BIOMEDICAL ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON

LARGEST-EVER GIFT ENHANCES STUDENT EXPERIENCE

CHAIR'S MESSAGE

Greetings!

Sought-after new faculty. Growing design opportunities for students. Expanding biomanufacturing in Wisconsin. An upcoming anniversary. There is always something new and exciting happening in BME, and I'm pleased to share a few of our latest successes with you.

On July 1, the Department of Biomedical Engineering turns 20. Anniversaries like these allow us to reflect on how far we have come and where we aim to go. The department started with just three tenured faculty members and a department administrator; we now have 21 faculty. In January, we welcomed three new assistant professors: Melissa Kinney, Aviad Hai and Colleen Witzenburg. Along with Kip Ludwig, hired in summer 2018, they bring their exemplary and interdisciplinary work in biomechanics, systems biology, tissue engineering and neuroengineering.

I am also excited to announce that we have received the largest gift in the department's history from a longtime supporter, Peter Tong. The gift creates an endowed department chair position—one of the first in the College of Engineering—that I am truly honored to hold. It will also help expand hands-on learning opportunities for students through new lab space, cutting-edge equipment, travel awards and more.

When students participate in experiential learning, like our design courses, it provides them with a chance to apply their engineering education to create a real-world solution that helps people in our communities. Two of our undergraduate students, Margaret Edman and Sara Jorgensen, are perfect examples. Since 2017, as part of their design courses, they have been creating a lighter, tighter and more adjustable ventilator to use on newborns during surgery. And recently, they filed a provisional patent application on their project.

Opportunities like this are what we strive to continue providing for our students for the next 20 years. In an ever-changing world, we dedicate ourselves to maintaining an environment where our students can thrive, explore and discover the next advancement to improve human health.

Read the latest BME news on our website (**www.engr.wisc.edu/bme**), and be sure to connect with us on Facebook (**@UWBME**) and Twitter (**@UWMadison_BME**).

ON, WISCONSIN!

Justin Williams

Peter Tong Chair of Biomedical Engineering and Vilas Distinguished Professor

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Gift supports graduate students with technical backgrounds

David Swanson (MSEE '72, PhDEE '76) may not be a BME alumnus. But as a graduate student in electrical engineering in the 1970s, he worked under Professor John Webster—a trailblazer of the biomedical engineering field.

That experience helped propel Swanson into a long and successful career in the medical device and technology industry. Now, he is keen to help others deepen their career preparation. He and his wife, Anne, have established the David K. Swanson Graduate Support Fund to assist first-year graduate students in biomedical engineering.

"I remember my days as a graduate student. The ability to live your life while you're getting a degree is a big deal," says Swanson, a 2008 recipient of a distinguished achievement award from the College of Engineering who retired after serving as chief technical officer at the medical device company ESTECH (subsequently acquired by AtriCure).

In particular, the fund aims to provide fellowships for students pursuing graduate studies in biomedical engineering after undergraduate training in technical fields, such as chemical and biological engineering, electrical and computer engineering, or mechanical engineering.

That preference isn't just based on Swanson's career arc. He says while hiring and observing new employees over his career, he found the pairing of a deep technical background with the exposure to medical and physiological applications in a biomedical engineering graduate program to be a powerful combination.

As a graduate student, Swanson helped Webster develop an undergraduate lab course in biomedical instrumentation on topics such as electrocardiograms and oxygen sensing. He went on to work at UW Hospital, Cardiac Pacemakers Inc. and Boston Scientific Corp. before joining ESTECH in 2005. He holds more than 300 U.S. patents—all since age 40.

The Swansons initially talked about making a planned gift toward the fund, but decided they wanted to be able to see the effects of their contribution.

"Having people benefit while I'm still living made a lot of sense," he says. "We were getting our estate together and we said, 'Well, why wait?'"

HISTORIC ENDOWED CHAIR BOOSTS BME

Peter Tong (MSEE '65) wants BME students to gain the kind of hands-on experience and entrepreneurial mentality that will kickstart their careers.

That notion explains Tong's longtime support of student prototype design competitions, first in the College of Engineering as a whole and, for the past 12 years, in BME.

Undergraduate students compete for the Tong Biomedical Engineering Design Award every semester. Two awards go to teams of juniors and seniors who develop exceptional prototypes. *Photos: Vishmaa Ramsaroop-Briggs.*

Now, through a major new gift to the department, Tong is opening the door to even more opportunities for BME students to enhance their educations.

In partnership with the Wisconsin Alumni Research Foundation, where he serves on the Board of Trustees and chaired the board from 2014-18, Tong is endowing BME's chair position with a $3 million contribution.

It is the largest gift in the department's history and is among a simultaneous trio of the first endowed department chair positions in the college.

"It's transformative," says Vilas Distinguished Professor Justin Williams, the first faculty member to hold the Peter Tong Chair of Biomedical Engineering. "This really is going to augment our resources so that we can more effectively pursue strategic initiatives, capitalize on emerging opportunities to give our students a world-renowned, cutting-edge education, and continue to be able to attract the best and brightest students here."

The endowed chair provides flexible funding. Williams will leverage that support to elevate both the undergraduate and graduate educational experience by purchasing new lab equipment in emerging areas of study and adding to existing support for student design projects, travel awards and more. The endowed fund will also support the department chair's research endeavors.

"We wanted to give the biomedical engineering department a longer-term commitment of our support," says Tong, who, along with his wife, Janet, has funded efforts that include the Tong BME Distinguished Entrepreneur Lecturer Series and the Tong Student Leadership Auditorium in the Engineering Centers Building. "This will help Justin and it will allow a lot of flexibility and freedom to grow the department."

Williams says the gift will support the department's efforts to provide undergraduate students with the kinds of laboratory experiences that take their knowledge, creativity and capabilities to new levels. Those offerings could include a new optics lab where students can build microscopes from scratch, a motion-capture facility for those interested in biomechanics and human performance, and a device setup with a particular focus on neural engineering.

"We will build laboratories and outfit them with the kind of state-of-the-art equipment that most undergrads at other biomedical engineering programs would never see," says Williams, noting that the timing of the gift is fortuitous, given the department is currently renovating a 2,500-square-foot lab on the first floor of its home in the Engineering Centers Building.

Vilas Distinguished Professor Justin Williams (left) and longtime BME supporter Peter Tong.

> **"This gift is really going to augment our resources so that we can more effectively pursue strategic initiatives and capitalize on emerging opportunities."**
>
> **Justin Williams, Peter Tong Chair of Biomedical Engineering**

True to Tong's belief in the design experience, the gift will also fund access to specialized instrumentation and advanced prototyping techniques, as well as provide startup expenses to students interested in developing their projects beyond the Tong BME Design Competition.

He's excited about the department's future, and so is Williams.

"It's the culmination of the last 20 years of Peter working with our department to get us to where we are today," Williams says. "And now, to take us to the next level."

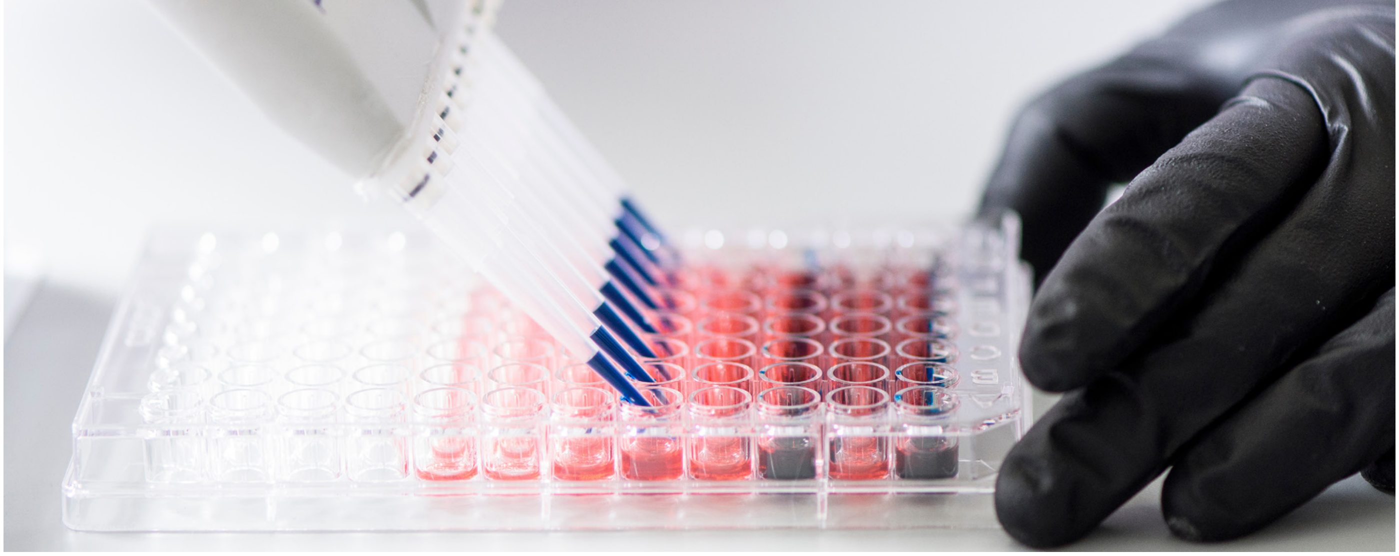


Photo: Bryce Richter /UW-Madison

BUILDING A BIOMANUFACTURING HOTBED

Bill Murphy

Cathy Rasmussen

To Bill Murphy and the other leaders of the Forward BIO initiative at UW-Madison, Wisconsin possesses all the elements to become a hub of biomanufacturing in the United States, the Midwest's version of Boston or San Francisco in this rapidly expanding industry.

"Our established, statewide excellence in research, technology development and workforce development make Wisconsin a powerhouse," says Murphy, the Harvey D. Spangler Professor and chair of the Forward BIO Initiative. "What we need is to coordinate and amplify the ingredients that are in place here. That is what Forward BIO is doing."

The initiative, which launched in September 2018, covers research, education and career preparation, facility access for startups, and two-way connections between industry and academia through its three pillars: the Forward BIO Institute at UW-Madison; Forward BIOLABS, a turnkey lab space at University Research Park on Madison's west side; and BioForward Wisconsin, a partnership organization of biohealth companies in the state.

And, with Murphy chairing the broader Forward BIO Initiative and directing the Forward BIO Institute, the Department of Biomedical Engineering will play a direct role in shaping efforts to strengthen the biomanufacturing industry in the state and the surrounding region.

Cathy Rasmussen, the institute's assistant director and innovation lead for the initiative, is also based in BME, while Assistant Professor Krishanu Saha is the institute's director of education innovation. Murphy and Rasmussen both see BME, a discipline that routinely brings together engineers and clinicians, as representative of the kind of work the Forward BIO Initiative seeks to promote on topics such as biomaterials, cell-based therapies, medical devices, pharmaceuticals, tissue engineering and regenerative medicine.

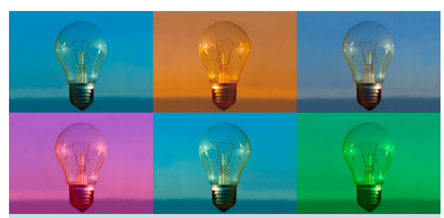
"The key research areas in BME are foundational to all of the components that we're talking about in terms of advancing biomanufacturing," says Rasmussen, who joined UW-Madison from the biotechnology firm Stratatech, a Mallinckrodt Pharmaceuticals company. "The interdisciplinary nature of how the faculty in BME work brings in a lot of new ideas and promotes growth."

The Forward BIO Institute is in the midst of making new faculty hires and developing a new master's program in biomanufacturing innovation with an eye toward a fall 2019 launch. In addition to teaching students technical skills to work with current and emerging technology, the program will introduce and encourage entrepreneurial thinking.

And, true to the broader initiative's priority of connecting academia to industry, Murphy says the institute hopes to create web-based course content that could reach audiences beyond the UW-Madison campus. The institute will also tap into industry knowledge through its Biomanufacturing Consortium.

By connecting faculty, staff and student to industry players and resources such as Forward BIOLABS—an incubator space that will let researchers focus on science rather than acquiring equipment—Forward BIO aims to accelerate the discovery-to-translation process.

"Once we effectively increase the number of technologies and innovators that catapult out of the universities and into the private sector, we will increase deal flow and create an exponentially growing biomanufacturing industry," says Murphy. "We are already seeing successful case studies, but we have only scratched the surface of what is possible."



Murphy earns inventor's honor

The National Academy of Inventors named Professor Bill Murphy to its 2018 class of fellows. Murphy has founded four spinoff companies and holds 21 issued United States patents (with 29 more pending).

Read more about Murphy's honor:
www.engr.wisc.edu/murphys-law-make-materials-biology-mind/

MAKING GENE EDITING SAFE AND SOUND


Sarah Gong


Krishanu Saha

The promise of gene editing using CRISPR/Cas9 technology is enormous: scientists believe the technology, which is capable of making precise changes to DNA, could be used to treat many human diseases by fixing deleterious mutations in patients' genetic codes.

Vilas Distinguished Professor Shaoqin "Sarah" Gong and Assistant Professor Krishanu Saha are each leading teams that are taking part in a national effort to improve gene editing through the National Institutes of Health's Somatic Cell Genome Editing Consortium.

Gong's group, which also includes Saha, is creating nanoparticles capable of delivering CRISPR to neurons in the brain to treat neurodegenerative diseases such as Alzheimer's disease.

"To date, successful genome editing has been mostly mediated by viral vectors," says Gong, describing an approach that carries methodological difficulties and safety risks. Her team is working on efficient, non-viral delivery vehicles that will facilitate safe genome editing in living animals.

Saha's team, which includes Associate Professor Melissa Skala, is developing quality control methods for improving genome editing therapies in the eye. The researchers will create human retinal tissues from pluripotent stem cells and then use specialized imaging and gene sequencing methods to define biomarkers for any adverse events after delivery of CRISPR-Cas9 genome editors to the tissues.

If successful, their work could significantly advance therapeutic genome editing in the eye and extend to more therapies involving more complex cultures and tissues.

"Screening for adverse events is essential for the development of safe genome editing therapies," Saha says. "By using 3D eye-like structures made from stem cells, our approach is groundbreaking in attempting to track these events in very complex tissues. If our approaches work well within these retinal structures, the impact of this work could be broad, with the potential to advance the development of genome editors administered to any tissue to treat a variety of diseases."

WHEN SEX MATTERS

How heart valves 'break' differently in men and women

Calcific aortic valve disease, the heart condition that can lead to valve replacement surgery, affects both men and women. But patients actually experience a different version of the same disease with potentially distinct underlying mechanisms, depending on their sex.

"We believe that both men and women are on a similar path to developing disease, but that at some point they diverge," says Vilas Distinguished Achievement Professor Kristyn Masters.

An expert in tissue engineering and heart valve disease, Masters has received a four-year, $1.5 million grant from the National Institutes of Health to model and understand differences in disease progression between sexes.

Nearly 10 years ago, her lab was the first to discover a key difference in cellular behavior in heart valve cells: Cells from male pigs more readily calcified than those from females.

A 2016 study from researchers at Universite Laval in Quebec revealed an underlying difference between men and women with similar cases of calcific aortic stenosis: The men exhibited higher levels of calcification in their valves, while the women experienced a greater buildup of collagen fibers, or fibrosis.

Masters plans to model the disease at different stages to determine the point at which men and women diverge. She and her students will build tissue-engineered models, which they'll treat with common risk factors for the disease, such as high cholesterol.

"What we don't know about these risk factors and how the disease progresses is whether it's a case of you have male cells and female cells and when faced with the same risk factor, they respond differently," she says. "Do they have different magnitudes of response? Or are they actually fundamentally activating different or alternative pathways in the cells based upon whether the cell origin is male or female?"

MORE: www.engr.wisc.edu/sex-matters-heart-valves-break-differently-men-women/

MATTERS OF THE HEART: WITZENBURG PREDICTS CARDIOVASCULAR TISSUE FAILURES

Colleen Witzenburg looks at the human heart and sees a wonderfully complex organ—one that's built of layers of fibers running in different directions, that is mechanically and electrically active, and that can adapt to changes.

But the mechanical engineer in her can also peer through the intricacy and awe of the heart and see it as a functional object.

"It's a pump. It's a really amazing and intricate pump, but it's still a pump," says the assistant professor, who joined UW-Madison in January 2019.

Witzenburg, whose bachelor's, master's and doctoral degrees are all in mechanical engineering, studies cardiovascular tissue structure and function. By gleaning quantifiable data, she attempts to predict the tears or ruptures that occur after sudden events, such as heart attacks, or conditions that develop over time, like congestive heart failure.

"The tissues we study are crucial to the load-bearing capacity of the cardiovascular system," says Witzenburg. "It is often life-threatening when these tissues are damaged or diseased and may require the replacement of an entire vessel or even the heart itself."

Witzenburg is interested in how the heart responds to disease from a structural perspective and, ultimately, using those insights to inform clinical treatment plans.

In particular, she's studying the tissue changes associated with genetic disorders that threaten to rupture the aorta, the body's largest artery, and unexplained congenital heart defects such as hypoplastic left heart syndrome.

Witzenburg is also exploring heterogeneity within tissues—the spatial variance in material properties, both in healthy and diseased tissue—and its implications for potential tearing or rupturing.

MORE: www.engr.wisc.edu/matters-heart-witzenburg-predicts-cardiovascular-tissue-failures/

MIND'S EYE: HAI BUILDS TOOLS TO EXPAND OUR UNDERSTANDING OF THE BRAIN

A typical surgically implanted electrode gives neuroscientists and clinicians a glimpse into the brain's inner workings. Yet it's a narrow view, akin to looking at a few pixels of an image with no sense of the larger picture.

"We don't have the tools to read from the entire brain," says Assistant Professor Aviad Hai, who joined UW-Madison in January 2019.

Hai is developing those next-generation tools—ones that can work wirelessly, that don't require major surgery, and that can reveal a more comprehensive account of neural activity across regions of the brain. Hai creates electrical, magnetic and electromagnetic sensors, including ones that work with existing technologies such as magnetic resonance imaging and magnetoencephalography.

"I am trying to revolutionize the way we acquire signals from the brain," he says. "For a few decades, we've been able to record and stimulate from very localized areas. And I think it's like measuring a little drop of water in an ocean of activity. You have tens of billions of units and orders of magnitude more connections. We don't have the technologies to understand the brain. I think neuroscience is stuck. There's a lot of good research, but we need better tools."

Hai detailed one of his novel devices— a wireless sensor capable of identifying electromagnetic fields in the brain that can then be detected using MRI—in an October 2018 paper in *Nature Biomedical Engineering*.

He's also used nanofabrication techniques to create cell-sized electrodes with unique topography that encourages closer connections with neurons, which exponentially amplifies signals. And Hai has applied molecular-based sensors, proteins designed to bind to neurotransmitters in the brain and show changes via MRI. He's deployed the latter to view the effects of antidepressant drugs on serotonin and dopamine levels across large volumes of the brain in rats.

MORE: www.engr.wisc.edu/minds-eye-hai-builds-tools-expand-understanding-brain/

COMPLEX CASE: KINNEY KEEN TO DISCOVER OUR SYSTEMS' SECRETS

Melissa Kinney likes solving puzzles so much that she's decided to make a career out of piecing together a dizzyingly complex one.

"To me, biology is the biggest, kind of craziest, most interesting puzzle you could possibly solve," says the assistant professor, who started at UW-Madison in January 2019. "We know little bits and pieces about how biology works in terms of cells working with other cells, in terms of how things go wrong in disease and so on. But we just don't understand how it all works together, honestly."

Therein lies the challenge in the field of systems biology, one of Kinney's areas of specialization. By analyzing gene expression in stem cells on large scales and studying the behavior and communication among those cells, Kinney hopes to learn more about how the human body's different systems function and develop models to guide tissue engineering.

Her work is fundamental in nature, but it could help inform disease modeling for more precise drug testing or, eventually, for stem-cell-based therapies.

For now, Kinney primarily focuses on blood cells, an area she delved into as a postdoctoral research fellow at Boston Children's Hospital and Harvard Medical School from 2014 to 2018.

"The blood is a really interesting system because it's one of the only systems in your body that still has very active stem cells in it," she says. "If we could make a hematopoietic stem cell, which is the blood stem cell, in a lab, then we can think about things like actually replacing a bone marrow transplant or being able to have a real impact on patient populations with incredibly long donor lists."

Kinney aims to educate students in analytical and computational techniques that will allow them to handle the growing deluge of biological data that's now available.

MORE: www.engr.wisc.edu/kinney-keen-discover-systems-secrets/

DEPARTMENT NEWS

Assistant Professor **Jeremy Rogers** earned a National Science Foundation CAREER award, which he'll use to develop imaging tools to monitor cells in the retina. The project could allow researchers to study cell activity and function before, during and after drug and gene therapies for sight damage.

The Biomedical Engineering Society named Vilas Distinguished Achievement Professor **Naomi Chesler** to its 2018 class of fellows in recognition of her work and leadership.

Assistant Professor **Randolph Ashton** is the new associate director for UW-Madison's Stem Cell and Regenerative Medicine Center. He previously served on SCRMC's executive committee and has helped advance the center's training and educational programs.

Professor Emeritus **John Webster** received the 2019 James H. Mulligan Jr. Education Medal from the Institute of Electrical and Electronics Engineers in recognition of his career in education.

Associate Professor **Pamela Kreeger** received a grant from the American Cancer Society for research examining the efficacy of an existing drug against metastasis in ovarian cancer.

Associate Professor **Melissa Skala** received a 2018-19 Wisconsin Alumni Research Foundation innovation award as one of the top-two invention disclosures submitted to the organization in the previous year. Skala earned the honor for her work on a noninvasive method to sort cancer immunotherapy cells.

John D. MacArthur Professor and Claude Bernard Professor **David Beebe** is part of two projects that received Collaborative Health Sciences Program awards from the UW-Madison School of Medicine and Public Health's Wisconsin Partnership Program. One looks at the intersection of stress, inflammation and immune response; the other aims to bring B-cell therapy to first-in-human cancer clinical trials in Wisconsin.

Associate Professor **Kip Ludwig** was among the authors of a paper in *Neuroscience Research* that shed light on the underlying neural process in neuromodulation and the effects of different stimulus parameters.

Undergraduate **Alli Abolarin** won a 2018 Alliant Energy/Erroll B. Davis Jr. Academic Achievement Award from the UW System and the Alliant Energy Foundation. Abolarin conducts research in neurodegenerative disorders and serves as a Leaders in Engineering Excellence and Diversity Scholar to encourage underrepresented students in the field of engineering.

PhD student **Ming-Song Lee** was among the first-round winners in Foxconn Technology Group's "Smart Cities—Smart Futures" competition.

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RENAISSANCE WOMAN

Hanna Barton (BS '18) ranks No. 4 on the UW-Madison list of all-time greatest discus throwers, and she finished sixth in the Big Ten Conference last season. But she's much more than an amazing athlete.

Barton entered the 2019 season as a two-time Big Ten Distinguished Scholar and three-time Academic All-Big Ten honoree. She is a University Innovation Fellow, trained by the design institute at Stanford University to bring design thinking to students across campus.

Through the Coach for College program, she has twice traveled to Vietnam to teach volleyball, biology and life skills to middle school students. After earning her bachelor's degree in December 2018, she's continuing her studies at UW-Madison as a graduate student in human factors and health systems engineering.

Photo: David Stluka

Photos courtesy: Hanna Barton