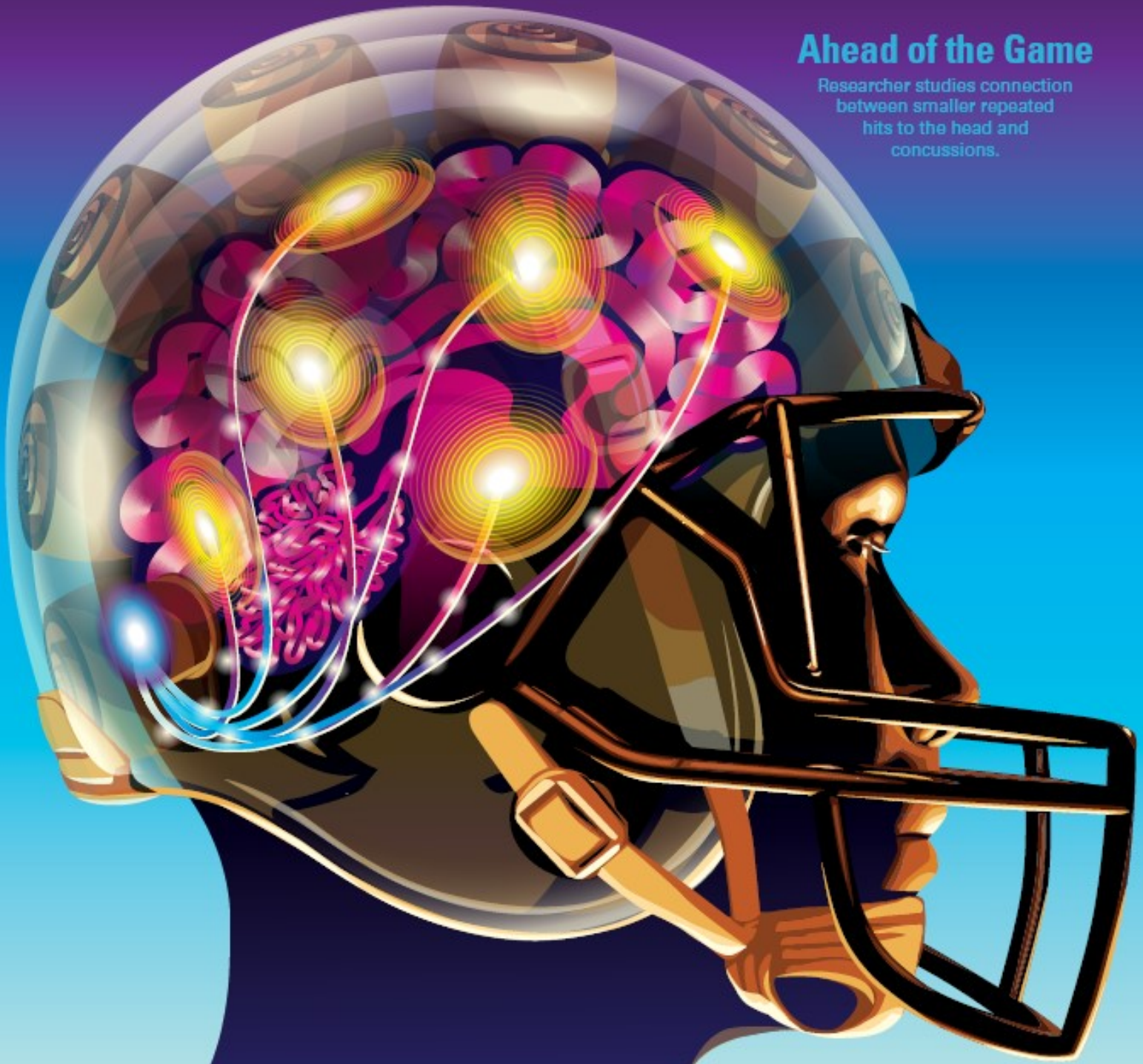
marquette engineer

OPUS COLLEGE OF ENGINEERING MAGAZINE **2019**



Ahead of the Game

Researcher studies connection between smaller repeated hits to the head and concussions.

Embracing Newness

Underrepresented high schoolers meet real-world engineering.

Gait Change

Dr. Gerald Harris takes orthopedic labs global.

Lift Off

Alumnus launches an industry to new heights.

marquette engineer
2019

Engineering superheroes

Each year, when I address the graduating class at Commencement, I like to connect my message to a current pop culture reference that will resonate with our young graduates. This year, it was none other than the blockbuster movie *The Avengers*.

What powerful message do the Avengers, a group of unique, superpower-wielding characters, have for our engineering students? Actually, these fictional characters are really just a reflection of us.

Our world is full of diverse people — people who look, think and act differently from us. Each person brings a unique skill, talent or superpower to the world, and only when we work together can those superpowers go on to make a real difference.

I asked our graduates: What is your superpower?

Maybe it is your insatiable curiosity that leads to groundbreaking research, like our biomedical engineering faculty who are bringing much-needed attention to concussion research (p.14).

Perhaps it is your ability to assemble groups of people for a common cause. For three engineering students, their superpowers combined to create 526 Pasta, a weekly gathering that brought together diverse groups of people, who might not normally mingle, to share a meal and build community (p. 2).

Or, your superpower might be compassion for those who really need superheroes, like Dr. Gerald Harris and his students who, for several years, have traveled the world to set up and operate gait labs in countries that lack the critical care needed for orthopedic patients (p. 18).

It gives me great pride to watch our students, alumni, faculty and staff use their superpowers each day to better our world. Our greatest superpower is our ability to love others, and as you read through the pages of this magazine, I hope you enjoy seeing the positive change we are making each and every day — at Marquette, in Milwaukee and beyond.

As engineers, our impact goes far beyond the technology we create, the buildings we construct or the devices we manufacture. We have the unique opportunity to think differently, act boldly and deliver real, meaningful change that can transform lives and communities.

What is your superpower?

Dr. Kristina Ropella
Opus Dean
Opus College of Engineering

Follow the dean on Twitter @DeanRopellaMU.

This issue of *Marquette Engineer* magazine is dedicated to the memory of Joseph DiGiovanni, Jour '87, 1965–2019. For the past four years, as a senior communication specialist at Marquette, Joe combined his remarkable gift for storytelling with his endless passion for Marquette to shine a light on what is best about the Opus College and the university. He will be forever in our hearts.

To read more about Joe, visit bit.ly/JoeTribute.

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OPUS College of Engineering
MARQUETTE UNIVERSITY

NOODLES WITH NEIGHBORS

By Gene Armas

Three mechanical engineering students hope their senior year "project" leaves a lasting impression at Marquette.

It's about building bridges — with friends, professors and anyone else in the Marquette community who wants to come over to their campus apartment on Friday nights to eat pasta.

But there's a twist.

Instead of lingering over linguine with the same friends every week, James McKenna, Chris Malliet and Phil Parisi set a goal to invite 526 different people to pasta night over the 2018–19 academic year.

Welcome to 526 Pasta, where guests arrive at 5:26 p.m., in apartment 526.

"It's super all-inclusive," Parisi says. "It's bringing everyone and everything together."

They started small, with Parisi and Malliet inviting a few friends to their apartment — No. 526 — early in the fall semester. McKenna lived down the hall. Some friends brought other friends. In a few weeks, they were making dinner for 20 guests. "It started to grow, and we thought, let's shoot for 526," Parisi says.

This is how it goes: Guests are invited personally by text and, upon arrival, add their names to a floor-to-ceiling sign-in sheet affixed to the wall. Returnees add a mark next to their name and pick up the pasta served on a paper plate in the kitchen. There are at least two pots of water boiling at all times. McKenna, Malliet and a good friend, mechanical engineering student Rachel Witt, handle the cooking. Then it's on to the common area — adorned with empty pasta boxes taped to the wall — to connect with friends old and new. The outgoing Parisi takes the lead as host.

The trio hosted more than 340 guests by spring. Then they got a last-minute boost to the count through a pasta night at the Annex during Senior Week, organized by Marquette President Michael R. Lovell, who was inspired to help out after partaking in pasta in April. "It's what Marquette is really about — that personal connection," Lovell says.

"We ended with 408 names on the wall," reports Parisi.

McKenna and Malliet graduated in May, and Parisi is in a co-op program this fall, so the heat was on to find someone to take the ladle to the next level. Courtney Tarnow, a senior in the Klingler College of Arts and Sciences, stepped up to the plates. She will get to work to meet the initial 526 Pasta goal of 526 guests. Once attained, she says, the next target is 844, Tarnow's house number.

From top right, clockwise: Founders James McKenna, Chris Malliet and Phil Parisi; Madeleine Mathias; Arts '19, and Bailey Bowe, Eau Claire, Wis.; President Michael R. Lovell; Ellie Hahn, Eng '19; students, faculty and President Lovell enjoy a 526 Pasta night; Lia Grandinetti, Arts and Sciences student.

CARE for a Precious Resource

Funding supports water research

Leveraging Opus College faculty research expertise, the Milwaukee Metropolitan Sewerage District is raising its game on addressing top issues affecting clean water resources, such as climate change, contaminant removal and green infrastructure effectiveness, with a $1.4 million investment in a program titled Water Coordinated Activities on Research for the Environment, or WaterCARE. MMSD is partnering with Dr. Daniel Zitomer, PE, chair and professor of civil, construction and environmental engineering, to seek annual proposals over the next four years from Marquette faculty members researching projects aimed at improving water resource reclamation and protecting the environment.

Proposals submitted last year resulted in four projects for the 2019–20 academic year, each with a unique perspective and plan for protecting vital water resources. One project, led by David Strifling, Eng '00, Law '04, adjunct professor of law and director of the Water Law and Policy Initiative, will investigate how well MMSD's own environmental objectives compare with similar Midwest utilities and explore whether the district is using currently accepted best practices to address climate change risks. In another study, Dr. Kyana Young is investigating the most effective methods to detect and treat contaminants such as pharmaceuticals and endocrine-disrupting compounds that may be found in some wastewater (see related story on p.12).

"MMSD's support enables Marquette researchers and educators the opportunity to work on practical solutions that will benefit the region and our society as a whole."

—Dr. Daniel Zitomer

Zitomer is conducting his own study to determine how wastewater solids can be pyrolyzed and transformed into clean, usable fertilizer through the application of high heat, as well as how renewable energy can be produced using the resulting waste byproducts. The fourth project, led by Dr. Anthony Parolari, assistant professor of civil, construction and environmental engineering, will determine how the buildup of road salt in cold-region green infrastructure, such as bioswales for stormwater management, may reduce their ability to effectively achieve treatment goals over time.

Zitomer anticipates issuing requests for proposals through 2022 for WaterCARE research projects, each of which lasts approximately one year, with budgets ranging from $10,000 to $100,000. Each project is conducted by a principal investigator working with graduate and undergraduate students.

The highly competitive program also gives students and professors the chance to be part of the decades-long, mutually beneficial and collaborative working relationship between Marquette and the district. "MMSD is a national leader in water resource protection. It's a great organization to work with," says Zitomer. "MMSD's support enables Marquette researchers and educators the opportunity to work on practical solutions that will benefit the region and our society as a whole." —JENNIFER ANDERSON

$1.4 MILLION //// 4 PROJECTS //// PROTECTING VITAL WATER RESOURCES

2019–20 ACADEMIC YEAR

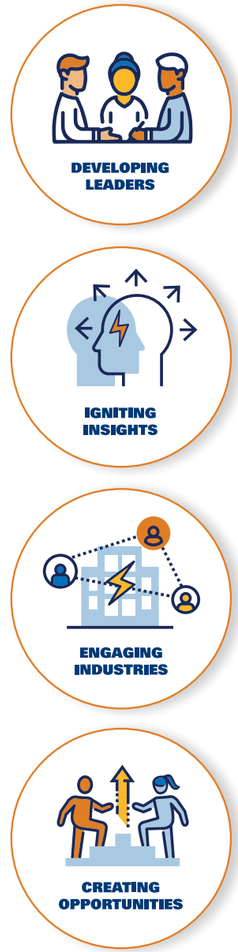
A Critical Spark

Innovation Alley update

Developed five years ago by Opus Dean Kristina Ropella, the Opus College of Engineering's nationally recognized, award-winning leadership development program, Engineers in the Lead, or E-Lead, got a significant boost from an inspired alumni couple. Chuck, Eng '89, and Karen, Eng '90, Swoboda have dedicated $1 million of a $2.5 million gift to immediately double the size of the three-year leadership program, which is supporting 20 engineering students and 20 students from disciplines across the university this fall (see related story on p. 28). The 40 students will begin as a cohort and a new set of 40 students will follow each additional year.

"While we often think of technology when discussing innovation, it is people who provide the critical spark that drives innovative thinking," Chuck says. "Marquette has a distinctive heritage when it comes to developing mission-driven, ethical leaders who work to find solutions to the world's most pressing problems."

Innovation Alley, initially introduced in Marquette's Campus Master Plan as a space for industry, students and faculty to work together to solve the world's greatest challenges, is evolving as it moves from ideation to development. While the vision includes a physical space in the future, it is forging ahead as a hub of creative programming, resources and partnerships to encourage innovation leadership and define the college's future. President Michael R. Lovell, Chuck Swoboda and Ropella hosted Innovation Alley visioning sessions with industry leaders from across the region in January.



"Without question, the number one theme that arose was developing an influx of innovation leaders," Ropella says. "Shaping our strategy around the people was a natural starting point for our Innovation Alley vision. Too often, leadership development is left up to chance. At Marquette, we feel called to intentionally and ethically prepare people to think and act differently and leave their manual at the door."

In addition to developing more leaders through the E-Lead program, Innovation Alley will focus on: igniting insights with a suite of thought-leadership practices including a podcast and faculty research; bringing together industry and academia to solve real-world problems; and creating opportunities for people of all backgrounds to participate in innovation. (These four initiatives are represented by the artwork at left.) The Opus College has launched a dedicated website that outlines its Innovation Alley vision. Visit **marquette.edu/innovation-alley** for more details.

Celebrate Engineers

Engineering Student Council ramped up E-Week activities in February with a blood drive, pancake breakfast, career fair, research forum and much more, and culminated the week with an Engineers Ball at Turner Hall in downtown Milwaukee. E-Week is part of a national celebration to honor the difference engineers make through their profession. Search "E-Week Marquette" on YouTube for a video created by the council members, some of whom are pictured here.

Teaming Up: Law and Engineering

To give students a general appreciation for how the legal and engineering disciplines interact to advance successful energy projects in Wisconsin, the Opus College and Marquette University Law School partnered this spring to offer law and engineering graduate students an Energy Law workshop. The two-credit course focused on the legal policy and technical framework for sustainable/renewable energy projects with special focus on Wisconsin. Jointly taught by Adjunct Professor of Law Arthur J. Harrington and Dr. Ayman EL-Refaie, Thomas H. and Suzanne M. Werner Endowed Chair in Secure and Renewable Energy Systems, the workshop provided a general overview of legal and technical considerations for emerging renewable technologies, such as biomass, geothermal, solar and wind projects. The workshop will be offered again in the 2019–20 academic year.

E-Lead Recognized

The Opus College's Engineers in the Lead program received the 2018 Inspiring Programs in STEM Award from *INSIGHT Into Diversity* magazine, the largest and oldest diversity and inclusion publication in higher education.

E-Lead, a three-year program focused on leading oneself, leading with others, and leading technology and innovation, received the award based on efforts to inspire and encourage a new generation of young people to consider careers in STEM through mentoring, teaching, research, and successful programs and initiatives. E-Lead was featured in the magazine's September 2018 issue.

Faculty Transitions

The following faculty and staff retired or were promoted to emeritus/a status in the past year: Dr. Ron Brown, Jessica Bulgrin, Dr. James Crovetti, Dr. Alex Drakopoulos, Deborah Epps, Pam Golanowski, Darlene Martins, Dr. Mark Nagurka, Dr. Barbara Silver-Thorn and Dr. Jack Winters.

Incoming faculty and staff for the 2018–19 academic year included: **Dr. Dinc Erdeniz** and **Dr. John Moore**, assistant professors of mechanical engineering; **Dr. Brandon Tefft**, assistant professor of biomedical engineering; **Dr. Dong Hye Ye**, assistant professor of electrical and computer engineering; **Dr. Jeffrey Starke**, executive director of Master's Across Boundaries; **Noelle Brigham**, Eng '97, Grad '99, and **Dana Cook**, Eng '06, professors of practice; **Steve Celichowski**, director of academic business affairs; **Kim Poehlman**, assistant to the dean; **Matt Curran**, KEEN project associate; and **Daniela Castillo**, Arts '14, office associate.

Virtual Collaboration

Meeting cancer patients' needs

A woman is seated calmly in a chair inside an exam room. The straps of a headset are fastened comfortably around her head, and her eyes are focused on a visual display. As the minutes pass, the woman "visits" several treatment rooms inside a clinical facility and learns from a virtual radiation oncologist about the process of receiving radiation therapy for her breast cancer. Although the patient continues to sit calmly in the chair, she feels as though she's lying on a table as a large machine rotates around her and administers radiation into her body.

This virtual reality simulation, complete with the "replica" doctor guiding her through the process, allows this breast cancer patient to experience what her treatment will be like before she undergoes it. It's one of the tools innovative Marquette engineers and Medical College of Wisconsin doctors are collaborating on to achieve the very best outcomes in health care.

Citing a 2012 study in *Patient Education and Counseling* that found clinically relevant levels of anxiety in some 45 percent of breast cancer patients, Marquette biomedical engineering graduate student Sophia Shanahan grounds her work for this virtual reality project on the importance of meeting patients' needs before they undergo treatment. "Even armed with brochures and standard 2D videos before their first treatments, the patient often faces a great deal of anxiety," she says. Immersing patients in a virtual reality scene may help alleviate their stress related to treatment.

"Our team can develop all of the technology we want, but without the clinical expertise, these would be merely theoretical projects."

—Dr. John LaDisa

Dr. Monica Shukla, assistant professor of radiation oncology at MCW, walks breast cancer patients through a virtual simulation of their radiation treatment.

Shanahan spearheaded the programming side of this project with mentor Chris Larkee, Marquette Visualization Lab (MARVL) visual technology specialist. Shanahan reflected on the evolution of virtual reality as a tool in medical technology: "There's so much potential for its medical and educational applications in the future," she says.

Equally involved are the experts at MCW, Drs. Monica Shukla and Carmen Bergom, assistant and associate professors of radiation oncology, respectively, and Dr. Melinda Stolley, professor in the Department of Medicine, who will assess the success of the project using psychological scales and measures. Individuals on both sides of the research acknowledge that neither Marquette nor MCW could execute a project such as this without the other. "There is real value in our joint program," notes Dr. John LaDisa, Eng '00, Grad '01, '04, associate professor of biomedical engineering. "Our team can develop all of the technology we want, but without the clinical expertise, these would be merely theoretical projects."

The team's next step is to conduct a clinical trial. "It is important to move the needle and ensure we are having the desired clinical outcome of reducing anxiety and improving treatment preparedness," adds LaDisa. —ANN CHRISTENSON, CJPA '90

Professional Distinctions

DR. JAY GOLDBERG

DR. MARK FEDERLE

Dr. Jay Goldberg, PE, clinical professor of biomedical engineering and director of the Marquette and Medical College of Wisconsin's Healthcare Technologies Management master's program, was elected fellow of the National Academy of Inventors, the highest professional distinction bestowed upon academic inventors who have improved quality of life, economic development and the welfare of society with their innovations. Before spearheading the master's program, Goldberg worked in a variety of medical device research and development roles. He holds six patents for urological devices.

Dr. Mark Federle, PE, associate dean for academic affairs and professor of civil, construction and environmental engineering, was inducted into the National Academy of Construction, an organization of industry leaders who have made lifelong contributions to the design, construction and engineering industries. Federle began the Construction Engineering program at Marquette in 2008 and became associate dean in 2013.

Influential Educator

Kate Trevey, Bus Ad '04, was recognized as one of the *Milwaukee Business Journal*'s 2019 Women of Influence. As the Opus College's director of engineering leadership programs, Trevey manages collegewide efforts to develop the leadership capacity of our engineering students, and also directs and teaches courses in the E-Lead program. The women chosen for this award are recognized for being "remarkable businesswomen." Trevey was selected within the Education Leadership category.

Doctoral Student Support

The Department of Electrical and Computer Engineering received a $597,000 grant from the U.S. Department of Education's Graduate Assistance in Areas of National Need Fellowship Program to support the financial and educational needs of doctoral students.

The three-year grant aims to increase the number of students who are prepared for, and motivated to, pursue careers in higher education and research in electrical engineering. The college has already begun to recruit students and is focusing on identifying fellows from underrepresented populations in engineering, such as women and minorities.

"This funding will allow our department to provide GAANN Fellows with a state-of-the-art doctoral research program in electrical and computer engineering," says principal investigator Dr. Edwin Yaz, PE, professor of electrical and computer engineering. "We will also offer extensive teaching and research experience through mentor-supervisor relationships and a special seminar in academic careers."

Drs. Fabien Josse, professor of electrical and computer engineering, and Susan Schneider, associate professor of electrical and computer engineering, are co-investigators of the grant.

$597,000 GRANT

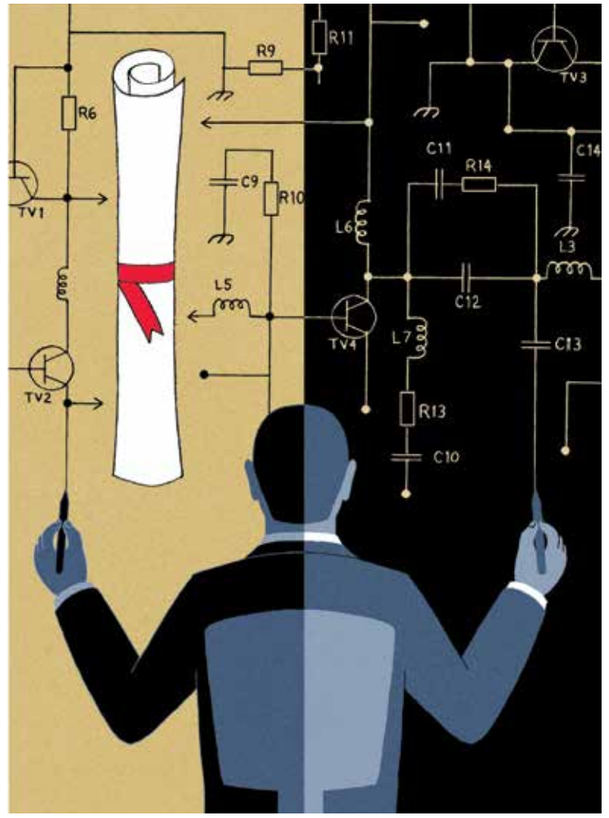
Grant Supports Image Accuracy Research

Dr. Taly Gilat-Schmidt, associate professor of biomedical engineering, has been awarded a four-year National Institutes of Health R01 grant for $1.4 million for a project titled "Spectral CT Metal Artifact Correction."

Radiation therapy treatment planning can be severely affected by the presence of metal objects such as implants and orthopedic hardware. Metal objects cause artifacts in CT images that obscure anatomical structures and alter the CT numbers important for radiation therapy planning and simulation. These uncertainties can cause underdosing of tumors and overdosing of healthy tissues. Gilat-Schmidt's project will develop a CT imaging method that uses spectral information to reduce metal artifacts while maintaining image accuracy and soft tissue contrast. Her collaborators include Dr. Emil Sidky, The University of Chicago, and the radiation oncology department at MCW.

Back to School

Graduate education evolves



As the Opus College completed year one of its five-year Master's Across Boundaries program to reimagine graduate engineering education including certificate, master's and doctoral studies, it launched its first new graduate certificate this fall. The 12-credit environmental engineering certificate is in response to the evolving needs of working engineers and offers a combination of face-to-face and online courses in a variety of topics, including air and water pollution, stormwater treatment technologies, and industrial water management.

Dr. Jeffrey Starke, hired as executive director of Master's Across Boundaries in 2018, has taken a holistic approach to understanding the needs of graduate education from the perspective of those in industry. He welcomed more than 30 industry partners to campus this spring to discuss how to shape new graduate program offerings tailored to practicing engineers. Part of the discussion included consideration of online and hybrid course offerings, certificate options and skill-set needs beyond the traditional notions of an engineering curriculum.

"Feedback from industry has been invaluable as we develop new graduate offerings that will be flexible and individualized for the practicing engineer's career goals," says Starke. "We want to know what skills they most value in their engineering workforce, and where we can partner to meet those needs."

Starke notes that while the desire to continue education is there, the time commitment and constraints of traditional graduate engineering programs can be limiting. He also learned that while managers find value in further technical education, they have an increasing need for essentials skills — such as leadership and communication — as they move their high-performers into management positions.

"We want to meet our students where they are at and equip them with the tools and experiences they need to move up in their careers and address global challenges," says Starke.

Supported by a $5 million GHR Foundation grant, the Master's Across Boundaries program also focuses on developing the graduate student's Ignatian mindset by integrating ethical studies to convey how the engineering profession can effectively serve others and work toward the greater good.

The college plans to launch additional certificate programs, including ones in machine learning and energy, for fall 2020. Noelle Brigham, PE, Eng '97, Grad '99, and Dana Cook, Eng '06, professors of practice, have joined the college's faculty to teach certificate courses.

—ALEXIS SCHLINDWEIN, COMM '13

"We want to meet our students where they are at and equip them with the tools and experiences they need to move up in their careers and address global challenges."

—Dr. Jeffrey Starke

Celebrating Our Distinguished Alumni

Distinguished Alumnus of the Year
Ramzi Y. Hermiz, Eng '87

With his passion for cars, Ramzi Hermiz found his "place" climbing the corporate ladder within the automotive industry. He serves as president and CEO of Shiloh Industries, an innovative solutions provider focusing on lightweighting technologies that provide environmental and safety benefits to the mobility market. Since joining the company in 2012, he has repositioned the once regional company into a global technology leader with locations throughout Asia, Europe and North America, and more than doubled its revenue to more than $1 billion annually.

Professional Achievement Award
John R. Hartnett, Eng '82

John Hartnett, executive vice president of Illinois Tool Works Inc., manages the company's global welding segment. He has held several managerial and executive positions over his impressive 39-year stint at the company. But as much as Hartnett enjoys managing, nothing compares to working with customers to pinpoint their problems and develop an innovated product that makes them more productive and successful.

"This year's honorees are true examples of servant leaders, using their Marquette education as a foundation to give back to their communities and use their engineering skills to make a difference in the world.

DR. KRISTINA ROPELLA
Opus Dean
Opus College of Engineering

Entrepreneurial Award
Craig A. Zoberis, Eng '90

Craig Zoberis is the founder and president of Fusion OEM, an original equipment manufacturer company in the Chicago area that produces more than 100 products — from simple assemblies of machined parts to complex electro-mechanical industrial machinery and electrical control panels. Zoberis takes pride in hiring for attitude over experience and providing a training matrix that allows employees to move up the pay scale as much as three or four times in a year. He does this to create a company culture of which people want to be a part, because a company is only as successful as its employees.

Service Award
Robert F. Sobczak, Eng '71, Grad '74

Rob Sobczak spent 14 years at GE Medical working on software and advanced technology product development. After leaving GE, he and his wife, Nancy, Eng '70, Grad '72, '07, founded SLY Air Racing and competed in the National Championship Air Races. After Nancy's passing, Rob established a fund in her name to support translational breast cancer research. He also wanted to honor her by giving back to the institution where they met, so he funded two endowed scholarships: one for men's basketball student-athletes and one for electrical engineering students. In 2017 he finalized a women's basketball scholarship and a women's chorus member scholarship, as well.

Young Alumna of the Year
Jennifer Moen Schneider, Eng '03, Grad '06

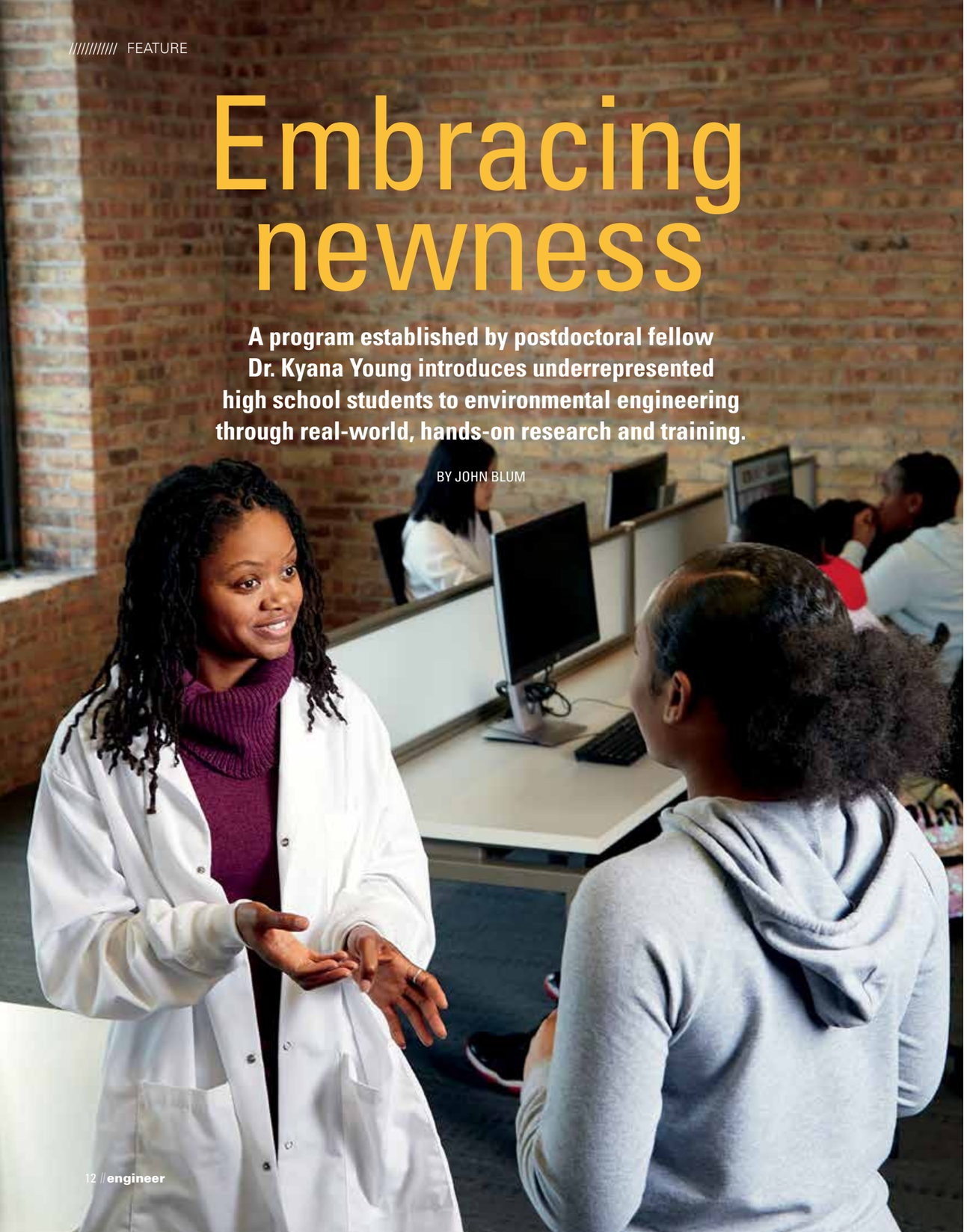
As the senior director of research and development for Titan Spine, Jen Schneider explores cutting-edge ways to set the firm's spinal implants apart from industry standards. Among the results: nanoLOCK®, the first cleared nanotechnology device for the spine that won the prestigious Whitecloud Award for Best Basic Science Research. She has also authored more than 30 peer-reviewed scientific papers and presents and holds 10 U.S. patents, along with a number of additional patents pending.

Nominate a deserving alumna/us for the 2020 Marquette University Alumni National Awards at marquette.edu/alumni/awards/nominate.php.

Embracing newness

A program established by postdoctoral fellow Dr. Kyana Young introduces underrepresented high school students to environmental engineering through real-world, hands-on research and training.

BY JOHN BLUM



During her three years as a postdoctoral fellow in environmental engineering at Marquette, Dr. Kyana Young seemed to have crossed disciplines by breaking the laws of physics: She could somehow be in more than one place at one time. On one Wednesday morning, about a dozen students from Milwaukee Marshall High School entered Marquette's Global Water Center lab and studiously dove into their research projects. Young scooted between groups, getting updates, offering advice, asking questions, consulting with the students' science teacher and partner mentors, and moving equipment. It was an incredibly active hour — and just a small moment in her incredibly active life at Marquette.

The high schoolers were here on a grant Young received from Marquette's Strategic Innovation Fund (now called the Explorer Challenge). The initiative, now in its third year, teams students from four Milwaukee high schools with mentors from corporate, nonprofit and governmental sponsors to complete original research for the sponsors' own real-world projects. Given Marquette's strengths in water-related issues, the research focuses on projects that mitigate contaminated drinking water.

These students are historically underrepresented in the field of environmental engineering. After Young's first few months in the Department of Civil, Construction and Environmental Engineering, she noticed that the demographics of the Global Water Center's researchers and tenants did not accurately reflect the city's demographics. With Marquette's *Beyond Boundaries* strategic plan serving as inspiration, she teamed up with Marshall faculty and Milwaukee Public Schools administrators to bridge that gap.

Providing a scientific and engineering context for these students is especially important to Young because her background mirrors many of theirs. "I was in my mid-20s before I even knew what an engineer was," she notes. Yet, she divided her time this past year between conducting Milwaukee Metropolitan Sewerage District-supported research comparing advanced oxidation processes in reducing pharmaceutical levels in wastewater, managing Marquette's lab space at the Global Water Center (a position backed by another Strategic Innovation Fund grant) and running the high school program.

So Young understands that, for the students she worked with, research is a brand-new experience, and an excellent opportunity. During 2018–19, the second year of the three-year grant, sponsors came from around the world, from the region and from the Global Water Center itself to partner with the students (see sidebar). A few students also worked on Marquette projects: assessing the health of the Kinnickinnic River with Dr. Krassimira Hristova, associate professor of biological sciences; and removing pharmaceuticals from drinking water with Opus College doctoral student Donald Ryan.

Besides creating a more robust pipeline for students pursuing water technology careers, the program raises awareness of water quality issues, which is particularly important since many of these students live in areas disproportionately affected by environmental and public health problems. Some of this awareness proliferates through students' year-end poster sessions when they present their work to peers, project sponsors, faculty and family. Young mentions, "I actually have had parents come in to see me who want to have discussions about water. I never thought that would happen. I thought students would do their research, go home and that's it. But it's much more."

Young was energized by "how many more students are embracing newness, new possibilities. Students told me, 'I never knew I could do that, but now I know I can.'" As an engineer herself, Young would certainly love everyone to pursue engineering careers, but she knows that won't be the case. "I'm so much more proud of them for allowing their experiences to expand, for what it means for them to have options."

Working with these student-researchers has made Young much more patient and a better listener, she says. Initially, she spent just one week training the students, but subsequently changed that to a month. According to Young, "Since this world was so new to the students, the additional time gave them a better base from which to work, which then led to better-run experiments." Young has also "learned how to advise students — to really listen and work with them — rather than just telling them what to do." These newfound personal skills allowed her to open up enough to share stories of her own research failures — important lessons to pass along since failure plays such an integral part of doing successful science.

As it turns out, as the students are learning to embrace newness, Young is doing much of the same: This fall, she joined the faculty of Wake Forest University's engineering department as an assistant professor. The high school program she initiated continues this academic year, managed by Marquette's Office of Research and Innovation.

Dr. Kyana Young, pictured left

Students are learning the scientific method the right way, which is also the hard way — by facing setbacks and then improvising solutions. Here's one example:

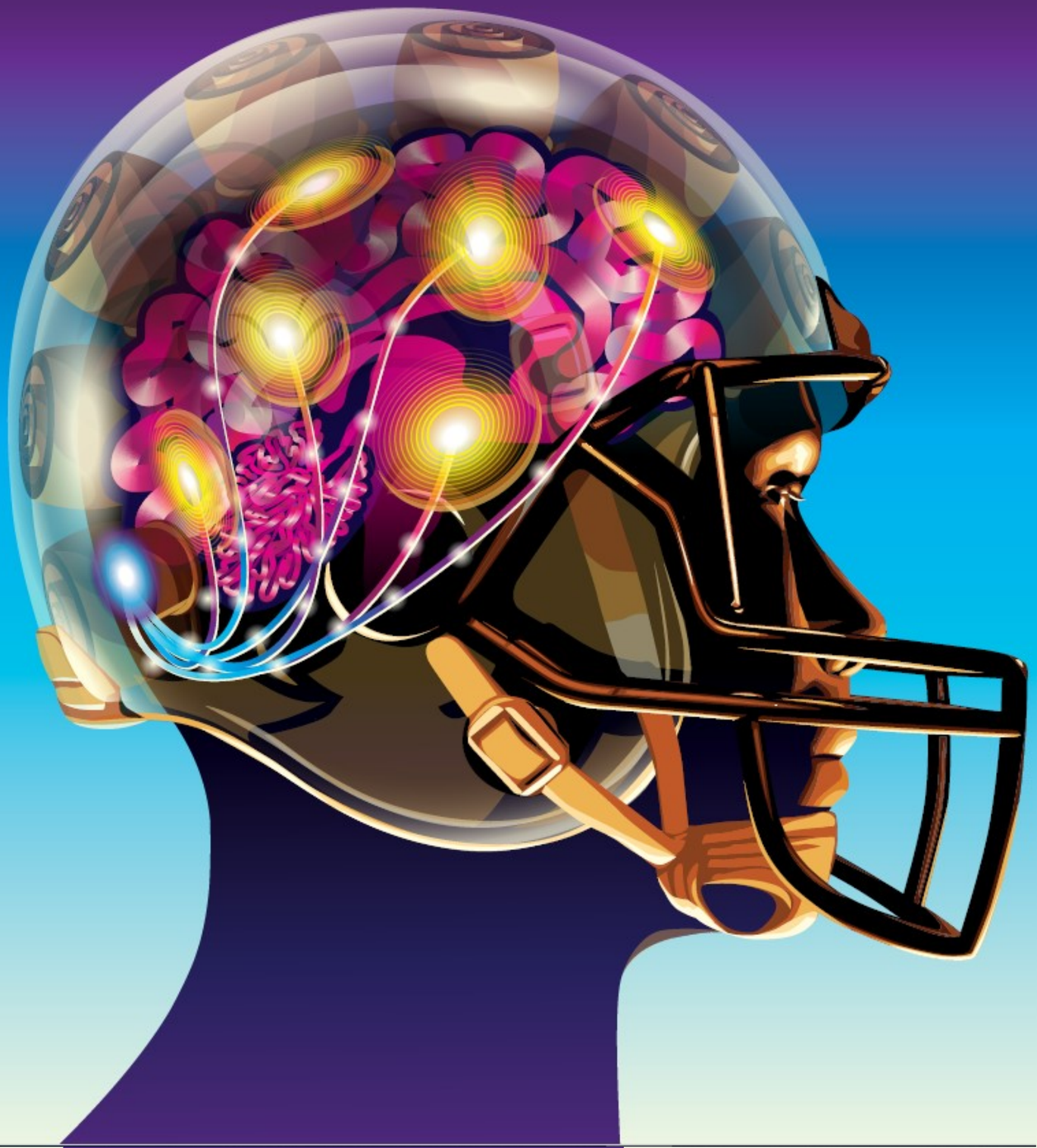
PROJECT:
Remove E. coli, total coliforms and arsenic using filtering media easily obtained in India

SPONSOR:
AG Care India; Kolkata, India

HIGH SCHOOL STUDENT:
Gerbrena Smith

SETBACKS:
Use of a single filtering medium did not work; water pump clogged.

SOLUTIONS:
A mélange of filtering media — sand, gravel, activated carbon — proved successful for E. coli and total coliforms, but not yet for arsenic; an electric water-pumping system was replaced with a gravity-based system.



BY ERIK GUNN

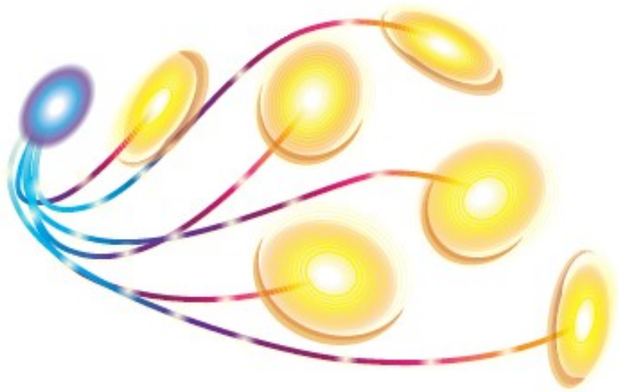
Biomedical engineering professor's research reveals repeated smaller hits to the head can add up to concussions.

Ahead of the Game

WITH A CRUNCH, two young men collide on the football field. One is sent sprawling, the game stops, and a trainer runs out to check the player on the ground. Briefly knocked out, he comes to. "I just got my bell rung," he says — but the impact was hard enough that he's taken out of play. A day later, a checkup finds he has some brief loss of balance, a ringing in his ears and a momentary gap in his memory.

For spectators, experienced athletes and even the health care professionals who treat them, that's what concussion looks and feels like. But associate professor in the Marquette University and Medical College of Wisconsin Department of Biomedical Engineering Dr. Brian Stemper has been on the trail of evidence that suggests dramatic incidents like that are only part of the picture.

Concussion, says Stemper, is showing up not just in athletes subjected to the most acute wallops in sports combat. Much less violent encounters can produce the same effects — if repeated often enough.



The repetition appears to be the key: The working hypothesis that Stemper, Grad '04, and his research team have developed is that a high number of blows to the head can lead to a concussion — even if none of those individual hits is hard enough by itself to cause a concussion.

Concussion is defined by cognitive changes; changes in the brain that might be observed with an MRI test; and, in some instances, emotional changes if they are correlated to exposure to blows to the head.

"A concussion is essentially an altered mental state from head impact," Stemper says.

Over the last decade, growing concern about the link between brain-damaging concussion and rough sports has thrown a spotlight on football all the way from the NFL to the youngest peewee leagues. The problem is genuine, says Stemper, but he also worries that it may have led to public overreaction. (His own adolescent sons play hockey, not football — and the oldest has already had a concussion on the ice.)

"Not every kid that plays football is going to get a concussion," he says. "Not every kid that gets a concussion is going to have lifelong consequences."

Concussion is also a lot more complicated than just getting hit on the head. The key is how the head rotates and accelerates after the blow. Head impacts in sports can occur in any direction but most often affect the front and side of the head. These impacts accelerate the head and cause it to rotate about the neck.

"It's a rotational acceleration of the head that causes the concussion," Stemper explains.

That's what led to his current line of study. A high-impact blow that causes the head to accelerate and produces a concussion has been long understood. "But we had a lot of concussions from low-impact acceleration," he adds.

To help understand why the cause of concussion varied so much, Stemper and his colleagues have spent years studying football players on high school and NCAA Division I and III college football teams, with portions of the research funded by the NCAA, Department of Defense, National Institutes of Health and the Department of Veterans Affairs. Participating teams wear specially equipped helmets lined on the inside with a half-dozen or so sensors about the size of a quarter. The sensors record every impact against the wearing player's head along with the head's subsequent movement. The sensors' data is then transmitted to a sideline receiver, which uploads it to an internet storage site.

For a study published last year, Stemper and his colleagues enlisted six NCAA Division I teams, whose players all used the sensor-lined helmets in the 2015, 2016 and 2017 seasons. The study tracked head impacts starting in spring practice through regular preseason training camp and regular season practice and play.

Of the 511 players in the study, 50 were found to have concussions over the three-year period. When those players were matched against teammates who played the same positions but did not have concussions, "between two-thirds and three-fourths of our concussed athletes had a high level of exposure" to repeated hits to the head compared with the control group, Stemper says.

Additionally, in more than half of the reported concussions, the players involved had only received head impacts that, according to standard biomechanics theory, would have had less than a 1 percent chance of causing injury, the researchers found.

Findings such as these have already been making their way into how college sports are run. For one thing, the research has shown that when it comes to blows to the head, "There's significantly higher daily exposure in preseason compared to the regular season," Stemper says. One obvious reason: Preseason practice is longer and more frequent.

Drawing on Stemper's research as well as that of others, the NCAA has established new rules aimed at reducing the risk of injury. Starting in 2017, the association eliminated two-a-day practices during the preseason. At first, with the number of daily practices cut in half, the NCAA allowed teams to extend the length of the preseason by maintaining the total number of practice sessions. That had an unintended consequence, though — actually increasing the exposure of student-athletes to the potential of getting hit in the head more often across the entire preseason. The next year, for the 2018–19 season, the length of the preseason was reduced, and head impact exposure was reduced as well, Stemper says.

There are other byways in the research Stemper does. For instance, he has worked on validating sensors similar to those used in football helmets but with a more compact and versatile format: an athletic mouthguard. That would allow the research to expand to other sports in which players don't wear helmets. It would also reduce the chance, he adds, that sensors embedded in football helmets might actually overstate the number and severity of head impacts, as improper helmet fit may allow sensors to record a head impact as the helmet moves without associated head movement.

Notwithstanding alarm in some corners about whether football is inherently hazardous, Stemper neither expects nor wants his research to shut the game down.

"What we're trying to do here is make football a safer sport," he says.

"A concussion is essentially an altered mental state from head impact."

—Dr. Brian Stemper

BRAIN TRUST

Researchers team up with Marquette student-athletes to better diagnose and treat concussions.

Imagine a gadget small enough to fit in an athletic trainer's bag, yet able to diagnose a concussion on the sidelines, moments after a rattled player leaves the field.

That's the long-range vision of an interdisciplinary team studying how concussion affects the brain's ability to adapt to meet the ever-changing and uncertain demands of skilled sensorimotor performance. The team consists of Marquette's Drs. Robert Scheidt and Leigh Ann Mrotek from biomedical engineering; Carolyn Smith, M.D., and A.J. Grove, M.D., from Marquette's Medical Clinic; and Dr. Jim Hoelzle from psychology; plus the Medical College of Wisconsin's Dr. Danny Thomas.

Dr. Robert Scheidt

Dr. Leigh Ann Mrotek

Consider how, while shooting baskets on a windy day, practiced players correct for the wind without thinking. "We adjust our throw as we see how much we miss," Scheidt, Eng '89, explains. "People can't tell you precisely how they adjust their movements to correct for errors. Fine adjustments happen at a subconscious level." How?

The answer: Sensorimotor memories of the last few shots guide sensorimotor adaptation — the intuitive adjustment to changing task demands. Scheidt's team is studying how concussion changes sensorimotor memory, altering the ability to adapt.

Partnering with Marquette Athletics, they're giving a sensorimotor test to concussion-free students (a control group) and to student-athletes who report a head injury and possible concussion. Concussed participants are tested within 24 hours of the injury, and then repeatedly over time to see how sensorimotor skills recover.

For the test, a person operates "a very boring video game," Mrotek says dryly. It's about the size of a kitchen appliance, a long way from fitting in a trainer's bag. The robotic control arm is programmed to produce resistance the player must accommodate to succeed. That's sensorimotor memory and adaptation at work, and after a concussion, they don't work as well.

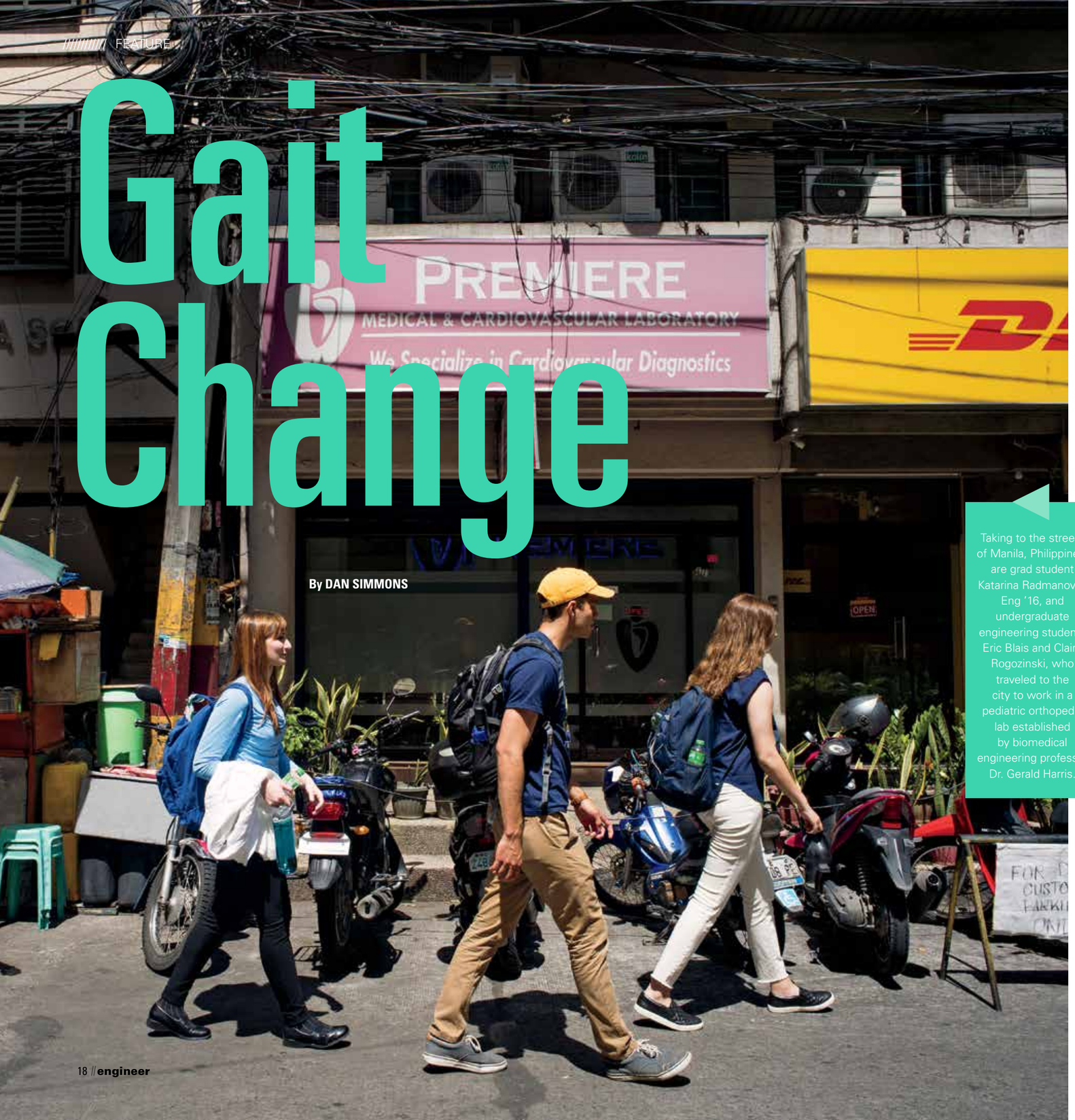
Among the test's benefits, the team sees one possibly unusual one. Mrotek points out that a small but significant number of athletes appear to deliberately underperform in other baseline brain-function tests. With a poor original score, they aim to obscure evidence of poorer performance after a concussion, so they can avoid diagnosis and return to play sooner. Scheidt and his colleagues believe their approach won't be misled that way.

Marquette's Strategic Innovation Fund paid for the team's initial research. The current phase is funded by a pilot grant from the university's Athletic and Human Performance Research Center, which supports innovative research aimed at improving athletic performance and recovery. The center's support "has allowed us to extend our work and really understand the capabilities of this approach," says Scheidt. The researchers expect larger studies to follow; scaling the technology down to pocket size and receiving regulatory approval will take more time.

—ERIK GUNN

Gait Change

By DAN SIMMONS



Taking to the streets of Manila, Philippines, are grad student Katarina Radmanovic, Eng '16, and undergraduate engineering students Eric Blais and Claire Rogozinski, who traveled to the city to work in a pediatric orthopedic lab established by biomedical engineering professor Dr. Gerald Harris.

Dr. Gerald Harris — with an eager team of student researchers — takes his gait analysis labs global to help fix children's orthopedic issues.

The 14-year-old girl's sweet face and slightly shy demeanor belied her circumstances. X-rays of her right leg told a different story, of pain and deformity. The tibia bone bent inward between the knee and ankle, at an angle so severe it looked like a flexed elbow. She had come to this clinic in Manila from a different Philippine province. The fracture happened when she was just 1, she explained to the medical team in her native Tagalog language, and her family lacked the money and resources to have it properly treated. Over time it bowed more and more, and the break point formed into a pseudo-joint. With age and weight gain, the pain grew worse.

Also in the room were Dr. Gerald Harris, PE, Grad '78, '81, professor of biomedical engineering and director of the Orthopaedic and Rehabilitation Engineering Center, who started this clinic in 2014, Dr. Jacob Rammer, Eng '09, Grad '15, '17, research assistant professor of biomedical engineering, plus a group of three Marquette students from their Global Mobility Outreach course, there as part of a service-learning trip. They got to practice skills and concepts learned in class in an extraordinary real-world setting.

"It provided us great practical experience working with surgeons and residents and others on the medical team," says Katarina Radmanovic, Eng '16, a third-year graduate student in biomechanical engineering. "But also, to be able to do it on the other side of the world in a completely different health care system, that was really cool."

Harris, who will retire from his teaching career in December, arrived at Marquette in 1987. His career spans a variety of classes and research interests — from gait analysis to bone and tissue characterization to total joint replacement and robotics. In recent years, he's turned his focus to the developing world, bringing first-world gait analysis labs to countries where his labs are often the only one of their kind. He and others who've joined the project install a runway of sorts, with cameras on the sides to capture muscle and joint movement in three dimensions, with a base plate below that provides useful feedback about force, torque and balance upon foot strike.

Sometimes, the patients are as young as 2 years old, with a variety of sensors attached to their bodies, and need parents to walk beside them for balance and reassurance. Most are a bit older, in kindergarten or early elementary grades.

The data provided by the human motion analysis lab helps doctors more effectively treat children with neuromuscular issues of all types, from cerebral palsy to clubfoot to

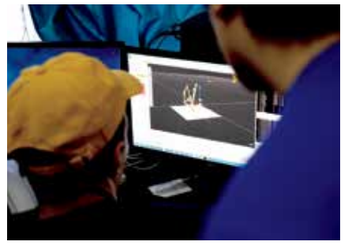
spina bifida. Recent upgrades in the software Harris' labs use have dramatically sped up the treatment process, cutting the time it takes to download and process useful data in half.

"By doing this, you're eliminating the birthday syndrome, where kids get a different surgery every year," Harris says. "There are lots of examples where surgeons will do something that's appropriate for a 6-year-old, but actually blows up by the time the child's 8 or 9. As they gain weight, their power-to-weight ratio changes. This system helps you avoid many of those errors."

He started the first such lab in Cali, Colombia, in 2012. His longtime friend and collaborator Dr. Peter Smith, an orthopedic surgeon, has been making twice yearly trips to a town near Cali as part of his Silver Service Children's Foundation. Smith and orthopedic colleagues perform surgery on 35 to 40 pediatric patients with orthopedic issues each trip. Harris had been refining his gait analysis system to be more accurate and less expensive for use in and around Milwaukee. But he got to thinking about expanding their horizons.

"I said, 'Peter, what do you think about us trying to put in a gait lab in Colombia to help you with your surgical decisions?'" Harris says. "He said, 'Yeah, why don't you come down and try it?'"

That first foray gave Harris and colleagues a chance to refine their methods and, through a lot of trial and error, establish a template that helped many children at little to no cost to them. And there was little reason it couldn't be repeated elsewhere, always in collaboration with orthopedic surgeons and their care teams.



"The engineer needs to know about the rehabilitative treatment and then the surgeon needs to know about the accuracies and inaccuracies of the motion analysis," Harris says. "What are the best planes of data and the worst?"

He's since opened clinics in Manila in 2014, Mexico City in 2016 and Mumbai, India, in 2019. A former postdoctoral fellow and current adjunct research professor Dr. Karla Bustamante started another lab in Chihuahua, Mexico. Harris is in talks to open labs in five new places: Hawaii, Uganda, Nepal, Argentina and a second India site in New Delhi.

"We're blessed that this is working out as well as it is," he says. "We're in this to help kids because the technology is very effective, and it's a great way to help a lot of kids who otherwise wouldn't get help."

A private donor has funded each of the labs, which typically cost about $60,000 for startup and about $12,000 in annual operating costs. Harris and Rammer, who recently accepted a new job at University of Wisconsin–Milwaukee, have worked to get the labs operational and visit periodically.

"We will set up a lab at no cost and support the lab to get them to be self-sufficient," Harris says.

Harris and Rammer brought the first group of Marquette students to Manila in 2018. The group oversaw the lab, with a dozen children going through a day, and also hosted a one-day clinic on a genetic disorder — osteogenesis imperfecta, or brittle bone disease — that's the focus of a research project headed by Harris. The students also helped to install a postural stability assessment program.

"It was a rigorous week," Harris says, "and they were exposed to all sorts of very interesting aspects of biomedical engineering, including surgery."

This year's students followed a similarly rigorous program, which included giving a summary presentation to the Filipino clinic staff. Biomedical engineering undergrads Eric Blais and Claire Rogozinski, along with Radmanovic, focused on the girl with the tibial malunion, or severely deformed lower right leg.

"That's just not something you really ever see in a developed country," says Radmanovic. In fact, it was an outlier for the Filipinos, too. "No one in the lab or hospital had ever seen anything like it," she says.

The students described how gait analysis identified how the leg deformity affected the girl's gait, caused one leg to grow longer than the other and generated pain and disordered functioning in her hips, knees, ankles and hamstrings. To remedy the issues, surgeons will break the pseudo-joint that's developed, then set the bones into alignment using metal pins and a metal halo-like device around the leg called an Ilizarov external fixator. The girl will be given a wrench, which she'll use to tighten the apparatus slightly each day.

"It will be fixed in three to five months," says Radmanovic, "which is pretty good given that severe of a fracture."

Radmanovic traveled twice as a Marquette undergraduate to New Orleans for service trips with student organization MARDI GRAS. The trip to Manila marked her first chance to combine her passion for biomechanical engineering with her desire to help people who can't otherwise access care. And it only grew her appreciation for Harris, her adviser.

"I can learn from him every day, not just in engineering but in how to be a more generous and giving person, which goes to the heart of these outreach labs," she says. "He really embodies Marquette's mission in all facets of life. I'm honored to work with him."

Opposite page: Harris' gait analysis systems are often introducing first-of-its-kind technology to a developing region. His systems give accurate and affordable diagnostic information to local surgeons who provide orthopedic care to children.

This page, from top: Therese Estrada, M.D., second-year Philippines General Hospital resident; from left, Joycie Abiera, M.D., residency director at PGH; Harris; and Carlo Sumpaico, M.D., pediatric orthopedic surgeon at PGH; from left, Edgardo Miguel Austria, M.D., first-year PGH resident; Rogozinski; Angela Dela Cruz, M.D., first-year PGH resident; Blais; Harris; Radmanovic; and Dr. Jacob Rammer; Rogozinski and Radmanovic explore the local fish market.

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HEALTH & HUMAN PERFORMANCE

DR. LEIGH ANN MROTEK
BIOMEDICAL ENGINEERING

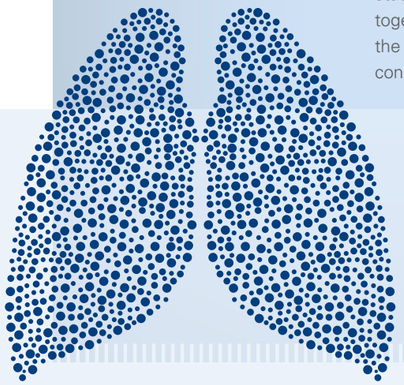
RELEARNING HOW TO MOVE

A few years back, tennis great Roger Federer reinvented his backhand to strengthen his game after a period of unsatisfying performances. It worked. But how did the competitor reteach his body to move differently after years of rehearsing the same movements? Dr. Leigh Ann Mrotek, research professor of biomedical engineering, is collaborating on a $406,266 National Science Foundation grant with Michigan State University assistant professor Dr. Rajiv Ranganathan and Dr. Maura Casadio, associate professor at the University of Genoa, Italy, to examine how people learn to perform a task differently than how they originally learned it.

Ranganathan is examining how well people can learn to perform a complex hand movement task and then relearn to perform the task under different conditions. At Marquette, Mrotek and Casadio are investigating how well violinists can execute a typical musical scale on a normal violin compared with a modified violin that requires the musician to play the same scale in a different order of movements. Faculty and students at all three universities will work together to test how well people can relearn the tasks depending on whether the new conditions are similar to or different from the original conditions; how long the person executed the original task; and whether practice conditions are different for the new condition.

"The expected findings will not only transform current theories of motor learning and movement rehabilitation, which largely ignore the existence and influence of prior coordination patterns," says Mrotek. "But the principles identified will also have broader implications for other fields of learning, like language acquisition, where prior learning has a critical influence."

Marquette is collaborating on this project and other related ones with the University of Genoa. Supported by a separate three-year NSF-IRES grant, students will prepare their research projects under the guidance of Marquette faculty, then travel to Italy to collect data and begin data analysis under the mentorship of the collaborating University of Genoa faculty. "The goal is to foster understanding of global health care issues and to cultivate the cultural competence required to develop biomedical engineering solutions to improve the health status of individuals around the world," says Mrotek.



breathe

In the U.S. alone, 75,000 deaths, 3.6 million hospital days and $5 billion in health care costs annually are attributed to severe cases of acute respiratory distress syndrome, or ARDS. Dr. Said Audi, Eng '88, Grad '90, '93, professor of biomedical engineering and director of graduate studies, was awarded a $378,335 grant from the National Institutes of Health to use clinical imaging and computational algorithms to detect and quantify changes in specific lung cellular targets during the progression and regression of ARDS. With this support, Audi expects to develop a clinical means for early detection of ARDS; new prognostic information for patients with mild ARDS; and an understanding of the role of a key cellular target in ARDS' progression and regression. Audi received the Opus College's 2019 Outstanding Researcher Award.

35,000+

The total square footage of the Clement J. Zablocki VA Medical Center's Neuroscience and Biomechanics Laboratories, which have been under the direction of Dr. Frank Pintar, Eng '82, Grad '86, since 1991. Pintar was named founding chair of the joint Marquette University and Medical College of Wisconsin Department of Biomedical Engineering in 2018. His most recent grants have focused on the physics of trauma to the human body, with a primary interest in head and spine injuries. His research derives engineering definitions of human tolerance to injury for the primary purpose of prevention, and the labs' findings have been used to define the safety design standards of today's automobiles, airplanes and military vehicles.

No. 3

Cervical cancer ranks as China's third most common cancer among women between the ages of 15 and 44, according to estimates from the Catalan Institute of Oncology/International Agency for Research on Cancer. Dr. Bing Yu, assistant professor of biomedical engineering, has developed SmartME, an affordable and portable microendoscope device on a smartphone platform, to revolutionize cervical cancer diagnoses in low- and middle-income countries. SmartME is expected to have a diagnostic accuracy better than those of benchtop diffuse reflectance spectroscopy (DRS) systems and high resolution microendoscopes (HRME) alone, and it can wirelessly transfer data to a remote server for processing, potentially returning results to the device within a minute or sooner. With a $300,000 grant from Smart Biophotonics LLC, Yu will conduct patient studies of SmartME in China this year.

DR. GUILHERME GARCIA
BIOMEDICAL ENGINEERING

PREVENTING AIRWAY COLLAPSE

Obstructive sleep apnea — a sleep disorder in which a person's breathing is briefly and repeatedly interrupted during sleep — affects between 2 and 7 percent of the adult population, according to a Wisconsin Sleep Cohort study. Caused when the airway fails to stay open, untreated sleep apnea can lead to serious health consequences, including chronic fatigue, hypertension, car accidents and even death.

Dr. Guilherme Garcia, assistant professor of biomedical engineering, is researching the biomechanics of upper airway collapse during obstructive sleep apnea. His team's goal is to quantify how mechanical stability of the upper airway is determined by a patient's anatomy and soft tissue properties. Their research includes computer simulations using 3D, anatomically accurate, patient-specific models built from MRI or CT scans.

Supported by a $200,000 Advancing a Healthier Wisconsin Endowment grant, Garcia's research is expected to help develop surgical techniques that are more effective at preventing airway collapse. "Also, if we can understand how the anatomic structure causing airway collapse correlates with airflow shapes recorded during a sleep study, we may be able to identify the anatomic structure causing airflow limitation," Garcia says. "This could help clinicians select individualized treatment for each patient."

Right now, identifying the site of airway collapse in patients with obstructive sleep apnea requires an endoscopy under sedation, an expensive exam that is not universally available. "If our research is successful, this could potentially reduce health care costs and help clinicians select more effective treatments," he adds.

WATER

DR. BROOKE MAYER
CIVIL, CONSTRUCTION AND ENVIRONMENTAL ENGINEERING

BACTERIA BUSTING

Elizabethkingia made headlines in the spring of 2016, when the bacteria strain was blamed for 66 confirmed infections and 18 deaths in southeastern Wisconsin, Illinois and Michigan. It was the largest documented *Elizabethkingia* outbreak in history. Samples from tap water, environments in common facilities and patient homes, and consumer products were all negative, and the outbreak source was never identified.

Elizabethkingia bacteria, commonly found in soil and water, typically pose little risk to human health. However, these bacteria also tend to exhibit a high degree of antibiotic resistance and mortality, according to Dr. Brooke Mayer, PE, associate professor of civil, construction and environmental engineering. Previous outbreaks in other regions provide evidence the bacteria can colonize sinks, pipes and aerators. "Given the emergence of this pathogen, recent serious outbreaks and evidence of bacterial colonization in plumbing, it's imperative that we develop a better understanding of how to effectively inactivate these bacteria in water environments," she says.

Armed with nearly $50,000 in funding from the National Science Foundation's RAPID program, which offers a mechanism for quick-response research on natural or anthropogenic disasters, Mayer and postdoctoral fellow Dr. Kyana Young studied the bacteria's response to common disinfectants, including free chlorine, chloramines, ozone and UV irradiation. Relative to reports for other bacteria, *Elizabethkingia* exhibited higher resistance to disinfection using free chlorine, ozone and UV.

"Of these strategies, ozonation most efficiently inactivated the bacteria and would be suitable for use in stemming waterborne outbreaks," says Young. "In comparison, chloramine disinfection was quite slow and is not recommended."

The pair's research results are of immediate interest as they contribute to deeper understanding of waterborne *Elizabethkingia* disinfection and could be used to avoid future public health disasters and limit outbreaks.

3D

Dr. Cris Ababei, assistant professor of electrical and computer engineering; Dr. Ronald Coutu, Jr., PE, V. Clayton Lafferty Endowed Chair in Electrical Engineering; and Mitchell Shreiner, Eng '19, teamed up to design and build a semi-autonomous underwater drone. Made from 3D-printed parts, a camera, video components, water sensors and more, the fully functioning vehicle is intended for water quality monitoring in pools, water treatment tanks, ponds and lakes.

"We hope this design will be adopted in educational and research settings, as it can serve as a platform to study 3D printing and mechanical design, embedded programming, controls, and wired and wireless communications," says Ababei. The project was supported by a William and Nancy Stemper Award.

3 fields + 1 lab

Engineering Hall's green roof, Marquette's Victory Garden and the stormwater treatment wetland below the 35th Street Viaduct are extending Dr. Anthony Parolari's research lab as he tries to identify whether such urban green spaces have a positive impact on water pollution. As investments in green infrastructure are growing, Parolari says it's vital to understand whether they create unintended consequences — such as nutrients running off into aquatic ecosystems. The assistant professor of civil, construction and environmental engineering is collecting data — via soil sensors that measure biogeochemical conditions and nutrient retention; soil and water samples collected during wet weather events; and resin bags capturing nutrient ions released by microbial activity in the soil — to determine the extent of nutrient retention in these systems. This data will be used to develop design recommendations to optimize retention and minimize harmful nutrient runoff. The Fund for Lake Michigan is supporting this yearlong project.

TRANSPORTATION & INFRASTRUCTURE

DR. JOHN BORG
MECHANICAL ENGINEERING

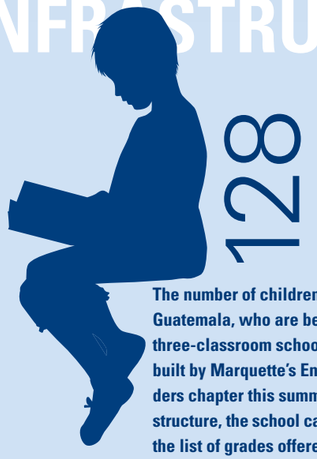
BLAST OFF

If hit by a blast or impact, explosives and propellants used in airbags, rockets, mining, munitions and other engineered systems can accidentally detonate. Dr. John Borg, PE, chair and professor of mechanical engineering, received a $1.5 million grant from the U.S. Air Force Office of Scientific Research to study the design and safety of materials that may be susceptible to accidental detonation.

The research is being done in Borg's Shock Physics Lab, where researchers investigate how condensed matter responds under extreme conditions. To test reactions, researchers use a gas gun with the capabilities to launch a 2-inch-diameter projectile down a 15-foot-long barrel at speeds of nearly 1,200 meters per second, or Mach 3, and measure thermodynamic response upon impact in a target tank via laser light.

For this project, Borg uses a surrogate system made of sugar and epoxy to imitate the substructure of explosive energetic systems. "The current perspective is that energetic systems are composed of both hard and soft components that create a pinch that stresses the material," Borg explains. "By mimicking these hard and soft materials with sugar and epoxy, we can run a series of tests to see how the system responds to differing stress loads."

X-rays, light and electron microscopy are used to image the sugar and epoxy substructure. Images are then imported as computer codes to simulate the dynamic response of the surrogate systems. The sugar and epoxy systems are subjected to shock and blast loads using the gas gun, and data collected from it will be compared with the imaging simulations to characterize how energetic materials can be modified to reduce accidental detonations.—Chris Jenkins



128

The number of children from El Aguacate, Guatemala, who are being taught in a new three-classroom schoolhouse designed and built by Marquette's Engineers Without Borders chapter this summer. Thanks to the new structure, the school can add kindergarten to the list of grades offered and now can accommodate an anticipated growth in students.

637,948

The number of heavy wheel passes applied to solar road panels at the Marquette University Heavy Vehicle Simulator. Dr. Ronald Coutu, Jr., PE, V. Clayton Lafferty Endowed Chair in Electrical Engineering, and Dr. James Crovetti, associate professor emeritus of civil, construction and environmental engineering, conducted this testing to validate the structural integrity and road worthiness of these panels as part of a research project sponsored by Solar Roadways Inc. and the Federal Highway Administration. This novel roadway material is intended to extend roadway replacement timelines, lower annual maintenance costs and provide energy to the power grid.

DR. AYMAN EL-REFAIE
ELECTRICAL AND COMPUTER ENGINEERING

HYBRIDS IN THE AIR

Marquette researcher Dr. Ayman EL-Refaie is partnering with The Ohio State University, University of Wisconsin–Madison and other universities in a NASA University Leadership Initiative to develop next-generation, high specific power electrical components to enable commercial hybrid propulsion for aerospace applications. EL-Refaie's team will concentrate on design aspects of motors and generators, with special attention to design challenges related to higher system voltage at altitude, winding design and thermal management.

EL-Refaie, the Thomas H. and Suzanne M. Werner Endowed Chair in Secure and Renewable Energy Systems, has focused his research on advanced electrical machines, advanced power electronic converters and their control, with special focus on transportation electrification and energy sustainability. "There is wide recognition that hybrid-electric systems can provide significant benefits for aerospace applications in terms of reducing fuel consumption, improving system efficiency and reliability," he says.

In this joint project, EL-Refaie's team is supporting the development of very lightweight motors/generators that can be used for MW-scale hybrid-electric propulsion systems for large commercial planes. The plane's propulsion is provided by both a jet engine as well as electric motors driving propellers (for a hybrid system) or only electric motors driving propellers (in case of electric propulsion) and covers a wide range of applications from drones to large commercial planes.

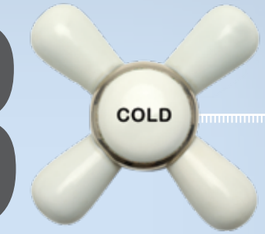
"Reducing the mass of the electrical components is critical in order to reap the benefits of the hybrid-electric system in aerospace applications," EL-Refaie says. "The specific power target for these electrical components is two to three times higher than what is currently state-of-the-art, and that is what we are trying to accomplish."

8,000+

To address complex, multidisciplinary discovery and innovation needs of more than 8,000 faculty and researchers, the National Science Foundation's Office of Advanced Cyberinfrastructure supports and coordinates the development, acquisition and provision of state-of-the-art cyberinfrastructure resources essential to advancing 21st century science and engineering research and education. This includes cyberinfrastructure technologies such as advanced computing, networks and services for computational and data-intensive research, which the NSF deems essential to sustaining U.S. economic competitiveness and national security.

Dr. Majeed Hayat, chair and professor of electrical and computer engineering, received $133,866 in NSF funds to develop a new approach to improving the performance of modern cyberinfrastructure systems by optimizing resource allocation based on advanced computational modeling and optimization of system performance. His research will enable software cyberinfrastructure, applications, and system architects to make effective end-to-end performance trade-offs, increasing the efficiency of important strategic computing systems.

CaCO3



Long-term deposit formation in water pipes affects the accuracy and reliability of flow meters. When new flow meters and their components are being tested before coming to market, determining how deposits affect them requires measurements over a long period. Dr. Florian Bender, research assistant professor of electrical and computer engineering, received $100,000 from Badger Meter to develop an accelerated test system that will speed the process of deposit formation in water pipes. "The system will be designed to permit varying the water temperature and adding specific ionic impurities to further control the nucleation process and promote rapid formation of either aragonite or calcite, the most common crystal forms of calcium carbonate deposits," Bender says. "It will allow for accelerated testing and development of flow meter systems and components that take deposit formation into account."

DR. HENRY MEDEIROS
ELECTRICAL AND COMPUTER ENGINEERING

A VISION OF THE FUTURE

As an undergrad research assistant using images to understand how bacteria colonies were populating in a petri dish, Dr. Henry Medeiros did not envision the dramatic progress that would take place in computer vision and image processing research in the years since. Now, as assistant professor of electrical and computer engineering, Medeiros is using similar techniques to develop computer vision applications for manufacturing, agriculture and security advancements.

One of his projects, supported with a three-year $299,930 grant from the National Institute of Standards and Technology, aims to measure the performance of a robotic manipulator mounted on an automated guided vehicle, or AGV. His team is investigating how accurately the robotic vision system can identify test points on a mapped artifact while both the AGV and manipulator simultaneously move. The machine-learning algorithms developed by Medeiros and his team are first evaluated in simulation and then executed on hardware, using both proof-of-concept models and industrial mobile manipulators. A motion capture system measures the performance of the robots during experiments. This robotic technology, currently used in space exploration and military operations, is being tested for use in manufacturing assembly.

"Computer vision research began 60 years ago, but in the first 50, progress was very slow," Medeiros says. With recent advances in machine learning, the field now is evolving at a much faster pace, and Medeiros thinks, "It's a great time to be a part of that." With even "more significant advances developing over the next decade," Medeiros' research seems to be surging with the technology tide.

Medeiros received the Helen Way Klingler Young Scholar Award from the university this spring.

LIFT OFF

By Brian Dorrington

After launching an industry to new heights, an entrepreneurial alumnus brings his innovator's spirit to the Opus College.

The decision to throw out the rule book and leave the manual in the dust came in an unceremonious, simple setting. Chuck Swoboda, Eng '89, then CEO of Cree Inc., sat across from his longtime colleague Neal Hunter at a small circular table.

It was time to go rogue.

For years, Swoboda said he envisioned that LED lighting was the way to illuminate the world. "For a long time, I tried to convert people and convince them that LED lighting was the future. Then, I realized that people are much better at embracing an idea that they can see," he says. "The first step in leadership is to start leading. You have to do something."

Swoboda and Hunter plotted their strategy. Hunter would lead a team of five people to pursue the holy grail of lighting — an LED light bulb — in a secret, off-site location. They'd do so for as long as it would take.

"When you run a business, you have processes, rules and boundaries — all things that make a business operate efficiently and predictably," Swoboda says. "But those same things were killing innovation. We needed a pirate ship, and we needed to give the team cover to break some rules.

"The challenge was: How do we get started? And the answer is: You start experimenting. You do some things that make people uncomfortable," he adds.

Day in and day out, the incognito team toiled, failed, persevered through countless prototypes and ultimately triumphed after nine months.

"I'd tell people we were never going to make a new light bulb because I didn't want it to be a distraction," Swoboda says.

On the day Cree announced its new invention, only a handful of people in the company even knew it was in the works. By letting the team work in secret, it created a powerful focus on the goal while avoiding the many distractions that could have derailed the project.

The results proved the courageous experiment was worth it, as the Cree LED bulb transformed the company and changed an industry.

Now retired from Cree, Swoboda will put some of his energy into encouraging another generation of innovative leaders. Serving as the university's first Innovator in Residence, he brings his innovator's spirit and entrepreneurial experience to the Opus College this fall to work with students and faculty alike.

Chuck and Karen Swoboda

Chuck and his wife, Karen, Eng '90, believe so much in the power of innovation and developing innovative leaders that they dedicated $1 million of a $2.5 million gift to launch Innovation Alley, a key academic priority that aligns with the university's strategic plan, *Beyond Boundaries*. (See Innovation Alley story on p.5).

"Chuck and Karen have been remarkable long-term supporters of Marquette and are living proof of alumni who … have gone on to truly Be The Difference," says Opus Dean Kristina Ropella. "Our students will benefit immensely from their generosity as well as from a proven CEO who embraces risk, sees change as opportunity and starts by developing each individual person."

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marquette.edu/innovation-alley