferty and Riehl are field testing AVs on an old track on the property of MGA Research. Their research involves mapping the facility grounds with RoadView, a LiDAR mapping company. Their team is currently working on two major projects: vehicle-to-vehicle communication technology and implementing a driverless shuttle in a low-income neighborhood. Vehicle-to-vehicle communication allows vehicles to communicate their actions to each other, which would be very helpful in reducing reaction times. For example, if there are multiple cars in a lane, when the lead vehicle brakes, it would be able to communicate this to the cars behind it, triggering them to brake as well and avoiding a collision. In the second major project, the researchers are pursuing a National Science Foundation grant that will put an AV into a low-income neighborhood in Madison, where public transportation is needed. Their proposal includes a driverless bus with dynamic routing, making this option more efficient than manned counterparts as the resources required to add a conventional bus route are astronomical to the city. In addition, this research team has also partnered with other companies in order to improve AV technology, such as RoadView for mapping capabilities, Peloton for convoy efficiencies, and Navya to bring this technology to the UW-Madison campus.



Located in the Mechanical Engineering building, the lab uses projectors and a full-sized car to simulate driving conditions.

Despite the many benefits of AV, there are some significant drawbacks that have hindered AV advancement. One of the biggest threats to driverless cars is malicious hacking. It has already been demonstrated that smart cars are susceptible to hacking with controls transferred from inside the car to an outsider. Another issue for AVs is the negative performance of driverless vehicles due to a lack of assertiveness. While people regularly, and safely, break traffic laws to reach destinations efficiently, AVs cannot currently be programmed to use the loose interpretations of traffic laws the way humans do. "[Human mobility] is something that is very difficult to program into these vehicles," Rafferty says. However, these issues are being addressed in earnest, not just by the researchers but by the public as well, through awareness and participation throughout the development process. There is also an unsolved dilemma driverless vehicles face of how to balance the safety of occupants with the safety of people in the vehicle's environment. Currently there are debates engaging both legislators as well as the public to make sure that driverless vehicles take a careful approach with this issue. Depending on the balance, there will be huge implications for the responsibilities of damages and liabilities. These questions seem to have no correct answer, but hopefully with the involvement and support of society, we can take this next technological step with confidence. Take the words of an expert—when asked if he would use a driverless car for his own personal use, Rafferty responds positively, "I have no hesitation getting in any of these driverless vehicles right now; they are incredibly safe, the only limitation is their adaptation to these few edge cases."

Imagine a car that can be summoned to your location and drive you to any location you desire without even needing to control it. This opens the door to many more possible uses of vehicles—the need for skilled drivers will be gone. Driverless cars would know how to respond to any situation much more rapidly and effectively than a human driver could. Furthermore, people who didn't have access to cars before, because of their age or a disability, could enjoy the comfort of traveling by car. An entire new audience can gain access to vehicles with AV technology, but more importantly, we could see cities undergo vast changes as it becomes more convenient to share driverless vehicles. There could be significantly reduced personal vehicle usage on roads. These changes are all on the horizon as researchers work to make AVs more adaptable to the needs of our society.

Written by: Junior Quintero
Photography by: Jason Hakamaki
Design by: Suzanne Kukec

The Complexity of Tumors

The finicky tendencies of cancer tumors are forcing researchers to discover how tumor tissues behave and what therapies are most effective in treating them.

Tumors, like people, are unique. They are irregular and unpredictable, and their effects can vary depending upon the individual affected. The word "tumor" itself is a generalized term for the word neoplasm, which is an abnormal growth of cells. A neoplasm, if left untreated, will continue to grow and metastasize, potentially leading to death. As growth occurs, the cells of the neoplasm often damage structures adjacent to them, further harming the affected individual[1].

A tumor, or the neoplasm mass, can be categorized as either benign or malignant. Those determined to be benign are non-cancerous and often localized, therefore not spreading to the rest of the body. Benign tumors usually respond well to treatment but, if left untreated, may grow in size and lead to more serious diseases. Malignant tumors, on the other hand, are cancerous growths. They are often difficult to treat as they resist drugs, are able to spread to other parts of the body, and they can recur even after removal1. The cause of tumors is often excessive cell division and growth. This process is usually regulated by the body, but if done incorrectly, an imbalance of both cell reproduction and cell deaths may lead to tumor development. Certain health problems are also often linked to tumors such as obesity, excessive alcohol consumption, and excessive sunlight exposure. Other types of cancerous tumors—adult T-cell leukemia, cervical cancer, and some liver cancers—have been linked to or are caused by viruses. Some are more common in a specific gender, others more common at a certain age, and still more related to diet, environment, and family history[2].

One of the more difficult tasks in understanding tumors is not determining the origin of the tumor itself but its behavior and how to go about treating it. Tumors can vary in many ways including their size, shape, and level of aggressiveness. Therefore, the process of choosing the correct treatment path is extremely important as every tumor acts differently. Benign tumors, as previously stated, often respond well to treatment and are non-life-threatening. Malignant tumors, however, require advanced medical treatment in order to halt their growth. Current types of treatment include surgery, chemotherapy, radiation therapy, immunotherapy, targeted therapy, hormone therapy, stem-cell transplants, and precision medicine[3]. However, many of these treatments, such as chemotherapy, are extremely invasive and have many negative side effects such as hair loss, extreme nausea and vomiting, fatigue, and appetite changes. Most people with tumors are also likely to require more than one treatment to combat tumor growth, and the process of choosing a treatment is oftentimes overwhelming and confusing. Negative outcomes can have life-changing consequences, so the correct treatment is extremely important for an individual's recovery.

The Wisconsin Institute of Medical Research has been doing cancer research for decades.

One particularly rare and aggressive type of tumor is known as a carcinoid tumor. These tumors are often hard to detect and grow slowly over a long period of time, taking years to develop. One woman, around the age of 50, was diagnosed with a carcinoid tumor after a routine colonoscopy. What her doctor initially thought was a normal polyp, a small and typically benign growth, turned out to be one of these aggressive tumors. This woman was luckier than most as her tumor was caught early on at less than a centimeter in diameter. This case was significantly less extreme than most, yet she still underwent extensive surgery where half of her large intestine, her appendix, and two feet of her small intestine were removed. These types of tumors could be better treated if more was known about their individual behavior and development mechanisms[4].

Currently, researchers are looking past just the treatment of tumors and are trying to determine what the specific growth-signaling pathways of a tumor are at a cellular level. For example, why are certain cells resistant to tumor growth while others are more receptive? Answering questions like this one may lead to the development of more effective and less invasive tumor treatments. Advances in genetic information about tumors have also increased significantly due to the Cancer Genome Atlas (TCGA) project, a collaborative three-year pilot project created to determine the possibility of using large-scale genomic analysis technologies to determine the important genetic changes involved in cancer[5]. If researchers are able to better understand individual tumor development mechanisms, they can move on to testing various signal inhibitors in model systems, and drug manufacturers can better investigate new treatments. Tumor therapies can then be better customized to a specific patient's needs based on the behavior of their tumor[6].

While current methods of tumor treatment are in many cases effective, the ability to personalize a treatment plan to a specific tumor would lead to significant improvements in the effectiveness of tumor treatment. Eliminating the "one-size fits all" type of treatment would lead to better overall health conditions for the patient and a higher likelihood of positive long-term results. While much progress still needs to be made, the road to breaking down finicky tumor behavior is quickly being covered, and a bright future lies ahead.

Written by: Lucy Shoemaker
Photography by: Jason Hakamaki
Design by: Steven Musbach

The McArdle Labratory for Cancer Research is the center for the University of Wisconsin's cancer reasearch.

1. "What Are Tumors." John Hopkins Medicine, 2016 Johns Hopkins University, pathology.jhu.edu/pc/ BasicTypes1.php?area=ba. Accessed 18 Mar. 2018.

2. "Tumor." Medline Plus, medlineplus.gov/ency/article/001310.htm. Accessed 18 Mar. 2018.

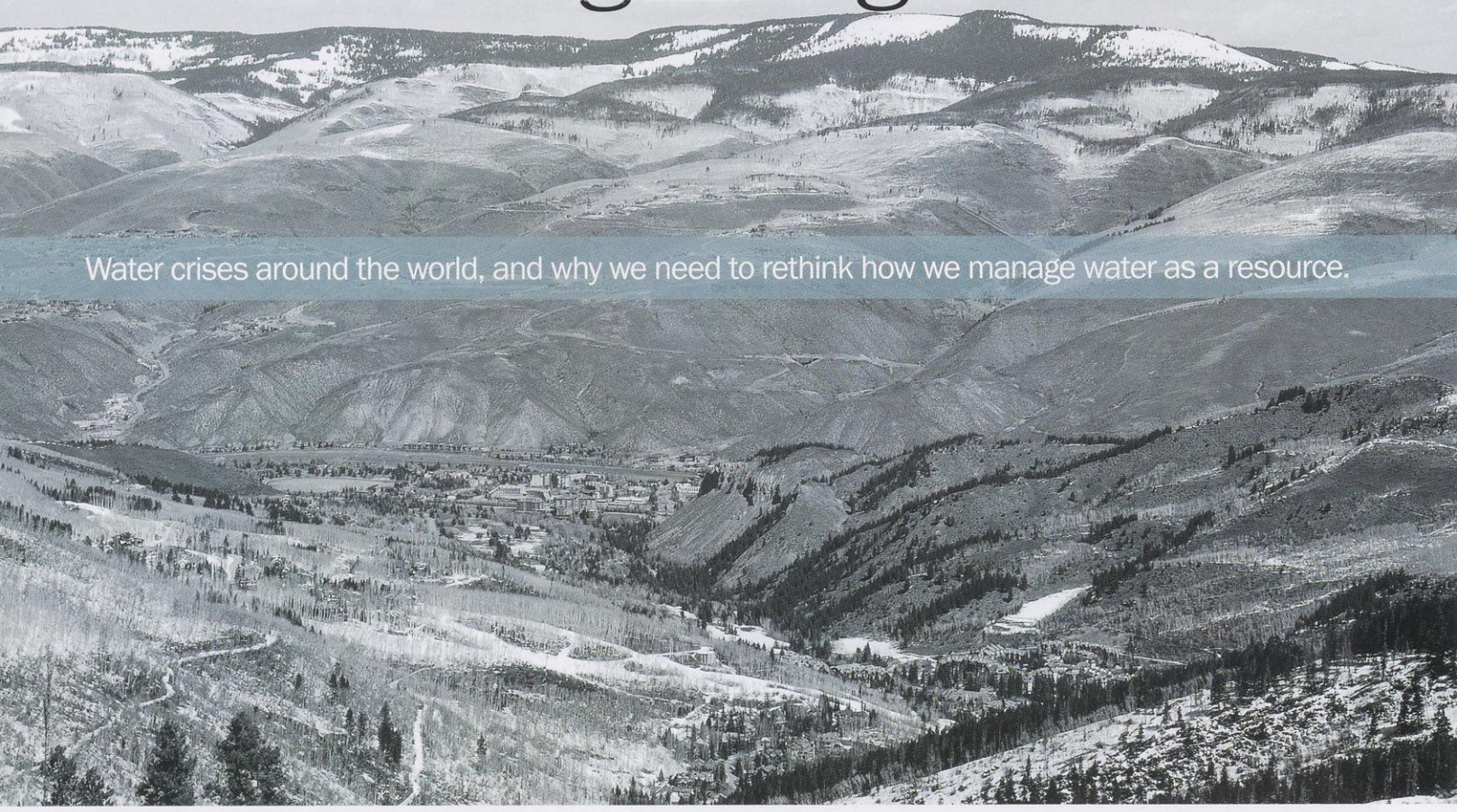
3. "Types of Cancer Treatment." National Cancer Institute, NIH ... Turning Discovery Into Health, www.cancer.gov/about-cancer/treatment/types. Accessed 18 Mar. 2018.

4. CASES; Rare Tumor Is Deceptive and Deadly. 2018 The New York Times Company, 16 Mar. 2002, www.nytimes.com/2002/03/26/health/cases-rare-tumor-is-deceptive-and-deadly.html. Accessed 20 Mar. 2018.

5. Hampton, Tracy. "Cancer Genome Atlas." JAMA Network, 2018 American Medical Association, jamanetwork.com/journals/jama/article-abstract/203742. Accessed 18 Mar. 2018.

6. "Caroline Alexander - Breaking Down Tumor Behavior." University of Wisconsin School of Medicine and Public Health, BOARD OF REGENTS OF THE U OF WISCONSIN SYSTEM, www.med.wisc.edu/research/ researcher-profiles/caroline-alexander/. Accessed 18 Mar. 2018.

DRY and getting DRIER



Water crises around the world, and why we need to rethink how we manage water as a resource.

Emission targets by 2040. Global temperature increase by 2050. Sea level rise by 2100. The far-off nature of climate change planning often makes the problem difficult to conceptualize, divorced from the reality of today. For millions of people around the world, however, climate change is already here and wreaking havoc in their daily lives.

As of March 2018, the water crisis in Cape Town, South Africa, continues unabated. Total storage in the system of dams supplying the city's water hovers around 23.5 percent. "Day Zero," the predicted day on which dam levels will fall to 13.5 percent capacity, is July 15, 2018. Levels this low will force city officials to shut off much of the city's municipal water supply. Residents' daily water allocation will fall from the current 13.2 gallons to a mere 6.6, which will be obtained from one of 200 collection points around the city. For context, the United States Geological Survey estimates the average American's water usage to be 80-100 gallons per day.

A situation as Mad Max-esque as this seemed impossible just four years ago. The city of Cape Town had recently completed its Water Conservation and Demand Management program. Beginning in 2007, the city increased the efficiency of its municipal water system by nearly 60 percent by replacing aging pipes, installing new meters, and better managing system pressure. A series of wet years had filled the dam system to almost 100 percent capacity. City officials forecasted that augmentations of their water supply would not be necessary until 2019 at the earliest.

Despite Cape Town's groundbreaking infrastructure improvements, its water supply remained dangerously insecure as just six major dams, fed chiefly by winter rainfall, contained 99.6 percent of the water supply for the entire Western Cape province. This fact became painfully apparent when, in 2015, the worst drought in Cape Town's recorded history began. It remains ongoing today.

The drought, however, only tells part of the story. South Africa's national Department of Water and Sanitation has been widely criticized for its management of the crisis. In 2015, despite clear indications of drought, the DWS increased water allocations to agriculture. Additionally, mismanagement of the agency has left them financially unable to provide any significant drought relief funding, leaving Cape Town to foot the bill for costly emergency desalination and groundwater withdrawal projects.

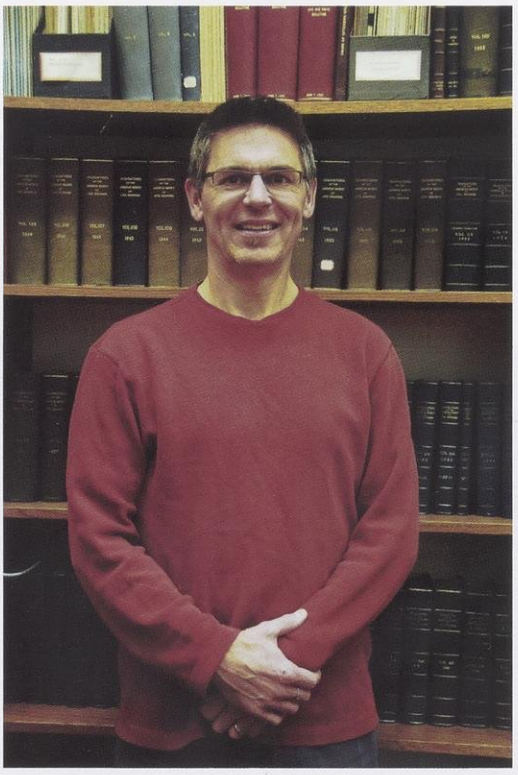
When we look at the long-term, generations into the future, are the practices we're following now sustainable?

Cape Town's inhabitants are not without blame. Population increase and the hot, dry weather exposed officials' forecasts of future demand as woefully optimistic, and any student of risk management will tell you that putting 99.6 percent of your eggs in one basket is courting disaster. Furthermore, many residents (particularly those in wealthier areas) have proved unwilling to follow water restrictions; until late February, the percentage of Cape Town's population complying fully with restrictions remained below 50 percent.

With Day Zero looming, Cape Town has dominated headlines around the world. Yet, for millions in Mexico City, the doom portended is already their daily reality.

The Mexico City metropolitan area sprawls over approximately 3,000 mi2, and houses over 21 million people. Providing sufficient water for it poses an understandable challenge. The Cutzamala reservoir system, the source of roughly 20 percent of the city's water, sits 75 miles away, and the water pumped from it must travel 3600 vertical feet to the city – a task involving about 0.6 percent of Mexico's total annual electricity usage. The city's chief source of water, however, comes from the groundwater aquifers beneath the lakebed upon which the city was built. The scale of this extraction causes the city to subside as much as 3 inches per year. However, even these massive hydrologic efforts are ultimately unable to provide the city with water. The government admits that nearly 20 percent of Mexico City residents do not have reliable access to water, and critics put the number even higher. Huge swaths of the poorer boroughs of the city must obtain their water from a fleet of water trucks or by collecting rainwater. Richer residents of Mexico City, meanwhile, consume orders of magnitude more water, and pay significantly less to do so.

Crises such as these are no new occurrence. An Australian drought spanning nearly the entire first decade of the 21st century left cities like Melbourne with less than a year's worth of water for municipal use. In 2008, Barcelona was forced to import water from France after its own supply ran dry. Severe drought forced São Paolo to shut off taps for days at a time in 2015. And California, which enacted its own water restrictions in 2015 in the face of a five-year drought, appears to have more dry weather on the horizon.



Professor Paul Block, head of Water Systems and Society research group.

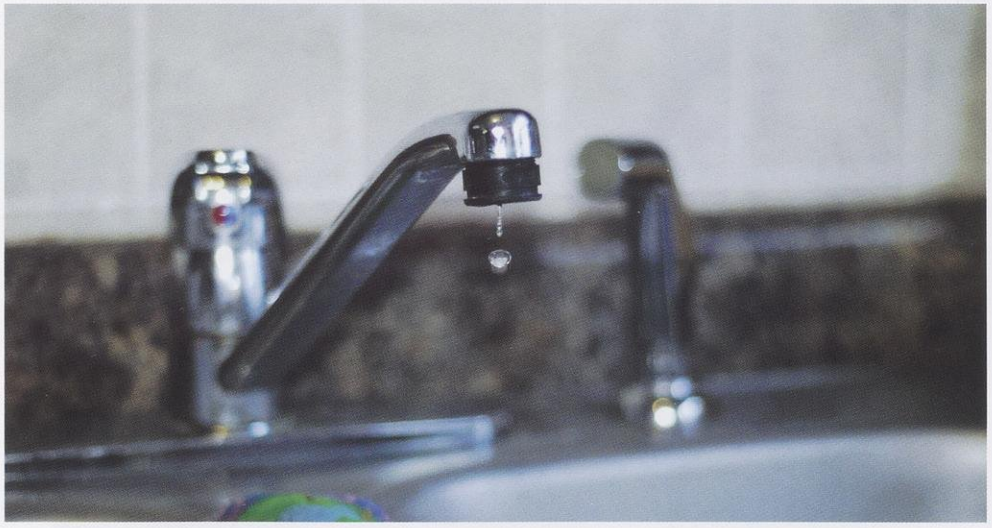
Our changing climate and continually growing population ensure that these issues are here to stay. The World Economic Forum's 2017 Global Risk Report estimates that water availability in cities could decline by as much as two thirds by 2050. The United Nations 2018 World Water Development Report estimates nearly 3.6 billion people currently live in areas threatened by water scarcity for at least one month every year, a population which could potentially grow over 5.5 billion by 2050.

These current crises and predictions of more to follow both suggest the dire need for our society to seriously reevaluate its relationship with water as a natural resource. UW-Madison Professor Paul Block, head of the Water Systems and Society research group in the College of Engineering, emphasizes that our society's current strategies of water management are insufficient. "In water resource management, we've always had this 'command and control' attitude that we can withstand the biggest droughts, or hold back the biggest floods," Block says. "Clearly, over the last few decades, we've realized that we can't do that, nor will we really ever be able to do that." Block describes the issue as one of changing supply as well as increasing demand. "The probability of these events [like Cape Town] increases in a changing climate," Block says. "It's still a low probability event, but it's more likely. The question becomes, how protected should our supply be against these events?... How much infrastructure do you build?"

While there certainly exists a need for more proactive infrastructure development, Block highlights the growing need to examine our consumption of water, and to develop more sustainable usage habits. In his own words, "one of the biggest things is changing our mindset to one more focused on conservation... When we look at the long-term, generations into the future, are the practices we're following now sustainable?"

Ultimately, the dire situations of cities like Cape Town emphasize the need for proactivity in these conversations. The rushed schedule on which Cape Town is building emergency desalinization and groundwater pumping facilities has driven up the facilities' costs per liter of water nearly fourfold, and they will ultimately be unable to meet the city's entire water demand. As a result, the city finds itself in the uncomfortable position of having to pray for rain. If we continue our current course of relative inaction, more cities may soon follow suit.

Written by: Patrick Byrne
Photography by: Carter Swedal
Design by: Suzanne Kukec



With water sources rapidly diminishing, innovative solutions must be explored.

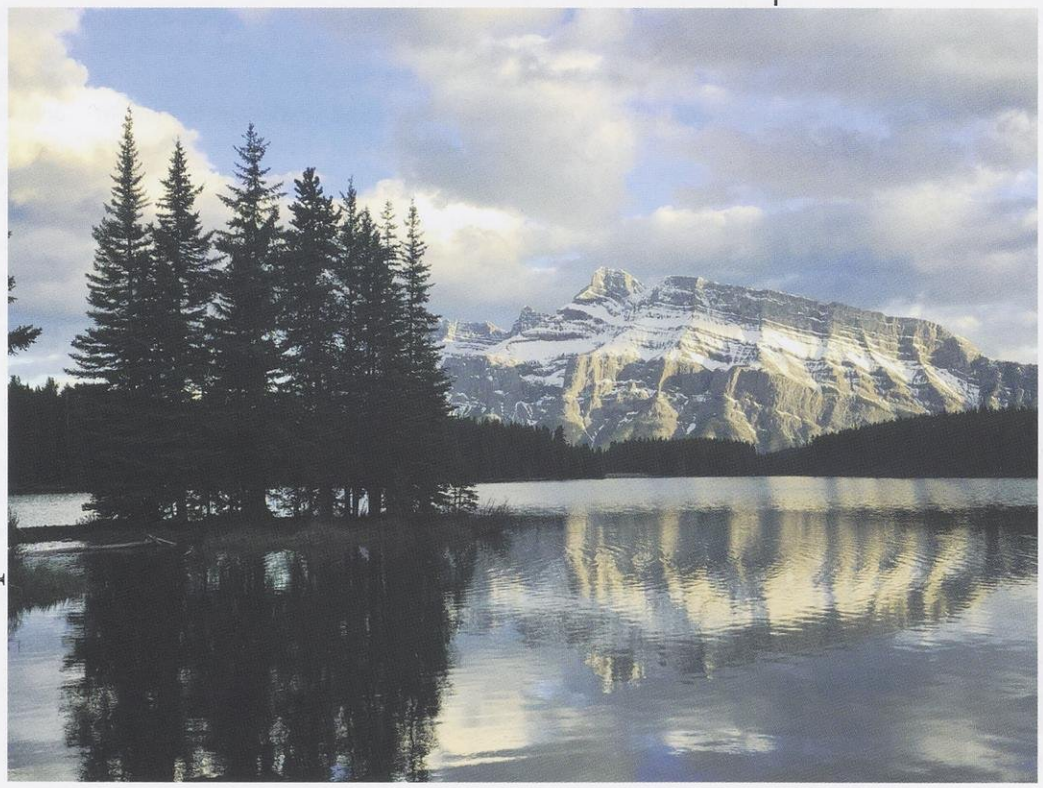
Landscape

Hickman Arch | Evan Bauch

Category Winner

Mirror Mirror | Claire Chen

Runner Up



Still Life

Red Deer Standoff | Alec Schultz

Category Winner

Variegated Meadowhawk | Evan Bauch

Runner Up

The Wisconsin Engineer's 10th Annual Photo Contest

Portrait

Sparkling Innovation | Courtney Lynch

Category Winner

A Break Outside | Paul Scharlau

Runner Up

Miscellaneous

Contemplation | Samuel Fritz

Category Winner

Clovers | Joshua Emory

Runner Up

The Wisconsin Engineer's 10th Annual Photo Contest

Cityscape

Capitol Snowstorm | Joseph Harter

Category Winner

Watercolor | Lexi Oxborough

Runner Up

Silicon Valley, Meet the Nuclear Engineers

A wave of American startups aim to use advanced nuclear technologies to disrupt the stagnating domestic nuclear energy industry

The United States has historically been a leader in both the innovation and regulation of nuclear energy dating back to the birth of the industry and the Manhattan Project in the 1940s. However, a three-decade drought in new reactor construction, coupled with growing nuclear interest by China, Russia, and others, has resulted in a very different outlook today. Contrary to widespread belief, public distrust of nuclear power is only partially to blame for this decline; inconsistent regulations and high investment costs have been equally significant barriers to industry advancement.

Regulatory issues notwithstanding, the United States still generates more energy from nuclear reactors than any other country, but that will soon change. While we currently have two new reactors under construction, in the next twenty years China is planning to build 61 and Russia has plans for 32. Perhaps in response to this overseas market, there has been a surge of interest in nuclear technology here at home.

This renewed interest isn't in traditional nuclear energy. Instead, Dr. Todd Allen, a professor in UW-Madison's nuclear engineering department who researches energy policy, has observed that "over the last three years or so, large numbers of private companies - it almost looks like a start-up culture - started spending their own money thinking they're going to develop the next nuclear product." These products and associated technologies are collectively known as "advanced" nuclear. Allen explains that "there are lots of definitions of what 'advanced' means, but I like to think of it as products that are aimed at different markets than gigawatt-scale." These startups, currently about 75 in total, are unique in that they plan to use these advanced technologies to create nuclear reactors for totally different markets than the traditional large-scale power plants.

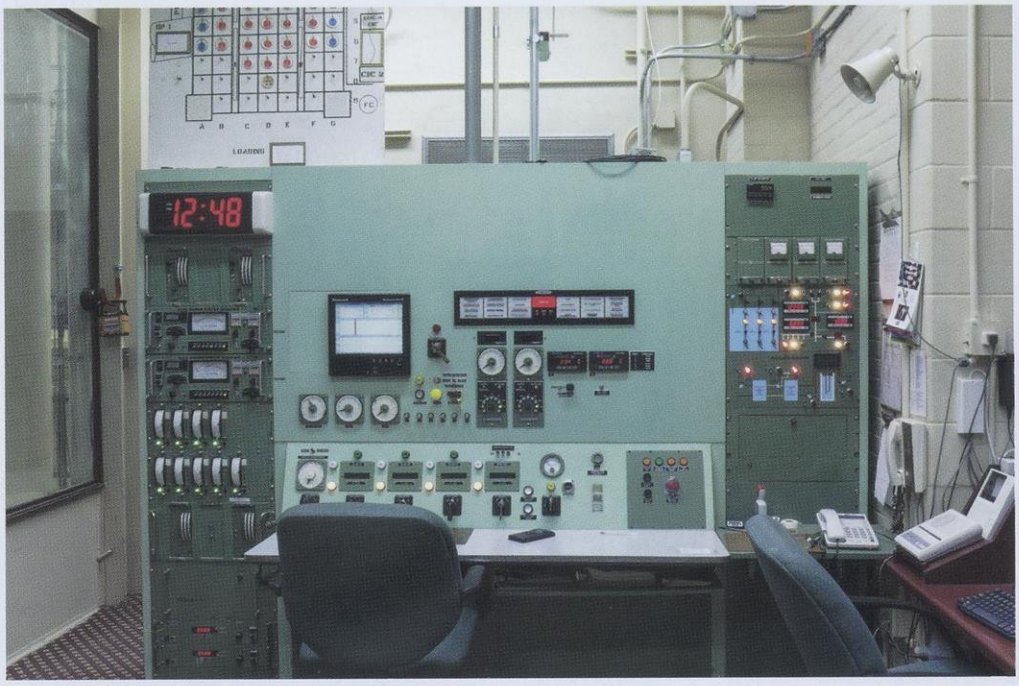
Traditional nuclear reactors, known as light water reactors (LWRs), are used at essentially all of the United States' operating power plants. LWRs use water to cool the extremely hot reactions of nuclear fission. Historically, they have all operated on a large scale, with each one producing about 1000 megawatts of electricity. In contrast, as Allen explained, advanced nuclear reactor designs will be aimed at markets often on the scale of 3-200 megawatts. This provides much more flexibility for nuclear power to be used in smaller or more remote communities where the whole town may only require five megawatts. Additionally, advanced nuclear reactors will be cooled much more safely and reliably by using salts or liquid metals instead of water and will produce far lower quantities of dangerous nuclear waste, with some designs even being able to use old nuclear waste as new fuel.

With advanced nuclear technology providing so many new avenues of research for private companies across the United States, it is in the federal government's best interest to establish clear and efficient regulations to help promote the success of these startups and avoid costly delays. Unfortunately, reforms in these areas have often been slow or nonexistent, inhibiting startups' ability to test their designs and understand what regulatory mandates they must meet. Updating this regulatory framework so it more efficiently addresses the needs of advanced nuclear startups without causing delays is one of the most important steps towards clearing the path for renewed nuclear energy investments.

Along with updating the regulatory process, Allen believes there are two other ways that the government could encourage nuclear innovation. First, he explains that we should create a "drive to commercialization [to] make these 75 companies compete" directly for government funding through incentive programs. This would promote competition rather than pre-selecting several companies to fund regardless of their success or failure. Second, he feels that "we don't spend the research money in a very focused way." Instead of detailing a specific solution to be researched, a prize should instead be awarded to whoever comes up with the best solution to the problem in general, irrespective of the way the solution is reached. These changes would place the government approach to nuclear energy research more

in line with the way it funds many other scientific endeavors, taking advantage of the competitivity of American companies and investors.

The United States has sometimes struggled to adapt its nuclear energy policies and regulations for a 21st century world. However, the emerging advanced nuclear movement has many people excited about the possibilities that these technologies provide to a new generation of innovators. Not only are advanced nuclear startups improving upon existing LWRs by modifying them for use in scenarios with lower electricity needs, they are also developing totally new techniques to make nuclear power plants cheaper and safer. Modernization of technologies can be a difficult, painful process; for the nuclear industry it might lead to the slow fade of the dominance of traditional, 20th century reactors. However, innovators are poised to replace those outdated reactors with nuclear power which is tailored to today's energy needs, rather than those of 1968.



Control panel used to operate and monitor the reactor

Written by: Ben Zastrow

Photography by: Jason Hakamaki

Design by: Suzanne Kukec & Edwin Neumann

Is LEED being replaced?

Overviewing a new environmental certification for buildings called RELi: will this be the new LEED?

UW Madison works to engrain sustainability in as many ways as possible, shown here with the solar-powered bike racks, which promote clean transportation as well as clean energy.

Derived to raise awareness about environmental issues in building design, Leadership in Energy and Environmental Design (LEED), has been the environmental building standard since its launch in 1993. However, significant shortcomings of this standard have risen to the surface, paving the way to the newest standard in environmental construction: RELi. RELi is like LEED, in that it encourages environmentally friendly building regulations but emphasizes resilience in addition to the environmental awareness. RELi has made resilience the focus point of the new standard. Resilience is defined as the capacity to quickly recover from complications, which drives REli standards. The elasticity, or ability to overcome challenges, that RELi values, is leading to big changes in the construction industry, which may provide a stepping stone to more efficient and sustainable infrastructure.

Although LEED standards have spurred attentiveness of environmental concerns within the construction industry, criticisms highlight how it lacks significant progress in terms of environmental growth in infrastructure. LEED has several issues that have led to unimpressive results: first, the LEED standard is overly complicated. The complexity of the system increases overall time spent on projects—increasing cost and wasting resources. Furthermore, the LEED system is based on a point system that building designers can manipulate to their advantage, which inadvertently makes the standards like a game to developers. Another issue LEED has is that the point system does not involve a hierarchy of credit points, resulting in small design decisions with little impact to be weighted equally to design aspects that improve the efficiency of the infrastructure more profoundly. LEED also fails to include standards pertaining to location. Locations susceptible to climate change disasters, such as the coasts of Louisiana, or extreme temperature variation, such as buildings in a desert, must consider factors that are dissimilar to those of different locations. However, LEED still offers "environmental plans", even though these do not take factors such as climate, and region into consideration. Finally, although LEED offers points for public outreach, it does not provide the necessary training for building operators to become proficient in this skill – thus allotting points for public education but not following up to ensure building is operating as the building was designed, which is one of the largest criticisms of the LEED standard. This is especially important because a building can be equipped with high tech ways of improving efficiency but cannot operate according to plan without building operators maintaining the conservation of energy within a building. All of the shortcomings of LEED listed above indicate a need for change within environmental standards for construction that will allot for improved efficiency of infrastructure.

RELi has been developed over the last six years to compensate for LEED's shortcomings by professionals and experts at various organizations.

Fortunately, these issues are fixable. RELi has been developed over the last six years to compensate for LEED's shortcomings by professionals and experts at various organizations. In short, RELi expands current sustainability rating systems like LEED, making the adoption process easier among professionals. RELi offers a balanced set of credits that span eight catego-

ries, providing designers with ample ways to customize buildings to allow for higher efficiency. This certification is comprised of three main components: The Resilience Action List, the Credit Catalog, and the Project Tally, which together eliminate unnecessary complexity within the system. Additionally, RELi incorporates five design patterns: resilience, restoration, regeneration, sustainability, and wellness. Each of these design patterns aims to improve the aspects of buildings most in need of environmental care. RELi's concern with buildings' ability to adapt to changes and interruptions, such as climate and damage, is at the heart of the mission, combining design criteria with an integrative process to develop a new generation of communities, homes, and infrastructure.

LEED's advantage still holds, as it is basically a household name within the construction industry; in contrast, RELi is not recognizable. The Wisconsin Engineer Magazine reached out to multiple Construction Management professors at UW-Madison who were not aware of this new standard's implementation, highlighting the discovery issue behind this novel certification. Currently, RELi is being spearheaded by The C3 Living Design Project. This certification has been mentioned many times by leaders such as Barack Obama and is being recognized by American Institute of Architects and the National Institute of Building Sciences which will lead RELi to becoming a more familiar standard.

Even though the theory behind RELi appears to be sound, the question remains: is it replacing LEED? The RELi standard was recently adopted by the United States Green Building Council, the same program that certifies LEED. Soon, RELi will be refined to forward resilience into design, construction, and operation of buildings. RELi is still in its early phases and will not entirely replace LEED for some time. However, the transition will be made. The construction industry will only be improved by the transition to RELi as it will provide not only new standards in efficiency of buildings but also a new state of mind when it comes to designing buildings and will provide designers with an innovative resource dedicated to ensuring more environmentally sensitive infrastructure.

These photos were taken in the Wisconsin Institute for Discovery, a LEED Gold Certified building. The LEED certification process is operated by the United States Green Building Council (USBGC) and provides third-party verification of green buildings. In 2018, Wisconsin ranked 17th in the Green Power Partnership Top 30 Colleges and Universities, thanks to sustainable, green buildings such as the WID.

Written by: Sarah Gerarden

Photography by: Mary Shaughnessy

Design by: Suzanne Kukec

Skinno
the Skincare App

Skincare is one of the hottest beauty trends of the decade, but it can be a confusing world to navigate. Lisa Guerrera and Christina Torres discuss their app, Skinno, which seeks to enlighten consumers on exactly what they're putting on their skin.

Lisa Guerrera (top), began to develop what would eventually become Skinno for her thesis project during her senior year of college.

Christina Torres (bottom) researches countless scientific articles on ingredients found in skincare products and seeks to make her findings understandable to the users of Skinno.

If you have ever dipped your toes into the dizzying, vast world of skincare, you may have wished for some sort of guide to steer you towards products that will aid you in the quest for clear, glowing skin and away from products that may irreversibly damage it. While information on what is beneficial and what is detrimental to healthy skin is available, in many cases it is difficult to find and oftentimes appears to be contradictory. Many healthy skin seekers have been forced to rely on the less than trustworthy advice of YouTube and Instagram influencers and the tiresome method of blindly testing products to build a reliable skincare routine. Fed up with this problem, Lisa Guerrera, a skincare enthusiast and recent graduate from the City College of New York, decided to create Skinno, an app dedicated to the personalization of and the scientific research behind skincare.

Guerrera, the CEO of Skinno, first got into skincare when she was around 12 years old and developed a bad case of cystic acne. "Skin has always been an issue for me," Guerrera says. "I turned to products for help, as most people do as teenagers…but I really liked chemistry and science, so I went deep in there." Guerrera has developed this passion throughout her academic career, graduating with a degree in chemistry, and is currently pursuing a Master's in cosmetic engineering at Manhattan College. In fact, the idea for Skinno developed during her senior research thesis, where she was given the freedom to combine her passion for skincare with scientific knowledge.

Guerrera decided to focus her project on chemophobia, or fear of chemicals, and how the cosmetic marketing industry preys on those fears. "People used chemicals as a dirty word," Guerrera says, "and it bothered me a lot. So, I wanted to focus on ingredients in that thesis, I wanted to talk about people's perception of chemistry." Skinno originated as the technical portion of that thesis. Essentially, the app is able to scan a list of ingredients, draw upon a database of scientific skincare research, and determine which products are beneficial and which are detrimental to the skin. The app also seeks to create a personalized skincare routine that works the best for each individual user's skin type. Skinno, although much too large a project for Guerrera's thesis, stayed in the back of her mind. Development began six months later at the 2017 Nestlé Skin Health SHIELD Hackathon. Guerrera and her team won first prize, and are currently competing in the Zahn Innovation 2018 Venture Competition, where they hope to win more funding for the app.

Although Skinno's development has happened within a relatively short time period, a lot of skincare research goes into the product. That's where Skinno's Chief Research Officer Christina Torres comes in. "We're trying to educate people about skincare ingredients," says Torres, another graduate of City College. "The [skincare] information that's out there and readily available to the public isn't incredibly scientifically accurate or centralized in one location…we're combing through the primary scientific literature and translating that into plain English, so the average consumer can actually understand the real science that's going on here." Essentially, the team behind Skinno is trying to create an accessible database of current scientific skincare literature. The hope for the app is that anyone, from a complete novice to a dedicated expert, can use the app to create a skincare routine that is best suited for their needs.

"Getting into skincare takes time, and it seems really daunting. There's a lot of products out there, and people get frustrated and just don't try. We want to fix that," Guerrera says. The Skinno team hopes to offer a more personalized and accessible way to navigate the world of skincare. It will be exciting to see where their passion takes them.

Written by: Erica Calvache

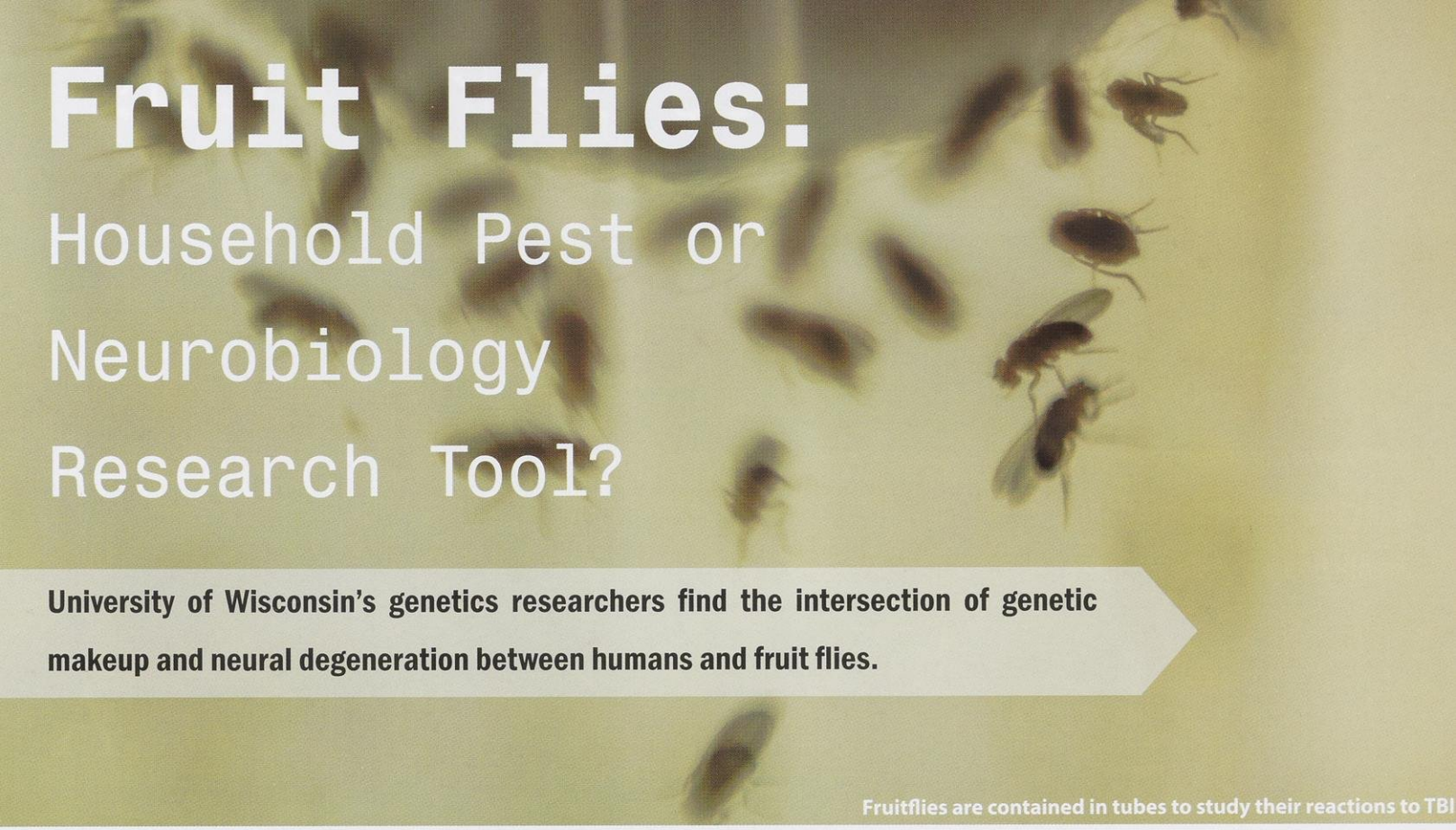
Photography by: Mayukh Misra

Design by: Suzanne Kukec

Fruit Flies:

Household Pest or Neurobiology Research Tool?

University of Wisconsin's genetics researchers find the intersection of genetic makeup and neural degeneration between humans and fruit flies.



Fruitflies are contained in tubes to study their reactions to TBI

Even at 3 millimeters in length, and bearing no agreeable visual similarities, fruit flies share an impressive 75% of their genes with humans. Scientists have gained much from this relationship by researching the neurobiology of fruit flies. Because of the genetic similarities between humans and fruit flies, huge advancements in the study of traumatic brain injuries, and our body's response to them, are being made. Scientists on the front line of this research include David Wassermann and his associates who study the field of medical genetics and aim to understand human neuronal disorders and degeneration.

Traumatic brain injury, or TBI, and our body's reaction to TBI are one of the many great phenomena in neurobiology today. The most common form of TBI is from concussions, usually caused by direct blows to the head from sports injuries, car accidents, or falls. These traumatic brain injuries can vary in severity and recovery time, but they usually cause neural degeneration, which is the progressive loss in the structure or function of nerve cells in our brain. Wasserman aims to understand the complexities of neural degradation, particularly in the differences between seemingly similar cases. He seeks to understand how one person can play an entire 30-year professional football career riddled with concussions, while another player may get one concussion and be sidelined for life.

Wasserman first began his work on fruit flies six years ago with Barry Ganetzki, an established scientist who has studied fruit flies for nerve functionality for over 40 years. They simulated mechanical injuries to the brain in fruit flies and studied the mortality rate of these flies. Through further analysis and use of microscopy, it was found that some of the flies developed small holes in the brain that made David and his associates wonder about the physical side affects of these changes. The flies that were subject to TBI showed psychological problems such as muscle coordination, memory loss, and extreme emotional response. Wasserman studied 179 unique varieties of genetic types of fruit flies to provide for more human-like results.

Deeper analysis of these flies that were subject to TBI revealed increased molecular permeability, or weakening of the lining of the intestine and the blood-brain barrier. This allows toxic molecules into the brain that can be harmful to bodily function and cognition. Without these barriers, there is no longer control of what substances flow into the brain. Another gene that was found to be correlated with TBI recovery was metabolism regulation. Wassermann identified the gene sequences responsible for the intestine and blood-brain barrier permeability, and regulation of metabolism, and traced this sequence in the human genome. Wasserman and his lab are working closely with researchers at the University of Pittsburgh to study these genomes in humans and regulate these biological processes through gene editing technology like CRISPR or attempting to prevent these causes through medication medical treatment.

Despite these recent discoveries, there is still a long way to go before a complete solution to debilitating traumatic brain injuries is found. The long-term goal of this lab is to identify which genes are specifically responsible for the discrepancy in rehabilitation of TBI in humans and to provide treatment to prevent long-term neural degeneration and promote a high-quality of living. There may be even be more advanced methods for preventing neural degeneration with gene editing . It may not be long before concussions are as treatable and preventable as the common cold. Even though fruit flies are so small and pesky, they can be a huge step in the process of understanding our own neurobiology.

Written by: Chris Hanko

Photography by: Mayukh Misra

Design by: Suzanne Kukec

Should Science be Political?

In a highly political climate, can scientists be involved in politics without jeopardizing their credibility as objective and unbiased rational chroniclers of evidence? UW-Madison faculty and students speak on the matter.

Science is a system of knowledge concerned with the physical world and its phenomena, entailing unbiased observations and systematic experimentation. Hypotheses, empirical data, and theorems define scientific studies that have been long tried and tested. Over time, the public has perceived the scientific community as an island of knowledge, with minimal connections or influence with the outside world. This isolation has created the moral obligation for self-checking of scientists, causing some societal distrust of scientists in this increasingly hyper-partisan political atmosphere. For the scientists, this distrust has left them at an impasse, raising different questions regarding the role of science in politics. Should scientists stick to objective facts and completely stay away from the political world? Are they obligated to engage in political advocacy? If so, what effect can this have on their credibility? Is there a middle ground where scientists can be involved in science while maintaining their objectivity? We explored these questions through conversations with different faculty and students involved in science at UW-Madison.

The first scientist we sat down with was Dr. Joseph Towles, an associate faculty lecturer in biomedical engineering. Towles' position on scientific political advocacy is that science is essential in more areas than just politics. "The beauty of science is that you can use evidence to make any important decision, not just political ones," Towles says. To Towles, all people, scientists or not, should participate in advocacy to a level of their comfort. Scientists may also have an advantage as they solve problems within their areas of expertise. This provides not only evidence but also credibility. Towles emphasizes the importance of evidence to scientists who choose to be involved in political advocacy: "The challenge is that often, political involvement is based on emotions and can be subjective and perceived as self-serving to someone with a different opinion." In addition to objectiveness, Towles states that the perception of a scientist might validate or invalidate their political stance. The public is often receptive to a messenger that resonates with them and then uses their scientific beliefs to shape policy. According to Towles, the best professors already implement this strategy to succeed in their jobs. These professors establish a connection by being empathetic to students' needs based on their social experiences, and then can teach the students with their knowledge-based expertise. Thus, Towles suggests that scientists who become politically involved must connect to the world around them, as different people with different beliefs and backgrounds often interpret science differently. For scientists, this emotional consideration can keep their message knowledge-based.

The second scientist we interviewed was Dr. Jamie Schauer, a professor of civil and environmental engineering and the director of the Wisconsin State Laboratory of Hygiene. Schauer's position needed the classification of the three types of relationships that connect science and politics: the politics that drive science, the effect of science in policy-making, and the integration of science and politics. To Schauer, scientists can choose to be involved in political advocacy. However, he believes in the ethical obligation to state a clear distinction between opinion and evidence-based scientific understanding. This distinction is important to Schauer, as his research is focused on the quantitative understanding of the origins and impacts of air pollution. Schauer's work is policy-relevant science that significantly influences the development of government policy. According to Schauer, spearheading this work does not necessarily equate to political involvement. Schauer does not advocate for specific policy but encourages the integration of scientific data into policy-making. To Schauer, science should not be the sole dictator of policy. Occasionally, the socio-economic climate may trump science. Schauer's research in developing countries has highlighted the dependence on fossil fuels for survival while increasing pollution. If only science is considered in policy-making, the solution to this pollution would be a complete divestment away from these fuels. However, the complete eradication of fossil fuels could lead to a sudden loss of these populations' means of survival. Thus, Schauer emphasizes his belief that policy-relevant science is necessary to solve the world's most pressing problems.

"It is my job to educate people, and I try to very carefully distinguish between facts, hypotheses and personal beliefs."
-Professor Jamie Schauer.

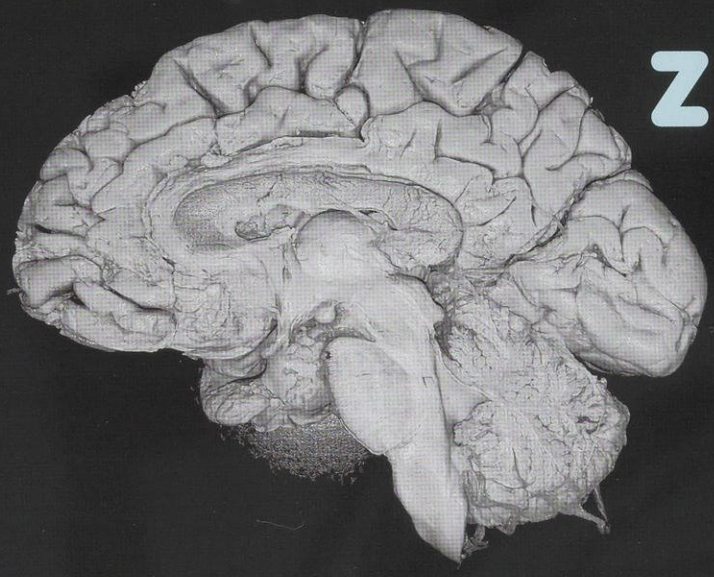
The third scientist we interviewed was former UW-Madison student, now graduate student at the University of Washington, Olivia Sanderfoot. Sanderfoot believes that scientists have a moral obligation to conduct responsible, ethical research and communicate their findings with the public: "[Scientists] can share these findings via publications in open access journals, giving public lectures, writing blogs, producing videos, speaking with journalists, or sharing posts on social media." Sanderfoot further adds that scientists can be political without being partisan, and that policy science is inherently political since it involves governmental affairs.

From these conversations, it is clear that the role of science in politics is challenging to navigate. Each person has their own exigence, but mainly, the scientists agree that some evidence-based political advocacy is acceptable, if not necessary. Already, science has its political roots – whether it influences policy or reflects the policy itself. Thus, there are many different degrees to which scientists can be politically involved. Most importantly, these scientists must maintain their credibility, which is highly dependent on how the scientist relays his or her message.

Written by: Jemimah Mawande

Design by: Suzanne Kukec

Just Sleep On It



Studying the millions of connections that the brain makes every day tells a story of why we need sleep.

As infants, humans sleep for most of the day. As a child, sleep becomes progressively less frequent. Teenagers generally want to stay up later and later. College students and adults can't seem to find enough time to sleep. As the body changes and age progresses, so do sleep patterns. Overall, humans are asleep for roughly one third of their entire life, and often this time could be used doing something more productive. Lack of sleep, however, can lead to decreased brain functionality, and chronic sleep loss can make these symptoms even worse. If sleep did not serve a significant purpose, then humans and animals would have stopped sleeping long ago. During sleep, the brain is disconnected from the world, meaning that the ability to promptly respond to a stimulus is lost. So, if we can accomplish more when we are awake, and we are less vulnerable to threats when awake, why exactly do we need to sleep?

Dr. Chiara Cirelli of UW-Madison's Center for Sleep and Consciousness has devoted her research to answering this very question. Cirelli's interest in studying the brain and how it related to sleep began as she studied medicine and neuroscience in Pisa, Italy at the age of 19, and she has never stopped trying to answer this question: why do humans and animals require sleep? The basic hypothesis that Cirelli and her colleague Dr. Giulio Tononi have been developing is called the Synaptic Homeostasis Hypothesis (SHY). Trillions of synapses exist in the brain which connect millions of neurons to each other and activate them. These connections tend to become stronger every day with each task performed or learned. During sleep, the brain undergoes a synaptic depression of most of these connections so that the brain can keep only the important connections and forget the unimportant ones.

From what you ate for breakfast to the answer to your homework problem, every piece of information throughout the day is stored in one of these connections. "When lying in bed, try to remember all of the details that you learned today. You will be surprised with how much you will remember," says Cirelli. It would get very overwhelming if the brain had to protect each one of these memories to the same capacity as the next. So, the brain must have a "smart" system in place to filter whether a synaptic connection is important or not. By the end of the day, the neurons used for learning are more active than other neurons, so these are the "most poised" to be protected from synaptic depression during sleep. SHY explains that sleep helps the brain to renormalize itself by downsizing certain synapses to make room for further connections the next day. If this synaptic homeostasis did not occur, the strength of synapses could be saturated, significantly diminishing the ability to learn new things and consolidate memories. "The evidence that sleep is important is overwhelming," remarks Cirelli.

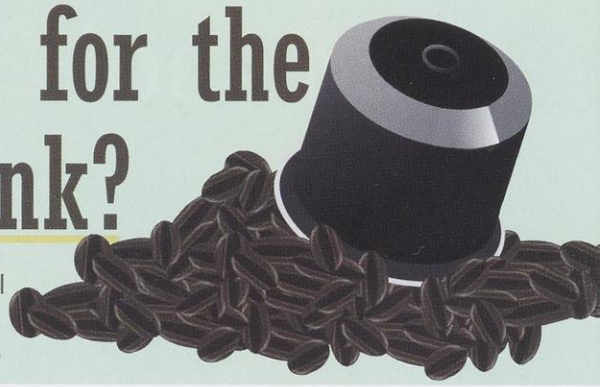
"In life, you have to try to find a question that you want to answer that is important—that you care about. So, it better be a big question."
-Chiara Cirelli

Testing SHY is difficult; it can take years to get just a small sample of data. There are several ways that Cirelli tests this hypothesis, and one is through in vivo stimulation, or a stimulus applied to a live organism, typically mice or flies. During this test, a pulse is sent to a group of neurons, and the output response from those connections is measured. It was found that, from the same intensity of stimulus, the response recorded was higher after the subject had been awake for several hours compared to several hours asleep. Using electron microscopy (EM), this result lead to the finding that in a very specific part of the cortex in the brain, there is irrefutable evidence of an 18% decrease of synaptic activity during sleep. Other studies have identified specific molecules in the brain that are key to downsizing the synapses during sleep so that the brain can be renormalized and reset once woken up. This is a step in the right direction for SHY to be proved correct.

The EM experiment took five years with five full-time researchers working on several different types of tests. To map out the entire brain and to fully understand why we sleep is a slow process, so researchers must be patient. Soon, there could be a breakthrough in neuroscience research to see how the billions of connections in the brain can explain why we need sleep. "In life, you have to try to find a question that you want to answer that is important- that you care about. So, it better be a big question," claims Cirelli. One thing is for sure—if you do not sleep and let the brain's mechanisms renormalize all the connections, it will be much harder to learn more and to be able to answer this great question.

Written by: Jordan Wolff
Photography by: Casey Shackow
Design by: Steven Musbach

Are coffee pods as bad for the environment as you think?



Holistic life cycle assessment and understanding of consumer behavior vital components in understanding environmental impact of single use coffee pods.

In an effort to appeal to the modern consumer, companies are creating an increasing number of single-use products. These products may be more convenient, but consumers counter the convenience with concerns about the environmental impact of unnecessary plastic waste. One such conscious consumer is Professor Andrea Hicks of the civil and environmental engineering department at UW-Madison. Hicks' research looks into the popular alternative to the conventional method of brewing whole pots of coffee: the single-cup coffee pods.

In order to better understand the true environmental effects of these coffee pods, Hicks took up a life cycle assessment of the product as a side project. With the current pervasive negative view of any sort of single-use product, especially coffee pods, Hicks expected the worst. The results of the assessment, however, were surprisingly optimistic. When comparing the environmental impact of single-serve coffee pods to the conventional whole-pot brewing method, "it's actually about the same, depending on the environmental impact category... we're talking about a marginal difference," Hicks says.

Hicks obtained these results from a holistic assessment of a cup of coffee. This assessment looks into the cultivation of the beans, the use in coffee, and the eventual disposal of the pods - "very much a cradle to grave approach," according to Hicks. Between these phases, Hicks considered many factors such as ozone depletion, possibility of acidification, fossil fuel depletion, and CO2 gas emissions. Ultimately, "The biggest environmental impact to coffee is growing coffee and the energy to brew coffee," Hicks says. When comparing single-serve coffee pods with pot brewing, the resources used for growing the beans are nearly the same, so the focus of the assessments were on the use and disposal life phases.

Dr. Andrea Hicks changing the way we think about coffee consumption.

Perhaps the most obvious impact comes from the disposal stage of the product. For nearly all single-serve coffee pods, as with other packaging material, disposal means being sent to a landfill. Even conventional brewing is not waste-free, however, as it requires single-use coffee filters. Other alternatives for coffee brewing such as biodegradable coffee pods are in the works, but products such as these require a thorough life cycle assessment to truly understand their effects and not be blindly accepted as the most environmentally friendly option. The decomposition emissions, such as CO2 and methane gas, from these biodegradable pods can have just as much environmental impact as plastic cups in a landfill. While the plastics in coffee cups are technically recyclable, the amount that is recoverable and the likelihood of consumers properly cleaning and recycling them are both small. "At some point, the effort is too high to be economically or environmentally worthwhile," Hicks says. This is a prime example of the importance of life cycle assessments to truly understand the components of a product that are not as visible or obvious as others.

An example of the ambiguous visibility of these coffee pods comes in the "use" phase of single-serve pods, which bring with them an even greater environmental impact than disposal. "Energy consumption is a huge part of it," says Hicks, regarding the overall impact of coffee consumption. Both conventional pot brewing and single-serve brewing often require more energy than necessary. Consumers often leave full pots of coffee in the machine, leaving the heat plate on to keep the pot warm, which continuously uses energy. Other factors outside of how the consumer brews their coffee, such as where they get their energy (natural gas, solar, etc.) and where they live, can greatly influence the amount and impact of energy used to brew. As with the previous assessment, the single-serve pods do not come out much worse than conventional pot brewing.

Attempting to quantify exactly what goes into the consumption and disposal of any product diverges from strict scientific analysis, and the more subjective influence of the consumer must be taken into consideration. "There's a human component and a technology component," Hicks says. The purchasing, use, and eventual disposal of products all rely on the choices of the consumer. Understanding this inherent subjectivity and trying to comprehend and compensate for it is a constant consideration in life cycle assessment and any sort of product design produced by engineers.

The rebound effect is an especially important facet of consumer behavior when considering environmental impact. According to this phenomenon, there will be a reduction in expected gains from new efficient technologies, meaning that the savings in energy expected from any new product is often not the reality due to how it is used. In the context of coffee consumption, the single-serve brewing machine should see a significant decrease in energy usage as it is only used for a short time. However, the tendency to leave the machine plugged in nearly constantly offsets much of the anticipated savings.

With novel technologies being developed daily to make everyday life more convenient and environmentally friendly, it is both the responsibility of the engineer and the consumer to consider the potential effects of their repeated choices. "It's not just the product technology and it's not just the human behavior, it's somewhere in the middle of what people do with it," Hicks says. The most seemingly efficient technology is useless in practice if it is not assessed holistically to understand all impacts so it can be used more responsibly by the consumer.

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