Notre Dame **Science**

The magazine of the College of Science at the University of Notre Dame

Spring 2018

COLLABORATE

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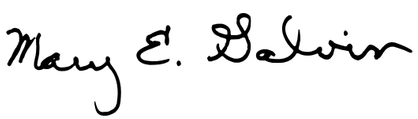
Collaboration fosters discovery, not only at the College of Science, but within all scientific endeavors. At Notre Dame, collaboration takes place in classes and labs, among students and with faculty. Together, graduate students and researchers solve fundamental scientific problems, and our faculty guide the process of learning and discovery while building partnerships with peers across the country and around the globe.

In this issue of Notre Dame Science we highlight the breadth and depth of collaborative research taking place. The Department of Applied and Computational Mathematics and Statistics (ACMS) has partnered with Athletics to provide data in an actionable format to help strength and conditioning coaches tailor training plans for individual athletes. Undergraduate ACMS students who are part of this collaboration are able to apply what they learn in class to real–world scenarios.

Collaborations happen in unexpected places, like a mile underground in an old mine in South Dakota, where physicists are studying the birth of stars. They happen among the University, industry partners, and NGOs, where each organization holds a key to answering an important scientific question. Some of the most fundamental scientific problems wouldn't be solved without these partnerships.

It is a privilege to be at Notre Dame and to be a part of the collaborations that are so key to scientific discovery.

Sincerely,



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Front cover photo:
Thomas Ueland, senior biological sciences major and soccer player, is at the intersection of science and sports. Photo by: Barbara Johnston

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IN THIS **ISSUE**

ALSO FIND US ON

Researchers create first low-energy particle accelerator beam underground in the United States

by Jessica Sieff

Nuclear astrophysicists successfully created the first low-energy particle accelerator beam deep underground in the United States, bringing them one step closer to understanding how the elements of our universe are built.

Through the project, called CASPAR (Compact Accelerator System for Performing Astrophysical Research), researchers will recreate the nuclear fusion processes responsible for energy generation and elemental production in stars to understand more about how stars burn and what elements they create while doing so.

CASPAR is one of only two underground accelerators in the world, located at the Sanford Underground Research Facility (SURF) in Lead, South Dakota.

The other, the Laboratory for Underground Nuclear Astrophysics (LUNA) is located in Italy, near Gran Sasso mountain.

"Installing and operating accelerators underground is a considerable challenge," said Michael Wiescher, Frank M. Freimann Professor of Physics at the University of Notre Dame. "CASPAR is unique since it covers a broader energy range than the LUNA accelerator. It allows us, for the first time, to explore reactions of stellar helium burning, which take place in stars like Betelgeuse, at laboratory conditions. Through these studies, we will learn about the origin of oxygen and carbon as the most important ingredients of biological life in the universe, and we will learn about the mechanisms stars have developed to produce gradually heavier elements through neutron fusion processes."

Wiescher and Research Assistant Professor Dan Robertson are leading the team from Notre Dame, working in collaboration with researchers from the South Dakota School of Mines and Technology and the Colorado School of Mines.

"The complexity of moving an accelerator facility deep underground is greatly outweighed by the potential benefits when recreating nuclear reactions of astrophysical interest," Robertson said. "Currently, a significant amount of the information we have about reactions that take place in the exact conditions inside a star can only be extrapolated from data in other energy ranges. This is mostly because the probability of that reaction is so small, and without a star's worth of material to play with, it is difficult to measure when competing with cosmic background. We hope to measure key reactions in elemental production scenarios directly, providing insights into their behavior and helping to understand how and where the material in our everyday lives was produced."

The 50-foot low-energy particle accelerator was assembled 4,850 feet underground in August 2015 and was transported in pieces from its original home at Notre Dame. Researchers loaded the pieces into a cage elevator and moved them to the experimental space in the former Homestake Gold Mine via mine trolley. Taking the project underground shields it from the cosmic radiation the Earth is exposed to on a constant basis, which can interfere with highly sensitive physics experiments.

"These kinds of studies need an environment free of cosmic rays as only provided at places like SURF," Wiescher said.

The nuclear fusion that takes place inside a star is what creates the elements that are necessary for life. Older stars, born around the time of the Big Bang, consist of very few elements, while younger stars include a buildup of heavier elements such as lead and gold.

Understanding that buildup of elements is just one of the many questions researchers hope to help answer through a series of CASPAR experiments.

With operations underway, the team plans to begin data collection in the fall.

CASPAR received funding from the National Science Foundation, the South Dakota Science and Technology Authority and the University of Notre Dame. For more on the history of the project, visit **nd.edu/features/caspar.**

The Nuclear Science Lab, led by Michael Wiescher, the Frank M. Freimann Professor of Physics, celebrated 80 years of excellence with a reunion of lab alumni held on campus in April 2018.

For more: isnap.nd.edu and search "80th".

80 NSL ANNIVERSARY 1938-2018

Solving the problem of drug-resistant malaria

The award of $11.5 million emphasizes the power of collaboration among three leading institutions focused on global health, genomics, and systems biology.

By Tammi Freehling

Michael Ferdig, Ph.D., is leading a new $11.5 million program project (P01) grant from the National Institutes of Health (NIH). Ferdig and his team are partnering with researchers at the Center for Infectious Disease Research (CID Research) in Seattle and Texas Biomedical Research Institute (TBRI) to better understand the genes in the malaria parasite that are responsible for drug resistance and virulence, in order to reduce and ultimately eliminate the often deadly disease.

Malaria is preventable and curable, and the widespread use of the drug artemisinin (ART) has been a key factor in significant reductions in infections and death. However, a recent rise in resistance to ART in Southeast Asia poses an imminent risk to ongoing global efforts to combat malaria.

To fight this, Ferdig, a professor in the Department of Biological Sciences and member of the Eck Institute for Global Health, and his collaborators have outlined an innovative approach to study the single-celled malaria parasite *P. falciparum*. Their project leverages their novel method for conducting experimental genetic crosses of the malaria parasite. A genetic cross is the result of breeding two different individuals, for instance, one parasite known for drug resistance and one known for drug sensitivity. The resulting offspring, individual siblings, inherit unique combinations of genes from each parent parasite, allowing researchers to identify the genes causing the drug resistance. This information can lead them to devise better methods to combat the parasite.

This new research collaboration utilizes genetically engineered mice with livers consisting of more than 90 percent human cells—for rapid and routine generation of large numbers of parasite progeny. In 2015, Ferdig and his CID Research colleagues, along with Tim Anderson and Ian Cheeseman at TBRI, published a paper in *Nature Methods* that established the proof of concept upon which this new grant award is based.

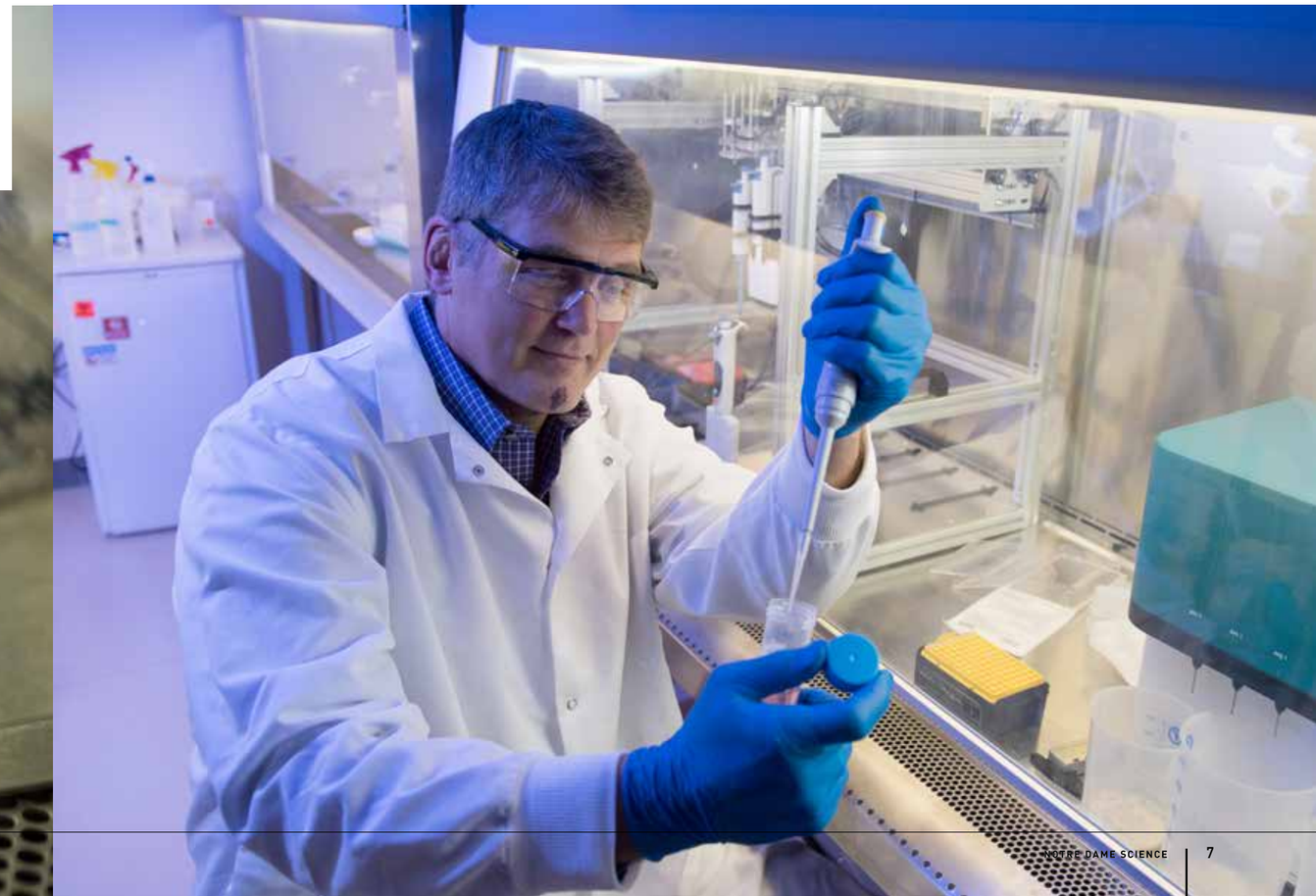
Now, for the first time, it will be possible to generate crosses rapidly from emerging malaria outbreaks. Ferdig explained, "This will allow us to speed the rate of discovery using genetic crosses by up to ten-fold—we've generated more genetic crosses in the past three years than were generated in the 30 years prior. This positions us to catch drug resistance as it is emerging so that we can devise ways to stop it in its tracks."

Ferdig, with expertise in integrated genetic analysis of malaria parasite crosses, has benefitted from another long-standing collaboration with researchers at TBRI, whose expertise lies in whole genome sequencing. The leadership of TBRI in evolutionary genomics of the malaria parasite provides connections to clinical cases of emerging drug resistance through collaborators in Southeast Asia.

The ultimate goal of this research program is to share methods, resources, and data with the broader malaria research community to enhance understanding of the genetic mechanisms of drug resistance and virulence. This effort will be enhanced by a Data Analysis Core centered at Notre Dame and led by Scott Emrich in Computer Science and Engineering. Regarding the collaboration, Mary E. Galvin, the William K. Warren Foundation Dean of the College of Science at the University of Notre Dame, said, "This team of three institutions is uniquely configured to redefine the landscape of malaria research and to discover new methods to stop the progression of multi-drug-resistant malaria." She added, "The award of this program project grant confirms the recognition of Notre Dame by the research community for its reputation as a leader in tropical disease research, and more recently, vector genomics. Professor Ferdig's leadership demonstrates Notre Dame's mission to advance knowledge in the search for truth and to be a force for good in the world."

This award is being issued by the NIH's National Institute of Allergy and Infectious Diseases, under grant number: 1P01AI127338-01A1. ■

Search "Ferdig" at science.nd.edu.



Bacterial survival strategy

Enzyme initiates repair of cell walls damaged by antibiotics

By Deanna Csomo McCool

Beta-lactam antibiotics, including penicillin, are the most widely used class of antibiotics in the world. Though they've been in use since the 1940s, scientists still don't fully understand what happens when this class of drugs encounters bacteria.

Now, researchers at the University of Notre Dame have elucidated how an enzyme helps bacteria rebound from damage inflicted by antibiotics not strong enough to immediately kill the bacteria on contact.

According to the study published April 9, 2018 in the Proceedings of the National Academy of Sciences, an enzyme in the bacterium *Pseudomonas aeruginosa* rapidly attempts to repair cell wall damage from certain antibiotics if those antibiotics aren't potent enough to immediately kill the bacteria. The repaired cell wall allows the bacterium to survive, and the infection to proceed unabated.

"It's a survival strategy," said Shahriar Mobashery, the Navari Family Professor in Life Sciences at the University of Notre Dame and the lead of the study. "The cell wall is the structural entity that encases the entire bacterium and its health is critical for the survival of the bacteria. If you have a drug that inflicts damage to the cell wall, the bacterium cannot cope with it, and it dies."

P. aeruginosa is one of the "nightmare bacteria" highlighted in a recent report from the Centers for Disease Control and Prevention. The report stated that lab tests had found "unusual resistance more than 200 times in 2017 in 'nightmare bacteria' alone."

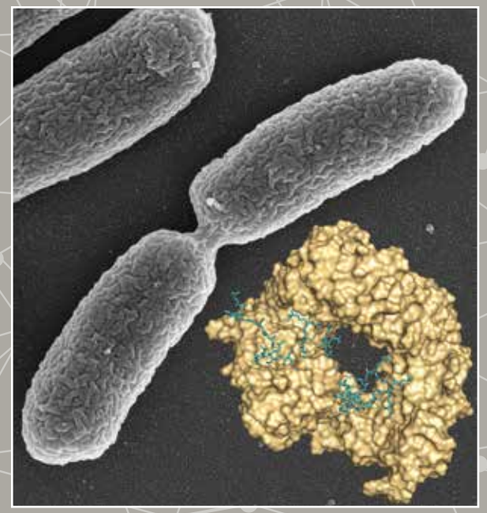
Mobashery collaborated with colleagues in the laboratory of Juan Hermoso of the Spanish Research Council in Madrid, Spain. Mobashery is also affiliated with Notre Dame's Advanced Diagnostics and Therapeutics, the Warren Family Research Center for Drug Discovery and Development and the Eck Institute for Global Health.

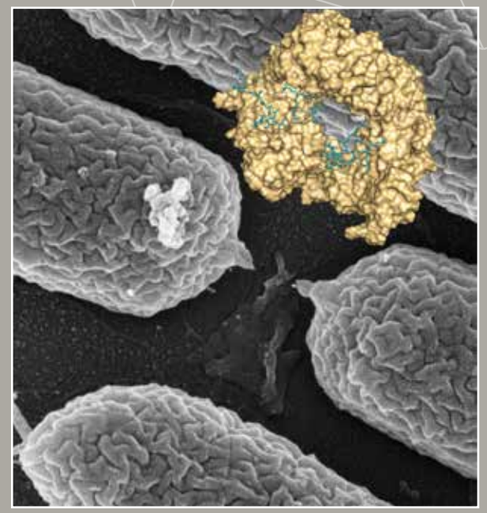
Cell walls are polymers made of many building blocks. In the bacterium *P. aeruginosa*, the wall is made of adjacent, long units that are linked together, or crosslinked. Mobashery's group studied how beta-lactam antibiotics prevent the crosslinking by inhibiting penicillin-binding proteins in the bacteria. Even though the crosslinks are not formed in the presence of the antibiotic, the long chains of polymers remain. These long chains of non-crosslinked polymers signal that the cell wall is damaged.

The enzyme Mobashery and his collaborators studied, the lytic transglycosylase Slt, recognizes the damage and quickly chops down the long chains, allowing the bacteria to fix the damage. Eventually the polymers in the cell wall are re-crosslinked. "It's sort of like if you're driving home tonight and get into a fender-bender, and by the time you get home, the car is already repaired," Mobashery said.

To reach their results, Mobashery's lab synthesized pieces of the cell wall, which they studied with Slt to determine how bacterial enzymes degrade it. They also sent purified Slt and cell-wall samples to collaborators at the Spanish Research Council. Researchers there grew the crystals and determined their structure in the presence of the cell-wall samples. The enzyme processes the cell wall by two types of reactions called the endolytic and exolytic reactions. This study sheds light on how these reactions take place en route to the repair process.

Mobashery has studied antibiotic resistance for 30 years. He said penicillin-binding proteins have been studied since the 1960s and lytic transglycosylases since the 1990s — but the issue of how they come together is new. Because of antibiotic resistance, this bacterium has become one of the most difficult bacterial pathogens to treat.





Co-authors of the study include Mijoon Lee, Shusuke Tomoshige, Kiran V. Mahasenan, David A. Dik, Dusan Hesek and Elena Lastochkin at Notre Dame, and Maria T. Batuecas, Teresa Dominguez-Gil, Claudia Millán, Isabel Usón and Juan A. Hermoso at the Spanish National Research Council.

The National Institutes of Health and the Spanish Ministry of Economy and Competitiveness funded the study. ■

Search "Mobashery" at science.nd.edu.

PROOF POSITIVE

Math Bunker provides tutoring, fellowship

By Deanna Csomo McCool

The Honors Calculus I and II courses are not for the faint of heart.

Even the class description serves as a warning: "This is not your high school Calculus course…whether you have had calculus or not, this course will challenge you in many ways."

"Honors Calc I my freshman year was the first class I remember taking where I didn't understand what was happening," said Caitlyn Booms, now a senior honors mathematics major who organizes volunteers for the Math Bunker, a tiny tutoring room inside the mathematics library in Hayes-Healy Hall. "That's a really difficult thing to go through, especially if you're going through it alone."

The Math Bunker tutoring program bridges that gap, serving students who want proof-based math tutoring and mentoring. Jeffrey Diller, professor and chair of the mathematics department, began the program to help retain students and facilitate connections among those in different years of study.

Almost all students who begin the honors math degree find themselves stumped during their first course and need to work as a group to brainstorm solutions to problems.

Two tutors, usually senior honor mathematics majors but sometimes juniors, staff the Bunker each night from Sunday through Thursday. The room is packed most nights with 10 to 15 students.

First-year honors mathematics students Kassandra Perez and Dillon Hasenour started attending during the fall semester. Perez quickly realized it was crucial to hear everyone's thoughts on how others tackled a problem.

"The tutors don't try to give you an answer but do try to guide you in the right direction," she said. "It's really helpful."


Caitlyn Booms


Dillon Hasenour


Kassandra Perez

The honors calculus material was different than any work Hasenour had done before. "We did the high school geometry, but this is not the same thing at all. For some problems you need to know little 'magic tricks' to pull out to finish the problem, so it's just really helpful to bounce ideas off other people."

The Math Bunker is a valuable place for tutors to share their own experiences with the honors mathematics program. Booms mentors students by assuring them that it's perfectly normal to not understand everything by the end of the course. She also reminds students that the learning curve for proof-based mathematics is steep, but once they can get over the hump, everything is easier.

Booms recently had coffee with a student who was concerned about the time she needed to put into the program—which is quite common. Fall classes usually average 30 students, and by the end of the year, perhaps only half remain.

"We talked for about an hour, and in the end I told her I've gone through the same thing," said Booms, who will be attending the University of Wisconsin-Madison to pursue her doctorate in mathematics. She said that tutoring at the Bunker expanded her horizons, as she found she loves both math and helping others.

The student decided to stick with the honors math major, but even if she hadn't, Booms said, "that's okay, because this is not for everyone…and that's totally okay."

Diller is pleased with the tutoring program and hopes to expand it. The students and tutors would love to see that happen as well.

"It wasn't anything I expected it would be, but it turned into such a friendly atmosphere," Hasenour said. ■

FIGHTING IRISH FIGHTING CANCER

By Brian Wallheimer and Tammi Freehling

While much is known about cancer, the networks of genetic and biological factors that contribute to the disease are complex. Making strides in cancer means putting emphasis on basic science that becomes the building blocks of downstream cancer research. Notre Dame scientists and engineers are building the foundational knowledge of the biological mechanisms associated with cancer and moving downstream with colleagues to use that information to develop new detection methods and therapeutics. This provides a sample of how the Fighting Irish are fighting cancer.

COLLEGE OF SCIENCE + COLLEGE OF ENGINEERING + NOTRE DAME RESEARCH

Brian Blagg
Charles L. Huisking Professor, Director of Warren Family Research Center for Drug Discovery and Development
Develops cancer chemotherapeutics that work on inhibiting proteins represented in all 10 hallmarks of cancer.

Brian Baker
Rev. John A. Zahm Professor and Department Chair
Focuses on immunotherapy, utilizing a diverse array of structural, biophysical, biochemical, and biological approaches to understand how molecules recognize targets.

Hsueh-Chia Chang
Bayer Corporation Professor of Engineering in the Department of Chemical and Biomolecular Engineering

Reginald Hill
Archibald Assistant Professor of Cancer Biology

Sharon Stack
Professor and Director of Harper Cancer Research Institute

Detects pancreatic and cervical cancer, cancers found in the head and neck, using lab-on-a-chip technology, which identifies microRNA in blood samples or saliva, offering quick, effective screenings for cancers that are difficult to detect at early stages.

Basar Bilgicer
Associate Professor, Chemical and Biomolecular Engineering and Chemistry and Biochemistry

Uses ligand-targeted liposomes, bubble-like particles that penetrate gaps in tumor tissue, to selectively deliver medication to cancer cells, leaving healthy tissues unharmed.

Tanyel Kiziltepe
Assistant Professional Specialist, Chemical and Biomolecular Engineering

Rich Taylor
Professor of Chemistry and Biochemistry
Works with polyketide natural products to develop new chemotherapeutic drugs. These drugs are derived from bacteria and are targeted to treat cancer and rare diseases.

Steven Buechler
Professor, Applied and Computational Mathematics and Statistics
Develops algorithms that sort through massive amounts of data to pinpoint molecular markers in cells that identify cancers that may need alternative forms of chemotherapy or no chemotherapy at all.

Crislyn D'Souza-Schorey
Morris Pollard Collegiate Professor of Biological Sciences and Department Chair
Investigates the mechanisms of epithelial glandular disruption as observed in ductal carcinomas and tumor invasion through the extracellular matrix.

Sylwia Ptasinska
Associate Professor of Physics
Studies the effectiveness of nitrogen atmospheric plasma jets for treating cancer.

Ryan Roeder
Professor, Department of Aerospace and Mechanical Engineering
Works on early detection of breast cancer. Develops gold nanoparticles that attach to indicators of cancer, making them visible on x-rays.

Matt Leevy
Research Associate Professor and Director of Biological Imaging for Notre Dame Integrated Imaging Facility (NDIIF)
Develops in-vivo imaging strategies to monitor the biological processes involved with metastasis.

Brad Smith
Emil T. Hoffman Professor and Director of Notre Dame Integrated Imaging Facility
Develops molecular imaging probes that detect dying cells to accelerate pre-clinical drug discovery and could help surgeons better remove cancer.

Siyuan Zhang
Nancy Dee Associate Professor of Cancer Research
Investigates the interaction between tumor and microenvironment at single cell level. Uncovers changes leading to tumor promotion to develop new therapies.

Xin Lu
John M. and Mary Jo Boler Assistant Professor
Studies prevalent cancers (prostate) and rare cancers (penile cancer and sarcoma). Uses integrated approaches centered on cancer genome mining and validation.

Athanasia Panopoulos
Elizabeth and Michael Gallagher Family Assistant Professor
Utilizes somatic cell reprogramming to provide new opportunities in targeted cancer therapeutics. Her work offers hope in the prevention of disease relapse.

Zachary Schafer
Coleman Foundation Associate Professor of Cancer Biology
Studies how cancer metastasizes, altering processes that often lead to death of cancer cells—regulation of this could control cancer's spread.

Laurie Littlepage
Campbell Family Assistant Professor of Cancer Research
Uses mouse models to study the environment surrounding cancer in the breast and prostate in an effort to create therapies that prevent or reverse the disease.

Connecting fields

ACMS and athletics collaboration benefits students in sports and science

By Deanna Csomo McCool

To someone who's not into math, the formula statistician Alan Huebner chalked on the blackboard in Hurley Hall could have looked like the formula to…well, anything.

But there's a clue in the graph he drew adjacent to it, with "performance" labeled on the Y axis and "day" on the X. Data from an athlete's training schedule can be added to the formula, then plotted on a graph. The results can show an athlete when to begin to taper down before a race or competition.

Yes, of course there's math for that.

"A big way people fall in love with statistics is through sports," said Jaihee Choi, a junior majoring in applied and computational mathematics and statistics (ACMS), with an economics supplementary major. And while not all athletes fall in love with statistics, knowing their own (or those of their team) can be a guiding force on and off the field.

Student athletes at Notre Dame have been training for peak performance since the days of Knute Rockne. But now, the University's 750 athletes have the backing of technology and data science, thanks to a recently established endowment that pays the salaries for two ACMS students who develop real-world experience while providing concrete tools that will help athletes, too.

The Mastrovich Endowment for Excellence for Sports Science funds the collaboration between Huebner, associate teaching professor and director of undergraduate studies in ACMS, and Jordan Webb, head of sports science and associate strength and conditioning coach for the Department of Athletics.

"The information we collect will help across the board in enhancing student athlete performance and well-being, including identifying individuals at risk for injury," Huebner said. "Jordan and the team are building infrastructure to store and collect the data so that results can be obtained very quickly and easily and be used by coaches to have insight into practice, training, games, and recruiting."

Myriad fields of data have been collected through the years from the University's sports fields. Choi and Dominic Angelotti, a senior ACMS major, started tackling the tangle of statistics during the summer of 2017.

The data were gleaned from on-body GPS, 3-D motion capture in the training room, game statistics, and injuries. Student athletes in several sports also fill out daily surveys indicating areas of soreness, hours of sleep, academic workload, and stress levels.

"We want to know how (athletes) perform on a daily basis; academics as well," Webb said. "We want to make sure we provide a positive experience at Notre Dame, whatever that may be for that player."

During August 2017, the University's student athletes funneled into the Edmund P. Joyce Center, where they were photographed by a bevy of cameras surrounding them as they jumped, stretched, and twisted in front of green screens. Webb and other coaches called out specific moves: "Jump as high as you can! Put your arms above your head and extend them back as far as they'll go! Now jump off the box into a squat!"

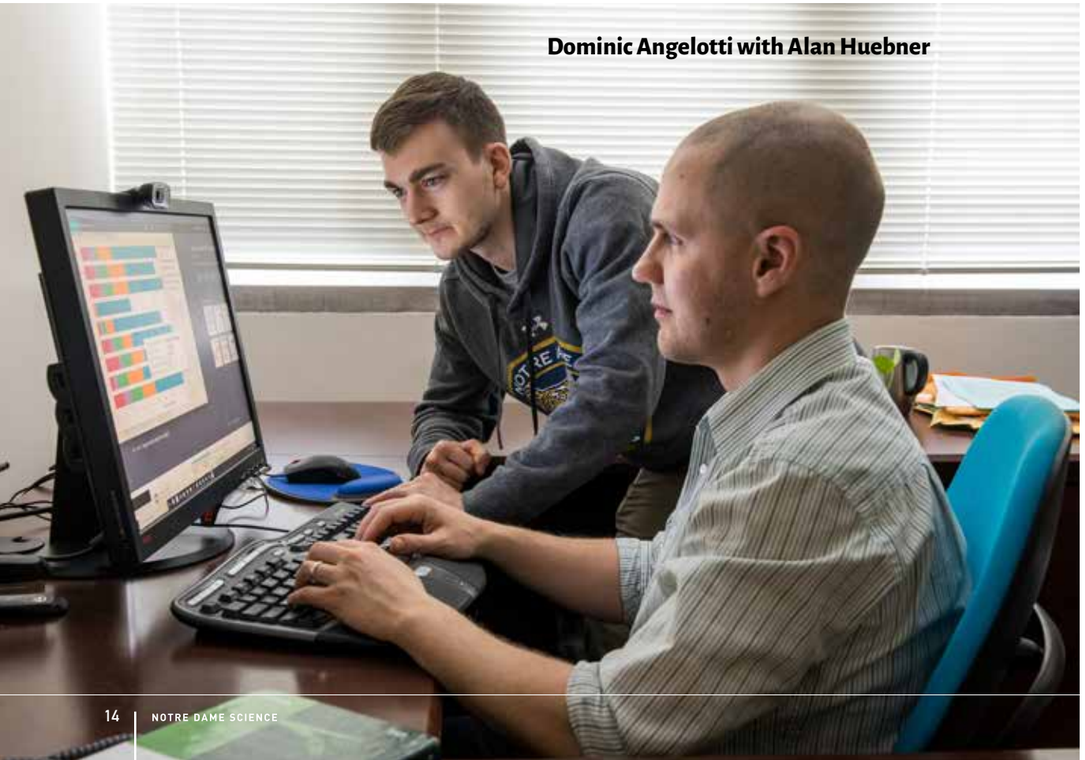
The system captured the biomechanics of the athlete's movements, displaying simple animations on computer screens along with data recorded from the angles, speed and forces they generated. The information can spotlight any deficiencies that could impact the athletes' performance.

After "cleaning" all the data through software and presenting the statistics in a visual format like a chart or bar graph, the information is vastly more accessible to non-statisticians than a mish-mash of numbers can ever be, Angelotti described.

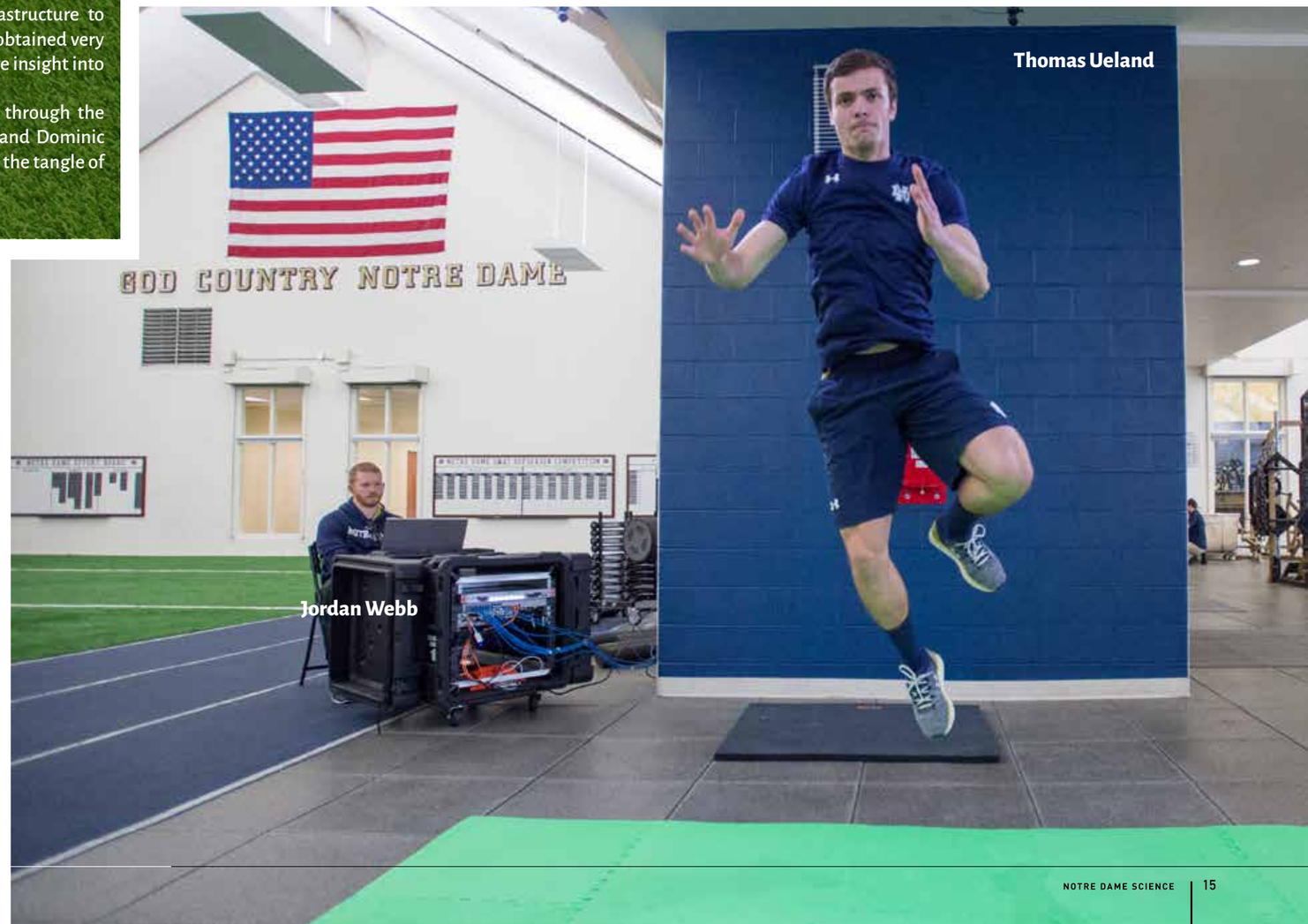
Junior neuroscience major Anna Rohrer, a runner, was pleased when she learned the results from her motion sensor capture would be used to guide her team's strength and conditioning regimen.

"Distance runners tend to be very weak in the hips and glutes, and if you don't strengthen your small weaknesses, then over time they add up to big things, and that's how you get hurt," she said.

And if athletes don't use the ▶

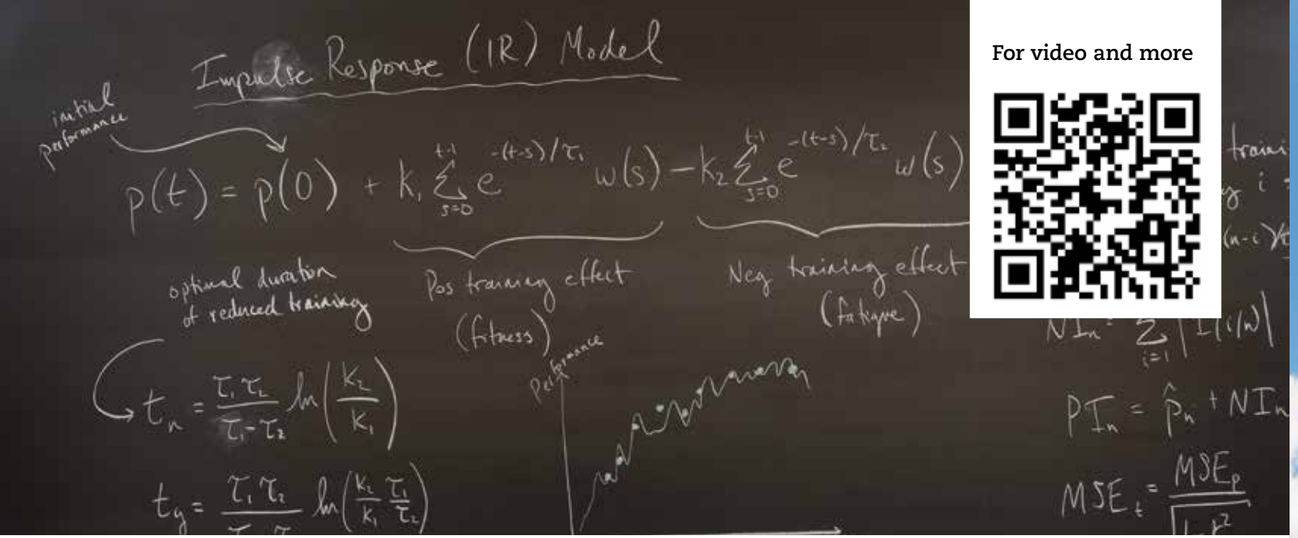


Dominic Angelotti with Alan Huebner



Thomas Ueland

Jordan Webb



For video and more

correct muscles for a specific move, the wrong muscles compensate and can lead to injury. That's potentially why soccer player Thomas Ueland, a senior majoring in biological sciences who plans to attend medical school, pulled his hamstring during the spring of his sophomore year. His biomechanical statistics proved that he uses his quadriceps more than his hamstrings.

"Because of that, I've been working a lot more on strengthening those areas," he said. "I like that the information we get now is highly individualized, and it's not just about strength or whether you can jump higher. It's leading to training that keeps you on the field."

For Choi and Angelotti, the experience to work on sports statistics has its own rewards. Having access to raw data is crucial as students move from the classroom to real-world jobs or graduate school.

"I can take a class where we test sample data sets, but you know you're going to get nice outputs," said Angelotti, who will pursue his master's in ACMS at Notre Dame in the fall. "With this data, I have to see how I can fit in things that aren't going to be laid out nice and pretty for the task that I want to do."

Although Ueland doesn't yet know what specialty he'll practice as a physician, he appreciates the collaboration because it showed how he can merge his passions for academics and sports. "Using data in the future to prevent injuries and maximize recovery and performance was a cool connection I never made before coming to Notre Dame," he said.

Mastrovich Endowment for Excellence for Sports Science founders Larry and Giovanna Mastrovich are the parents of two Notre Dame graduates, David Mastrovich ('14) and Zach Mastrovich ('17). Zach Mastrovich graduated with a bachelor of science degree in ACMS. Larry Mastrovich is a member of the College of Science Advisory Council. ■

Data science with heart

By Deanna Csomo McCool

Combining Notre Dame's mission to be a force for good with great data science, the inaugural year of the University's online Master of Science in Data Science program began with a lecture from one of the world's most prominent data scientists.

Hadley Wickham, chief scientist at RStudio and an adjunct professor of statistics at the University of Auckland, Stanford University, and Rice University, was the perfect speaker to kick off the program, said Director Roger Woodard.

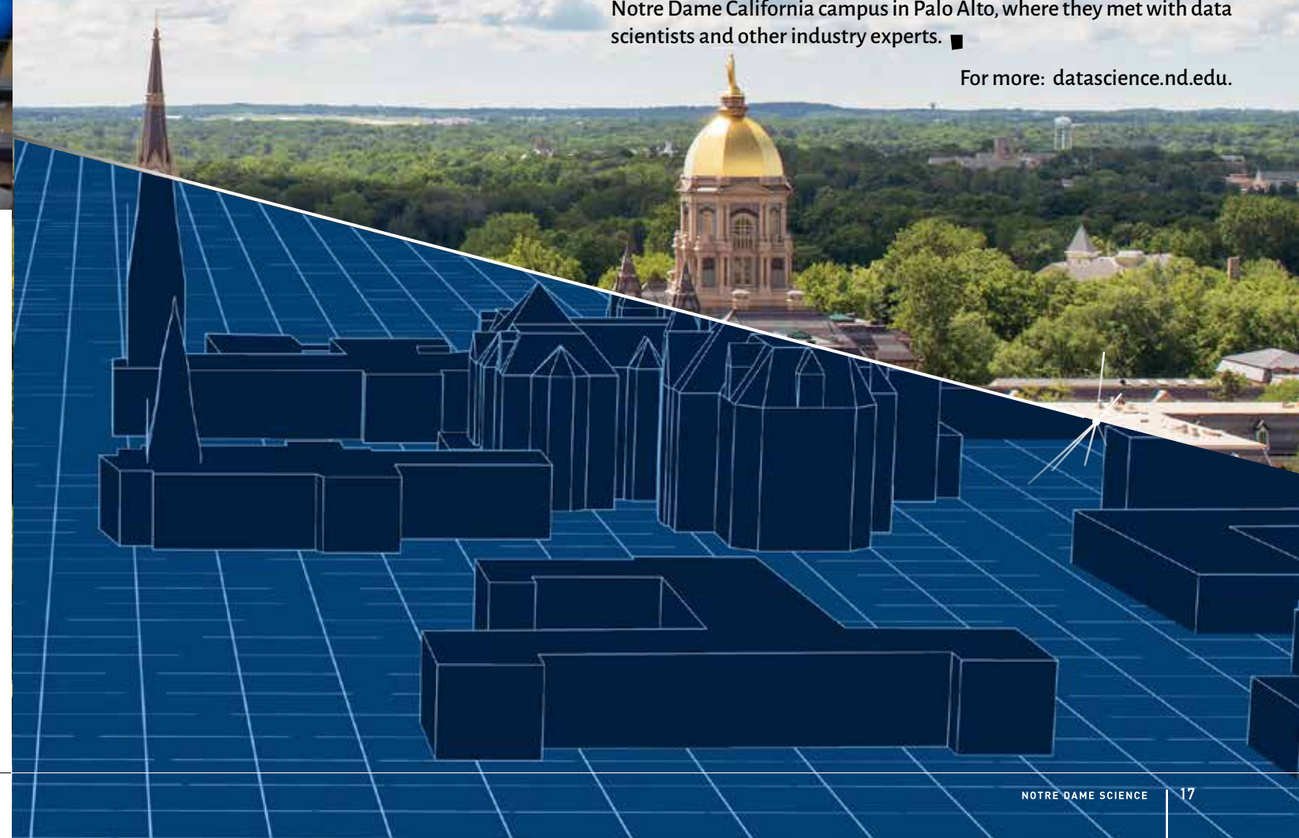
"Not only are we doing great data science—technical stuff—but we also focus on doing things that align with Notre Dame's mission. We make sure that we concentrate on the ethical use of data science," Woodard said. "We are trying to do things that are good for the community."

The half-time, 21-month degree program is completed mostly online through a custom-built digital platform that incorporates a social aspect to online learning. Offered by the Department of Applied and Computational Mathematics and Statistics (ACMS), the program also includes in-person immersion weekends like the one at which Wickham spoke. Notre Dame faculty from ACMS, psychology, computer science and engineering, and the Mendoza College of Business teach the courses.

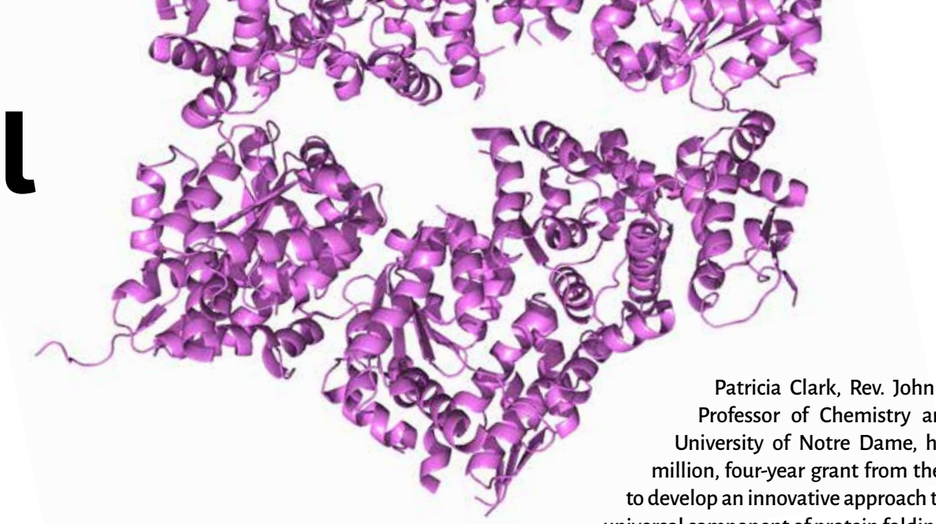
Wickham developed several packages that extend the usefulness of the R language, a type of statistics software computing system. He said he's impressed with the structure of the master's program. "Notre Dame really thought about it and developed the courses well," he said.

Some of the program's 35 students gathered in January at the Notre Dame California campus in Palo Alto, where they met with data scientists and other industry experts. ■

For more: datascience.nd.edu.



Fundamental forces



New biophysics program advances biomedical research

By Deanna Csomo McCool

Biophysicists study life at every level—from atoms, molecules, and cells to organisms and environments. Understanding the interconnectedness of biology and physics has become essential to scientific research.

The University's new Stavropoulos Center for Interdisciplinary Biophysics unites expertise across many departments under a shared commitment to understand the fundamental processes that underlie biological functions.

Directed by Patricia Clark, O'Hara, C.S.C., Professor of Chemistry and Biochemistry, the graduate program was developed to attract a cluster of elite research talent to the University.

"This field of knowledge is crucial as we seek to explore the physical principles of biology and make advancements in human health," said Mary Galvin, William K. Warren Foundation Dean of the College of Science.

The William and Linda Stavropoulos Family Foundation donated $10 million in 2016 to create the center, which links departments in the College of Science and College of Engineering. Students work with several other Notre Dame interdisciplinary centers and institutes including the Radiation Laboratory, Warren Family Research Center for Drug Discovery and Development, and others. They collaborate with biophysics faculty, postdoctoral students, and other graduate students in all areas of biomedical research.

Bill Stavropoulos has served on the College of Science Advisory Council since 1988 and was chairman and CEO at The Dow Chemical Company. Linda Stavropoulos, a former teacher, serves as president of the William and Linda Stavropoulos Family Foundation. Their two children, Bill and Angela, are both Notre Dame graduates. ■

For more: biophysics.nd.edu

Biophysicist Patricia Clark awarded $1.1M Keck grant for protein folding study

By Deanna Csomo McCool

Patricia Clark, Rev. John Cardinal O'Hara, C.S.C., Professor of Chemistry and Biochemistry at the University of Notre Dame, has been awarded a $1.1 million, four-year grant from the W. M. Keck Foundation to develop an innovative approach to replicate in test tubes a universal component of protein folding within cells.

Results from this medical research grant could shed new light on how deadly bacterial infections spread.

Clark and her colleagues, including Masaru Kuno, professor in the Department of Chemistry and Biochemistry, will exploit a new technology to tackle the complex folding mechanisms of autotransporter proteins, which are proteins with properties that help them cross bacterial membrane systems. Autotransporter proteins contribute to infections from bacteria such as *E. coli* and *Salmonella*.

"I am deeply grateful to the Keck Foundation for their support of highly innovative, paradigm-breaking research projects," Clark said. "This high level of innovation is necessary to break through the technical barriers that constrain our current understanding of protein folding."

Proteins are long chains of amino acids that fold into specific three-dimensional structures, giving them their active shapes and determining their interactions with other molecules in the cell. Protein folding has been studied in test tubes for more than 70 years, but the folding process is different inside cells. In the cell, proteins fold from one end to the other as they are synthesized or transported across a membrane. Currently, there is no way to replicate this "vectorial" folding mechanism in the test tube.

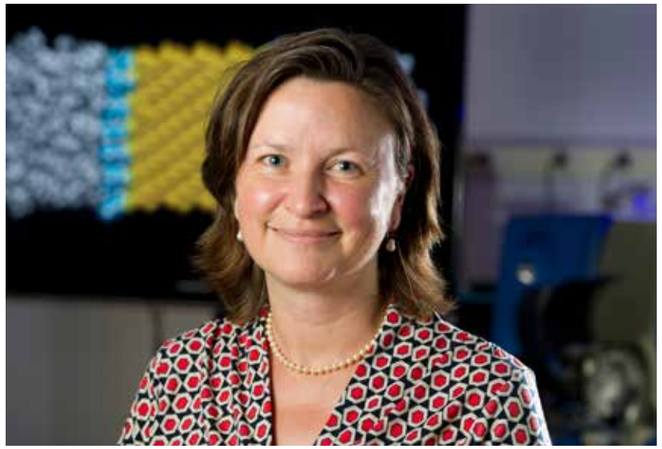
Fully understanding how the vectorial folding mechanism responds during each of these membrane transport processes may be the key to eventually stopping the fold in its tracks. Clark will use a combination of other proteins and solid-state technology to develop a way to initiate this type of protein folding in the test tube, allowing her and her colleagues to study cellular folding mechanisms in unprecedented detail.

By learning more about why proteins fold like they do, Clark and her colleagues may be able to prevent the spread of infectious diseases.

"We are honored that the Keck Foundation has recognized Professor Clark's and Professor Kuno's groundbreaking medical research in molecular biophysics," said Mary Galvin, the William K. Warren Foundation Dean of the College of Science. "We are grateful to the foundation for providing this grant, the first to the University in nearly 20 years, for work that has the potential to transform the understanding of how proteins fold and spread disease."

Based in Los Angeles, the W. M. Keck Foundation was established in 1954 by the late W. M. Keck, founder of the Superior Oil Company. The foundation's grant-making is focused primarily on pioneering efforts in the areas of medical, science and engineering research. The foundation also maintains an undergraduate education program that promotes distinctive learning and research experiences for students in the sciences and in the liberal arts, and a Southern California Grant Program that provides support for the Los Angeles community, with a special emphasis on children and youth from low-income families, special needs populations and safety-net services. ■

For more: wmkeck.org.



Alumni Profile

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Mark Hoyer '81

Dr. Mark Hoyer '81 enjoys a rewarding career as a pediatric cardiologist and Director of Cardiac Catheterization and Interventional Cardiology for Riley Hospital for Children at Indiana University Health.

Describe you path to medical school, and ultimately, to your specialty in pediatric cardiology.

After graduating from Notre Dame, I took a Health Professions Scholarship with the U.S. Air Force and went to Ohio State University for medical school.

I always enjoyed studying the heart. When I did one of my clinical rotations in adult cardiology, I was really encouraged and supported by the staff and faculty. For a while, I was thinking about going into internal medicine, but my wife reminded me about how much I enjoyed my time in pediatrics. I am forever grateful for the decision to go into pediatric cardiology—it is so rewarding. It's truly something completely different every day.

What is your favorite part of your work?

Because I have pursued a pathway toward intervention, the amazing thing is there's almost always something you can do to help a child. It keeps me wanting to move forward because I'm always learning something.

Is there a particular case that changed you?

A little baby had a complication during a procedure we performed and did not survive. I realized I had to be forthright and honest with the family about what happened. That was a humbling experience that had an impact on me, and a reminder of the privilege I am given to care for these patients. Even if I have done a procedure 50 times or 500 times, it's always a family's first time to bring their child to me. I never take that for granted.

What lessons from Notre Dame have you taken with you through your career?

I played tennis at Notre Dame for four years. Freshman year was tough academically, and I had lots of pressure from teammates. I learned that succeeding was not so much about winning and losing, but more about how we conducted ourselves. ■

Search "Hoyer" at science.nd.edu.

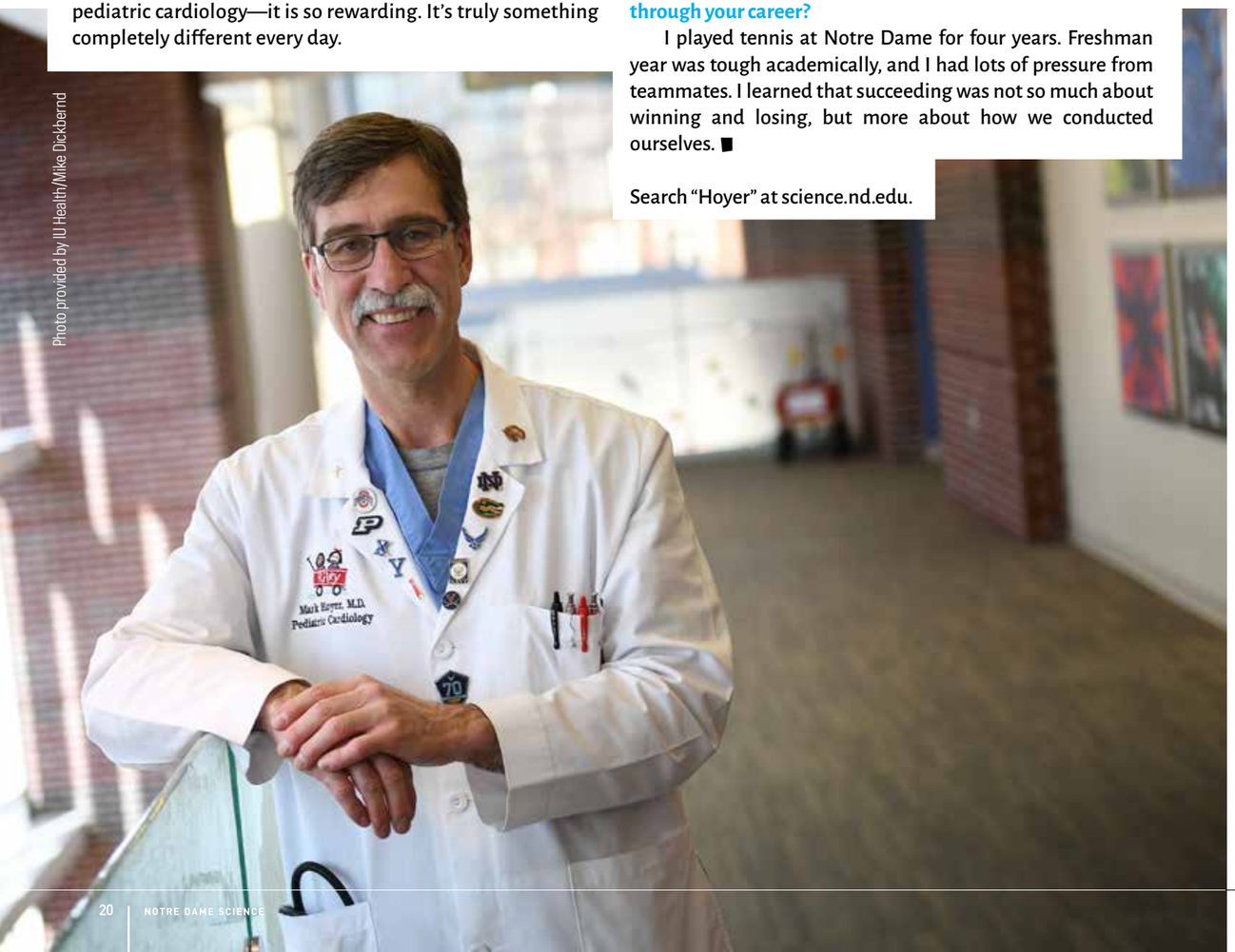

Photo provided by IU Health/Mike Dickbernd

Alumni Profile

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Ann E. Weber '82

Ann E. Weber, Ph.D., is senior vice president of drug discovery at Kallyope Inc., a New York City-based biotechnology company focused on harnessing the potential of the gut-brain axis. She retired in November 2015 from Merck & Company, where she was most recently vice president of lead optimization chemistry at Merck Research Laboratories (MRL). In this role, she was responsible for the discovery of innovative therapeutic agents across disease areas. She joined MRL as a senior research chemist in 1987.

Weber's research interests include the design and synthesis of ligands for G-protein coupled receptors, ion channels and enzymes. Her work has led to over 40 development candidates, including Januvia® (sitagliptin), a treatment for patients with Type 2 diabetes; Janumet®, a fixed dose combination of sitagliptin and metformin, and Marizev® (omarigliptin), a once-weekly treatment for type 2 diabetes that was approved in Japan in September 2015. One additional drug candidate, vibegron for the treatment of overactive bladder, is in late-stage clinical trials.

Weber is the author or co-author of over 80 publications. She is co-inventor on over 35 issued U.S. patents. Her awards include the Robert M. Scarborough Award for Excellence in Medicinal Chemistry, American Chemical Society (ACS); the Heroes of Chemistry Award (ACS); the Discoverer's Award (PhRMA), recognizing scientists whose work has been of special benefit to humankind; and, and a Directors' Award, the highest honor that Merck confers on its employees. She is a 2013 Liberty Science Center Women in STEM Honoree and the recipient of the 2015 Gift of Mentoring Award from the Metro Women Chemists Committee. In 2017, Weber was awarded the Perkin Medal, one of the highest honors given in the field of applied chemistry, by the Society of Chemical Industry, America Group, for her work in developing Januvia® and Janumet®.

Before joining Merck, Weber obtained her bachelor of science degree in chemistry *summa cum laude* from the University of Notre Dame. She earned her doctorate in synthetic organic chemistry from Harvard University. ■

Getting the lead out

By Tammi Freehling with contributions from Brendan O'Shaughnessy and Jessica Sieff

A December 2016 *Reuters Investigates* report highlighted more than 2,800 areas across the country where lead poisoning rates were at least twice as high as in Flint, Michigan, but received little to no funding or attention. One such area is a census tract in South Bend, just one-and-a-half miles southwest of the Notre Dame campus. Funding grants that had previously paid for testing homes for lead had been depleted in 2016.

To help tackle this problem, faculty from the Eck Institute for Global Health and the Department of Biological Sciences created a new Lead Exposure course for the 2017 spring semester. Heidi Beidinger, assistant professor of the practice, and Lacey Ahern, adjunct assistant professor of the practice, designed the course to produce research to identify the cause of high lead levels and help guide the St. Joseph County health department's response. Students studied the problem from many angles, including neurological impact, legal frameworks and environmental remediation. They learned how to conduct home lead tests and create digital maps showing home and neighborhood danger areas.

In the summer of 2017, Marya Lieberman, professor in the Department of Chemistry and Biochemistry, and some of her students lent their expertise to the cause. With homeowners' permission, they tested paint and dust samples in homes where children had been exposed to lead, to try to determine the source of the poisoning. Graham Peaslee, professor in the Department of Physics, and his students joined the cause by using their particle accelerator to rapidly test the samples collected. Working together, they have created low-cost sample collection kits and have distributed them to a local high school, engaging citizen scientists to help pinpoint areas of lead contamination. The students send the kits back to Notre Dame where samples are analyzed in Peaslee's lab and homes with troubling results are targeted for follow-up education on steps the homeowner can take to make the home safe from lead.

This work has been supported in part by Green & Healthy Homes Initiative and the College of Science. ■

Search "lead" at science.nd.edu.

Standing Ovations

Faculty Accolades

Ani Aprahamian, the Frank M. Freimann Professor of Physics, was elected as secretary to the International Union of Pure and Applied Physics Commission on Nuclear Physics.

Maxime Brodeur, Ortenzio Family Assistant Professor of Applied Medical and Nuclear Physics, received a $530,000 Major Research Instrumentation (MRI) grant from the National Science Foundation to conduct research on the Standard Model of physics at the University of Notre Dame's Nuclear Science Laboratory.

Mark Caprio, associate professor of theoretical physics, associate chair, and director of graduate studies, received the 2017 Father James L. Shilts, C.S.C./Doris and Gene Leonard Teaching Award from the College of Science.

College of Science faculty **Patricia Champion**, **Antonio Delgado**, **Samuel Evens**, **David Galvin**, and **Alan Huebner** received the Rev. Edmund P. Joyce, C.S.C., Awards for Excellence in Undergraduate Teaching.

Patricia Clark, Rev. John Cardinal O'Hara, C.S.C., Professor of Chemistry and Biochemistry at the University of Notre Dame, has been awarded a $1.1 million, four-year grant from the W. M. Keck Foundation to develop an innovative approach to replicate in test tubes a universal component of protein folding within cells.

Justin Crepp, Freimann Assistant Professor of Physics, has been selected to serve on the Exoplanet Science Strategy committee that's part of the upcoming 2020–2030 National Academy of Sciences decadal survey in astronomy, astrophysics, and planetary science.

College of Science faculty **Justin Crepp**, **Lizhen Lin**, **Robert Rosenbaum**, **David Medvigy**, and **Andrew Putnam** received Early Career Development (CAREER) Awards from the National Science Foundation for their excellence in research.

Malgorzata Dobrowolska-Furdyna, the associate dean for undergraduate studies and the Rev. John Cardinal O'Hara, C.S.C. Professor of Physics, won the Distinguished Achievement Award from the South Bend Alumni Association for her role in organizing the Ace for Science tennis tournament.

Norman Dovichi, Grace-Rupley Professor of Chemistry and Biochemistry, received the 2018 American Electrophoresis Society Lifetime Achievement Award. Dovichi was also listed among the top 10 omics explorers in The Analytical Scientist's 2017 Power List for his contributions to genomics research.

Umesh Garg, professor of experimental nuclear physics, was named a Fellow of the American Association for the Advancement of Science.

Stuart Jones, associate professor of biological sciences, with a team of 15 collaborators from nine research institutions, received a $1.5 million NSF award to study sustainability of recreational fisheries.

Prashant V. Kamat, Rev. John A. Zahm. C.S.S., Professor of Science, was named to Clarivate Analytics' 2017 Highly Cited Researchers list, which identifies scholars who published the most articles that are in the top one percent of most-cited articles.

Xin Lu, John M. and Mary Jo Boler Assistant Professor of Biological Sciences in the Boler-Parseghian Center for Rare and Neglected Diseases, was awarded a Young Investigator Award from the Indiana Clinical and Translational Sciences Institute.

Anand Pillay, the William J. Hank Family Professor of Mathematics, received an honorary doctoral degree from Waterloo University's Division of Mathematics.

Sylwia Ptasinska, Associate Professor of Physics; **Kenneth Cecire**, QuarkNet national staff teacher; and **Allen Oliver**, research professor; are among eight at Notre Dame to be awarded Luksburg Foundation Collaboration Grants for projects with Pontificia Universidad Católica de Chile faculty in Santiago, Chile.

Andrew Putnam, professor in the Department of Mathematics, was named a fellow of the American Mathematical Society for 2018.

Cody J. Smith, the Elizabeth and Michael Gallagher Family Assistant Professor of Adult Stem Cell Research and member of the Center for Stem Cells and Regenerative Medicine, received a Spinal Cord and Brain Injury Research Fund grant from the Indiana State Department of Health and the Indiana Clinical and Translational Sciences Institute.

Jennifer Tank, Ludmilla F., Stephen J., and Robert T. Galla Professor of Biological Sciences and director of the Environmental Change Initiative, was elected president of the Society for Freshwater Science.

Zoltán Toroczkai, professor of theoretical physics, received an international collaborative grant from the National Science Foundation's Division of Intelligent Information Systems for research on brain neuronal networks.

David Veselik, director of undergraduate studies and associate teaching professor in the Department of Biological Sciences, was one of three recipients of the Dockweiler Awards for the 2016–2017 academic year.

Rich Taylor, professor of chemistry, received the 2017 Faculty Award, Office of the Provost.

Professors **Mitchell Wayne**, **Colin Jessop**, **Randal Ruchti** and their High-Energy Physics team received more than $1.2 million from the United States Department of Energy to develop radiation-resistant optical devices that can be used in a wide variety of scientific and technical applications in partnership with the California Institute of Technology, the University of Iowa, and the University of Virginia.

Michael Wiescher, Frank M. Freiman Professor of Physics, was elected into the Academy of Europe for a lifetime of outstanding achievement and received a career award from the American Astronomical Society Laboratory Astrophysics Division for his contributions to laboratory astrophysics. Wiescher and **Dan Robertson**, research assistant professor in physics, both received a Media Legends Award from the Office of Media Relations for their work with the press that spotlighted academic excellence at the University of Notre Dame.

Postdoctoral Scholar accolades

Henry Clay Conner, Ph.D., received a Postdoctoral Training Award in Translational Research from the Indiana Clinical and Translational Sciences Institute.

Tyvette Hilliard, Ph.D., received a highly competitive 5-year K01 Research Career Development award from the National Institute of Health and National Cancer Institute and is the first-ever K01 awardee from the University of Notre Dame.

Student accolades

Andrew Grose '18, a senior preprofessional and Spanish double major, has been named Valedictorian for 2018. Grose will spend a gap year studying Iberian and Latin American Literature before attending medical school.

Harisa Spahic '18, a senior chemistry and biochemistry major, has been named Salutatorian for 2018. Spahic will attend medical school in the fall.

Dominic Acri '19, a junior neuroscience and behavior major and TESOL minor, was selected for the Udall Foundation's 2017 Tribal Policy Scholar. He is the University's second-ever Udall Scholar and the first in one of the Native American categories.

Juniors **Ashley Ahimbisibwe** '19, an applied and computational math and statistics major, and **Kaitlin Salyer** '19, a physics and French double major, were awarded full merit-based scholarships for the 2017–2018 academic year through the Clare Boothe Luce Program. The undergraduate awards program recognizes outstanding women in the science, math, and engineering fields, where women are most underrepresented.

Mark Hawk, biological sciences graduate student, was selected among more than 1,500 applicants to attend the National Graduate Student Symposium hosted by St. Jude Children's Research Hospital, an event for the nation's top Ph.D. students to present their work and learn more about St. Jude's advanced research facilities.

Annmarie Leonard '18, a senior biochemistry major, was named a co-author on a paper about ovarian cancer and the primary author of a chapter in the book Methods of Cell Biology.

Alyssa Lesko, biological sciences graduate student, was selected to present her work at the 2017 Future Fellow Research Conference at St. Jude Children's Research Hospital in Memphis, Tennessee, a conference for the nation's elite doctoral students to showcase their work.

Sarah Lum, chemistry and biochemistry graduate student, won the Young Scientist Award at the MSB 2017 conference, a gathering of scientists in the Netherlands that focus on microscale separations and bioanalysis. The Young Scientist Award was established to recognize researchers under the age of 35 in the field who set an outstanding example for other scientists.

Maria Cristina Miranda-Vergara, a graduate student in the Department of Chemistry and Biochemistry, was awarded the 2017 Leiva Graduate Fellowship in Precision Medicine by the University's Advanced Diagnostics & Therapeutics initiative.

Samuel Rudisill '18, a senior neuroscience and behavior major, won a first-place award at the Pediatric Research Forum for Medical Students for his research on infant anesthesia and sedation.


Andrew Grose


Harisa Spahic

If you receive an award between May and April, and wish to be included in the next issue, please email **science@nd.edu** ATTN: Editor.

New Faculty

Brian Blagg
Director, Warren Family Research Center for Drug Discovery and Development
Charles L. Huisking Professor of Chemistry and Biochemistry
Research: Drug discovery and development, specifically 90 kDa heat shock proteins (Hsp90)

Arnaldo Serrano
Assistant Professor, Chemistry and Biochemistry
Research: Analytical chemistry focusing on femtosecond nonlinear and multidimensional spectroscopies

Stefano Castruccio
Assistant Professor, Applied and Computational Mathematics and Statistics
Research: Statistical models with applications for assessing renewable energy resources and mortality from air pollution

Dr. Bernard Nahlen
Director, Eck Institute for Global Health
Professor, Biological Sciences
Research: Addressing the many diseases, including malaria, that disproportionately impact people in low- and middle-income countries

Michael Pruitt
Assistant Professional Specialist, Applied and Computational Mathematics and Statistics
Research: Green's function as a tool in the study of harmonic functions

Geoffrey Siwo
Research Assistant Professor, Biological Sciences, Center for Research Computing, Eck Institute for Global Health
Research: Computational biology, network science, artificial intelligence and nanotechnology

Roger Woodard
Director, Master of Science in Data Science program
Professional Specialist, Applied and Computational Mathematics and Statistics
Research: Statistics education and computationally intensive methods

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COLLEGE OF SCIENCE AND COLLEGE OF ENGINEERING ALUMNI were part of the Rockets, four Boeing F-15E Strike Eagle air crews from the 336th Fighter Squadron that performed the flyover at Notre Dame Stadium prior to the football game against Georgia on September 9, 2017.

From left to right: 1st Lieutenant Jordan Hoover '14 (College of Engineering), Captain Matthew Mooney '10 (College of Engineering), and Captain Trent McMullen '12 (College of Science, Mathematics).