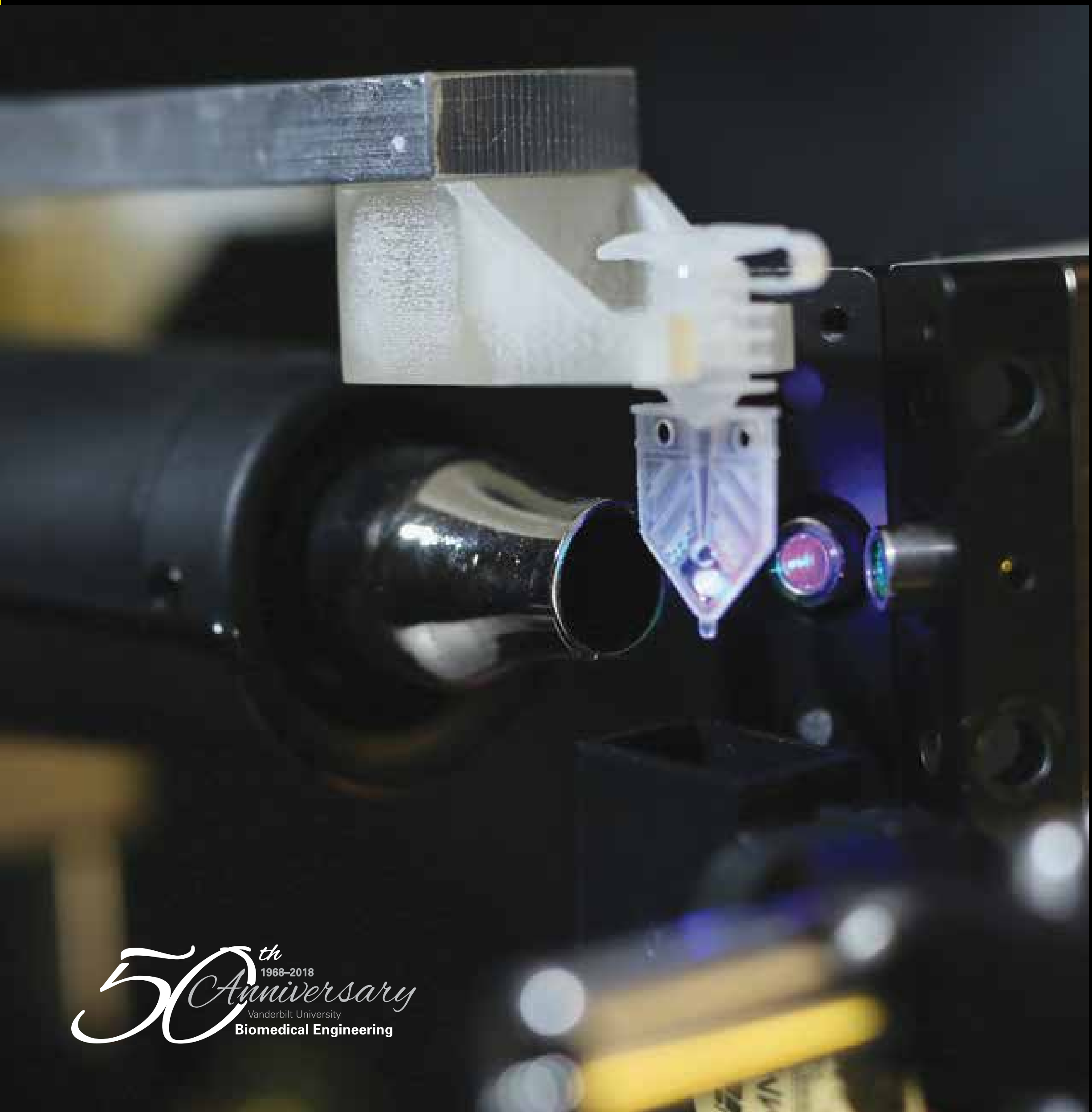
# BME

BIOMEDICAL
ENGINEERING
AT
VANDERBILT
UNIVERSITY






NASHVILLE, TENNESSEE

2017
2018

VANDERBILT | SCHOOL OF ENGINEERING

50th Anniversary 1968–2018 Vanderbilt University Biomedical Engineering

**Vanderbilt's hometown of NASHVILLE is a vibrant, engaging city known proudly as "Music City, U.S.A." and one of the fastest growing areas in the Upland South. The university's students, faculty, staff and visitors frequently cite Nashville as one of the perks of Vanderbilt, with its 330-acre campus located a little more than a mile from downtown.**

Nashville's downtown area boasts a diverse assortment of entertainment, dining, cultural and architectural attractions. The Broadway and 2nd Avenue areas feature entertainment venues and an assortment of restaurants. North of Broadway lie Nashville's central business district, Legislative Plaza, Capitol Hill and the Tennessee Bicentennial Mall. Cultural and architectural attractions are found throughout the city.

Named America's friendliest city three years in a row, Nashville is a metropolitan place that exudes all the charm and hospitality one expects from a Southern capital. *Fortune* magazine named Nashville one of the 15 best U.S. cities for work and family. It has ranked as the No. 1 most popular U.S. city for corporate relocations by *Expansion Management* magazine and been named by *Forbes* magazine as one of the 25 cities most likely to have the country's highest job growth over the coming five years. GQ posted an article dubbing the city "Nowville." The *New York Times* has declared Nashville a new "it" city. We're No. 3 in *Travel + Leisure*'s America's Best Cities.

The city proper is 526 square miles with a population of nearly 659,000. The 13-county metropolitan area population is more than 1.7 million, making it the largest metro statistical area in Tennessee. Major industries include tourism, printing and publishing, technology, manufacturing, music production, higher education, finance, insurance, automobile production and health care management.

Nashville is comfortable and affordable, beautiful and friendly. When we say "Welcome to Nashville," we mean it.

# BME

**BIOMEDICAL ENGINEERING AT VANDERBILT UNIVERSITY**



**Cover Photo: DNA duplicator small enough to hold in your hand**
Vanderbilt biomedical engineers' prototype adaptive PCR (polymerase chain reaction) device, a machine that amplifies and detects DNA. An ultraviolet laser (right) illuminates the small sample in the center; the spectrometer (left) detects levels of fluorescence. The adaptive approach promises to reduce complexity, improve reliability, reduce environmental sensitivity, and shrink PCR tools from desktop to handheld size. It could open PCR for use in the field or at the bedside to identify different diseases by their DNA signatures. (Anne Rayner / Vanderbilt)

# New BME chair drawn by engineers and clinicians working in harmony in Music City

Vanderbilt Department of Biomedical Engineering Chair Michael King took the reins of a department on the eve of its 50th anniversary with an ambitious agenda.

He's revamped the department's External Advisory Board and plans to add as many as seven new faculty members in the next few years. He's made a mission of raising the profile of the department, a five-minute walk to Vanderbilt University Medical Center, itself a Top 10 world-class research institution with frequent and eager clinical and basic science collaborators.

"It is a very exciting environment," said King, whose own research combines nanotechnology, cellular engineering and drug delivery.

"The convergence of technology and foundational knowledge makes it an amazing time to be researching new cures and disease mechanisms, and with nanotechnology, gene editing and other techniques, engineers are in a great position to impact public health and patient outcomes."

To that end, the External Advisory Board was a priority. The board includes top academic leaders outside Vanderbilt, industry representatives, entrepreneurs with their roots in engineering and medicine, BME alumni, and clinicians who use new technology.

"They give us a great perspective representing constituencies, future employers, also some historical perspective," King said, who was named the J. Lawrence Wilson

Professor of Engineering earlier this year. "They have a broader perspective and are not knee deep in policy discussions. It is also a way to educate the broader community about what we are trying to achieve."

In his own lab, King and colleagues study the mechanisms of cancer as it spreads to distant organs and are developing new ways to stop metastasis. A significant breakthrough came in attaching therapeutic proteins to white blood cells that go on to attack and destroy cancer cells as they flow through the bloodstream.

The less toxic and more effective approach could change how metastatic cancer is treated. The research was the cover article in the Feb. 10, 2016 issue of the *Journal of Controlled Release* and has inspired more recent studies on the use of blood cells as drug carriers.

Developing and testing therapeutics in animal models of cancer that more closely resemble human disease continue in parallel with the analysis of human clinical samples from Vanderbilt and collaborating institutions.

"It has been very successful," King said. "It seems like the right platform for us to develop the next generation of therapies."

King and his family are thrilled with their new home, academically and otherwise. He and Cynthia Reinhart-King, recently named a the Cornelius Vanderbilt Professor of Engineering, and their two sons, ages 4 and 11, partake of Nashville's many recreational opportunities. An avid runner, King said he may be over his marathon phase, though living in Music City USA has inspired him to pick up the guitar again.

He's planning special events for the big anniversary of a department that always has been ahead of the curve.

"Even from the earliest days, at a time when no one was talking about translational research, we had engineers collaborating side by side with clinicians," King said. "Those types of interactions are in our DNA."

Such strong ties and physical proximity to the Medical School can make the department more attractive to potential faculty hires as well as top graduate students, he said. Vanderbilt's location in the center of Nashville, with its own growing reputation as a high-energy "it" city, makes the case even stronger.

"I think one of our biggest selling points is this amazing city we are in," King said. "It is a destination city."

## BME EXTERNAL ADVISORY BOARD*

**Gilda A. Barabino**
The City College of New York

**Steve Boronyak**
(Ph.D. '15)
Ethicon

**Tamara Brown**
(BE '93)
Praxair, Inc.

**Tosh Chilkoti**
Duke University

**Dr. Andre Churchwell**
Vanderbilt Heart and Vascular Institute
(BE '75)

**John Dayani**
Cardiovascular Care

**Newton de Faria**
Cornell University

**Arthur Gmitro**
The University of Arizona

**Steve Hartmann**
(MS '98, Ph.D. '02)
Medtronic

**Chris Jarrett**
(BE '05, MS '08, Ph.D. '14)
Stryker Communications

**Dr. Michael T. Osborne**
Massachusetts General Hospital

**Alyssa Panitch**
University of California, Davis

**Barry T. Peterson**
Philips Respironics

**Thomas Pfeiffer**
(MS '10, Ph.D. '14)
Siemens Healthineers

**Shelly Sakiyama-Elbert**
University of Texas, Austin

**Bruce Tromberg**
University of California, Irvine

**Jonathan Wells**
(BE '02, MS '04, Ph.D. '07)
Lockheed Martin

**Jerry Wilmink**
(BE '02, MS '04, Ph.D. '07)
WiseWear

*Reflects degrees from Vanderbilt School of Engineering Department of Biomedical Engineering and related fields at Vanderbilt.

# Potential heart valve calcification treatment early fruit of $5.3 million federal research grant

A treatment targeting rheumatoid arthritis may be the first drug to treat calcification of heart valves, giving cardiologists a non-invasive option to slow and perhaps prevent a fatal course of heart disease.

W. David Merryman, associate professor of biomedical engineering, leads the promising research with an R35 Emerging Investigator Award from the National Heart, Lung and Blood Institute. It provides $5.3 million over seven years. The program funds promising researchers instead of projects, allowing them to dive deeply into their fields over longer periods rather than spending precious time seeking funds for time-sensitive projects.

Merryman and his Vanderbilt School of Engineering and School of Medicine collaborators found the arthritis drug—a monoclonal antibody known as SYN0012—shows promise in keeping heart valve leaflets supple.

The focus is cadherin-11, a binding protein necessary for normal wound healing that acts as an adhesive between fibroblast cells in connective tissue, including heart valves. As hearts age and lose elasticity, overactive fibroblasts produce mass amounts of cadherin-11 (CDH-11) until the leaflets that make up aortic valves can barely move.

The rheumatoid arthritis drug, an anti-inflammatory, physically binds to CDH-11 on the surface of cells and prevents them from binding together.

"The antibody we're working with blocks fibroblasts from becoming the active type that leads to disease," Merryman said. "It keeps them from becoming inflamed."

His research into CDH-11 dates to 2013, when two of his first Ph.D. students compared two studies of heart valve cellular responses with conflicting conclusions. One found a chemical compound caused valve fibroblasts to become active, similar to the process in valve disease. Yet the other study found the same compound prevented the cells from calcifying.

A piece of the puzzle was missing, and they realized the study teams affected the outcome by inadvertently turning CDH-11 production on and off.

Studying heart valves preserved from surgeries showed patients suffering from calcification had, in some cases, 50 times as much CDH-11 in their valves as patients without the condition. Another study showed patients carrying a NOTCH1 genetic mutation eventually would suffer from heart valve disease because it leads to CDH-11 overproduction.

The findings were published in *Circulation* (June 13, 2017), the journal of the American Heart Association.

SYN0012 is in human clinical trials for rheumatoid arthritis treatment. When those are complete, Merryman hopes to gain permission to run clinical trials for treating heart valve disease.

"Aortic valve stenosis, even though it involves only a little piece of tissue, has a catastrophic effect on the heart," Merryman said. "The heart wall weakens. Part of your heart has died. The rest can't do all the work."

As a valve calcifies, the heart pumps harder to push blood through it, enlarging the heart chambers. The result is heart failure and the only treatment has been surgical valve replacement.

About 750,000 Americans per year suffer heart attacks, and those plus all other varieties of heart disease are the No. 1 killers in America. About a quarter of Americans suffer aortic valve stenosis by age 65 and about half by 85.

"We believe there is potential for using this drug at the first sign of valve disease to prevent the progression," Merryman said. "You likely cannot reverse the damage, but we believe the drug can prevent it."

# Cynthia Reinhart-King conducts seminal cellular bioengineering research

Cynthia Reinhart-King is a cellular bioengineer whose seminal work on extracellular matrices has contributed to a breakthrough in understanding tumor formation.

She was the first to show how the matrix, or the non-cellular glue in all tissues and organs, can stiffen when a tumor forms and interfere with the effectiveness of cancer treatments. Her lab has significantly pushed this work on cancer and on atherosclerosis forward by using a multi-scale approach to understand how cells integrate physical and chemical cues within their environment.

The multi-scale approach includes looking at disease progression at the tissue level, the cellular level and the molecular level. "This integrated approach has the power to uncover novel therapeutic targets to slow and perhaps prevent plaque accumulation in arteries or the spread of cancer from a primary tumor," she said.

Reinhart-King, formerly an associate professor of biomedical engineering at Cornell, joined the department in January 2017 and was recently named Cornelius Vanderbilt Professor of Engineering.

"My goal is to move fundamental science applications toward clinical research and patient care. I can do that here," she said.

"The move to the School of Engineering is significant because a world-class medical center is steps from my lab rather than over 200 miles away. This allows me to pair up with physicians and move more quickly towards affecting patient treatment. It's a great collaborative environment," she said.

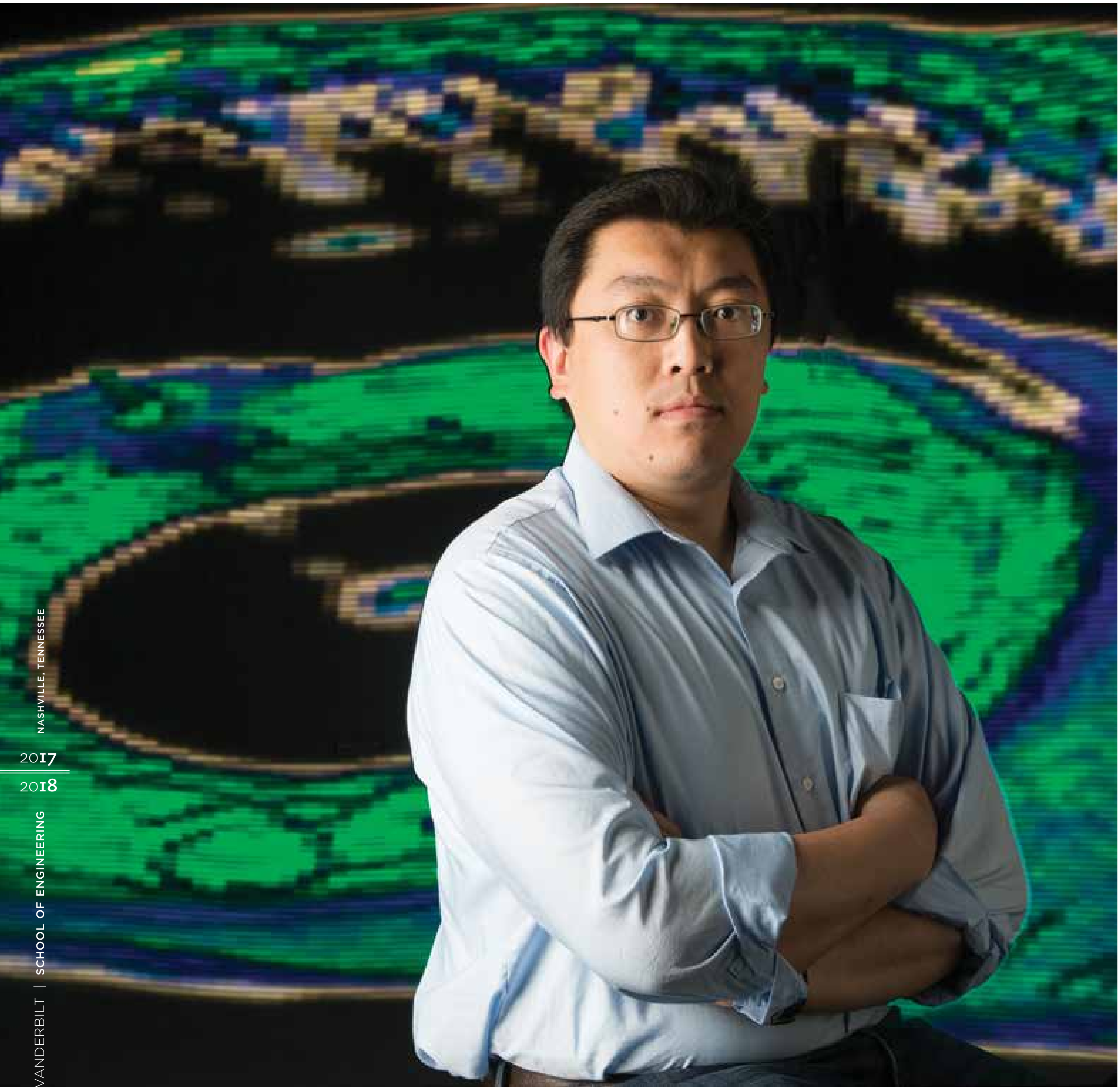
Reinhart-King is currently working with a medical center senior investigator to transition her research into studying diabetic retinopathy, the leading cause of blindness in diabetic patients, which shares many of the same hallmarks as blood vessels in tumors. With a Vanderbilt radiation oncologist, she is taking her cancer research a step further to investigate new therapies to intervene with tumor stiffening and tumor recurrence.

The citations of her cellular bioengineering research number in the thousands. In addition to a number of awards and honors, she is the recipient of a NSF Faculty Early Career Award and the Rita Schaffer Award from the Biomedical Engineering Society (BMES). She is a fellow of the American Institute for Medical and Biological Engineering and BMES and has won numerous awards for teaching and mentoring.

Reinhart-King recently was named a F1000 faculty member. In that role, she helps to identify the most exciting and important research related to the cytoskeleton across the field of cell biology by contributing recommendations and reviews.

Her groundbreaking research and well-equipped lab in Vanderbilt's new Engineering and Science Building brings to the school another important advantage: "It certainly has helped attract terrific graduate students and postdocs."

# New faculty member advances optical imaging and real-time surgery guidance



Yuankai "Kenny" Tao joined a growing department as assistant professor of biomedical engineering, bringing expertise in optical coherence tomography and novel ways for surgical integration of it.

His work will help guide surgeons' real-time decision making while removing damaging scar tissue on the back of the eye that can lead to disorders such as macular holes and retinal detachments.

"Your retina is essentially brain tissue, and we can do imaging of that through the pupil before surgery," Tao explained. "But you have all these neural layers that are on the order of microns. Surgeons need to manipulate these in real time, and that's essentially like manipulating wet Kleenex. They're that delicate and transparent, and seeing them is tremendously difficult, even with the dyes surgeons use to help.

"By integrating optical coherence tomography into surgical microscopes, they can see these semi-transparent structures in high resolution," he said.

Tao, in fact, has helped develop optical coherence tomography. After getting his Ph.D., he joined Jim Fujimoto, the founder of the field, for postdoctoral research. In 2016 Tao moved his Diagnostic Imaging and Biophotonics Laboratory from the Cleveland Clinic to Vanderbilt.

Earlier this year, he and collaborators had two papers published in the Proceedings of SPIE, the professional association for optics and photonics technology. In one, they presented enhancements and new designs for a modular scan head coupled to ophthalmic surgical microscope-integrated and slit-lamp imaging optics. The second showed imaging of tissue deformation and dynamics during simulated ophthalmic surgery, integrating a visualization system for side-by-side views and real-time feedback.

Tao's work also has important applications for cancer margin detection.

He said was eager to get to Vanderbilt and Nashville—the former for the opportunity to work with researchers and clinicians at the Vanderbilt Eye Institute and the Vanderbilt Institute for Surgery and Engineering, the latter for its cuisine—and climate.

## TWO BME PROFESSORS NAMED TO ENDOWED CHAIRS

Two new senior biomedical engineering faculty members have been named to endowed chairs.

Michael King was named the J. Lawrence Wilson Professor of Engineering. King also is chair of the Department of Biomedical Engineering. Cynthia Reinhart-King was named a Cornelius Vanderbilt Professor of Engineering.

Michael King works at the interfaces of cellular engineering, drug delivery and nanotechnology. He uses tools and concepts from engineering to understand medically important processes that occur in the bloodstream. His approach to drug delivery could change the way metastatic cancer is treated.

The current editor-in-chief of *Cellular and Molecular Bioengineering,* Michael King has written textbooks on the subjects of statistical methods and microchannel flows. His research also includes investigations into disease mechanism and how cells respond to fluid forces.

Cynthia Reinhart-King investigates tissue formation and tissue disruption during diseases such as atherosclerosis and cancer.

A recognized leader in biomedical engineering, she has helped uncover how aging-related changes in blood vessel structure and composition contribute to atherosclerosis. She was the first to show how the matrix, or glue that holds cells together, can stiffen when a tumor forms and reduce the effectiveness of cancer treatments.

She is a member of the board of directors of the national Biomedical Engineering Society and served as the program chair of the 2016 BMES Annual Meeting.

Both joined Vanderbilt as BME faculty members in January 2017.

# Biophotonics Center lights the way to earlier disease detection, better surgical outcomes

Taken together, the parathyroid glands are the size of a grain of rice and very difficult to distinguish from the thyroid itself and surrounding neck tissue.

Though tiny, their importance is significant—they regulate the body's calcium levels. In up to 20 percent of the 100,000 thyroid surgeries performed in the U.S. each year, the parathyroid glands are accidentally removed, vastly complicating post-operative treatment.

Led by Anita Mahadevan-Jansen, Orrin H. Ingram Professor of Biomedical Engineering, researchers discovered parathyroid tissue has a much higher fluorescent intensity than surrounding tissues. Their novel optical detection method, licensed to a medical device company, will allow surgeons to see what they previously could not. FDA approval is pending.

Mahadevan-Jansen is director of the Biophotonics Center at Vanderbilt, a trans-institutional effort that focuses on optical guidance, diagnosis, imaging, and stimulation. Working with colleagues in the School of Medicine and the College of Arts and Science, plus existing cross-disciplinary Vanderbilt institutes, its researchers push the frontiers of what can be detected and treated with sophisticated forms of light.

The labs have pioneered the application of pulsed infrared lasers to activate neural tissue without damage or contact. They've developed a non-invasive method of detecting skin cancer, which combines confocal imaging and Raman spectroscopy to diagnose malignancy without taking skin and lesion biopsies.

A separate system detects breast cancer margins in the operating room, and a new method to identify and classify Inflammatory Bowel Disease (IBD) could be incorporated during a routine colonoscopy or when IBD symptoms are present.

Earlier this year, the announcement of the first-of-its-kind sensor, a customized endoscope to detect molecular markers of IBD in the colon, was published in The Optical Society's journal *Biomedical Optics Express*. Earlier detection would benefit many of the U.S. adults with IBD because symptoms are typically fairly advanced by the time of diagnosis.

"With current methods, ultimately the diagnosis is dependent on how the patient responds to therapy over time, and you often don't know the diagnosis until it's been a few years," Mahadevan-Jansen said.

The center has 5,000 square feet of lab space, both core and thematic labs, including spectroscopy/diagnostics, Raman spectroscopy, optical imaging, optical coherence tomography, neurophotonics, high-power lasers, and bioluminescence imaging, plus a state-of-the-art optics teaching lab.

The Biophotonics Center also is taking the lead on a three-year, $3 million effort to build next-generation instruments that exceed the limitations of commercial microscopes.

# BME FACULTY TO LEAD $3 MILLION NEXT-GEN MICROSCOPY DEVELOPMENT

Orrin H. Ingram Professor of Biomedical Engineering Anita Mahadevan-Jansen will lead a three-year, $3 million interdisciplinary effort to build advanced microscopy systems.

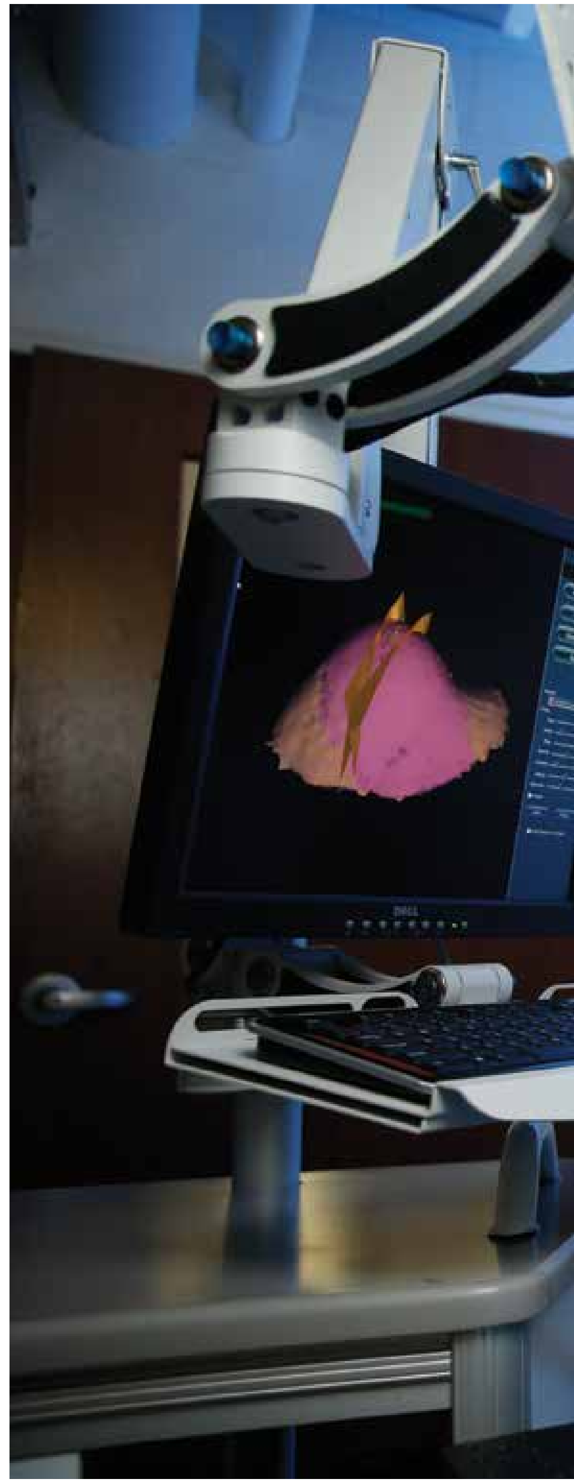
The team will develop next-generation microscopes that exceed the limitations of commercial microscopes while advancing novel techniques that push the boundaries of what scientists can observe and measure with light.

Mahadevan-Jansen, director of the Vanderbilt Biophotonics Center, will be joined by Matthew Lang, professor of chemical and biomolecular engineering, and Duco Jansen, professor of biomedical engineering and associate dean of graduate studies. The collaborative project also includes six scientists from the College of Arts & Science and the School of Medicine.

Called Biomedical Microscopy—Immersion, Innovation, Discovery (BioMIID), the project is part of Vanderbilt University's $50 million Trans-institutional Program (TIP). The five-year investment seeds and expands research and teaching collaborations across disciplines.

The 2017 TIPs grant will provide $1 million a year for three years and encompass research and training opportunities for undergraduate and graduate students as well.

# Institute marries engineering and surgery to fast-track improvements in patient care



A new study by Vanderbilt researchers shows software mapping in the operating room could reduce tracking errors for more than a half-million liver cancer patients who have surgery each year.

The liver and its vital blood vessels shift in the body, while tumors or other masses inside the liver slip around, too. Surgeons already can swab the exposed liver with a special stylus, capturing the shape of the organ during surgery. Its GPS-like ability is better than feeling for tumor and blood vessel location, but even this road map can be off by centimeters.

In a blinded, randomized 20-patient bystander study over the past two years at Memorial Sloan Kettering Cancer Center in New York, surgeons said the new technology improved tumor registration in more than 70 percent of cases. The findings of Michael Miga, Harvie Branscomb Professor, and his team were published July 2017 in the journal *Surgery*.

Such advances are what drive faculty and students in the Vanderbilt Institute for Surgery and Engineering (VISE).

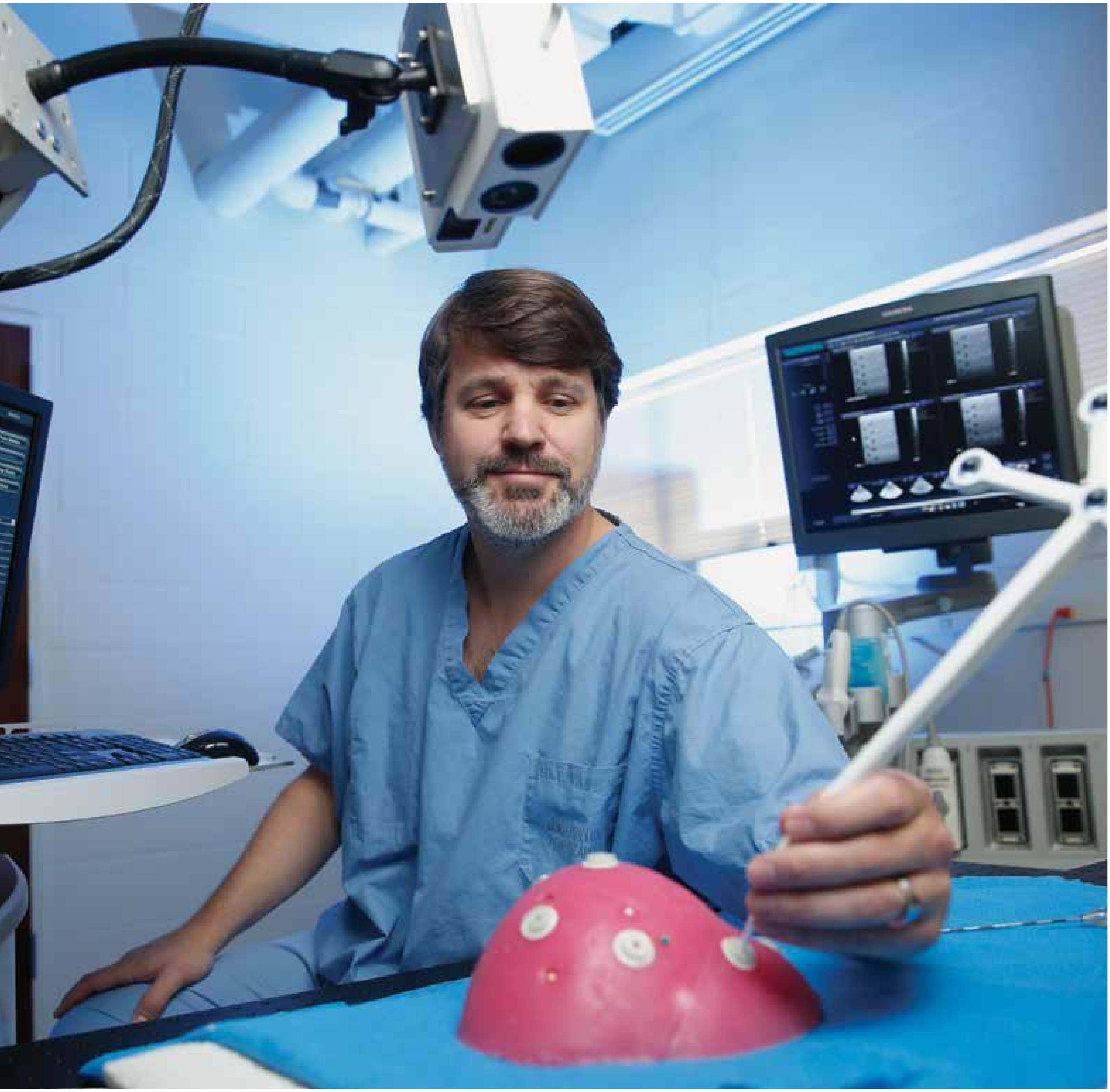
"We are in the business of creating and translating technology to improve the care of patients who walk through our doors now, not 20 years from now," Miga said.

In the case of liver surgery, for example, existing procedures force surgeons to use as much art as science to find tumors and decide how much can be resected while still allowing the liver to grow back. Miga said the new research represents a historic contribution toward soft-tissue, image-guided surgery for the abdomen.

Other VISE projects include needle-sized, tentacle-like robots, advanced manual laparoscopic instruments with wrists and elbows, image guidance for high-accuracy inner ear surgery and abdominal soft tissue procedures, and swallowable pill-sized robots for interventions in the gastrointestinal tract.

Until recently, the advancement of procedural medicine has lagged largely due to the lack of translating BME research. VISE was created to fix the gap. The robust collaboration aims to speed up the conception, development and realization of complex technology and processes in an environment where engineers and clinical practitioners interact daily.

The faculty members include 18 from engineering—biomedical, mechanical, and electrical engineering and computer science—and from 17 medical disciplines. Nearly two dozen active projects also involve more than 50 graduate students, 23 undergraduates, three postdocs, and a staff of eight.



Engineering expertise includes modeling, robotics, imaging, image processing and analysis, devices, system integration, and instrumentation.

VISE was formed in 2011 when a team of Vanderbilt engineers and surgeons came together to formalize the collaborative efforts that they had been previously pursuing informally. Led by Director Benoit Dawant, Cornelius Vanderbilt Professor of Engineering, the initiative was elevated to a formal Vanderbilt institute with more internal funding in 2015.

"We have a culture of leveraging technology to improve patient care," Miga said. "We have a complimentary cadre of medical doctors and engineers who are pushing the needle further in that area and a three-decade history of getting our research out of the lab."

# Advanced imaging targets biological functions to improve disease diagnosis, treatment

Combining biomedical imaging and computational sciences gives researchers and clinicians powerful new tools in understanding—and ultimately treating—cancer, neurological disorders, and other diseases.

At Vanderbilt University of Institute of Imaging Science (VUIIS), cross-disciplinary teams of engineers, basic scientists, medical researchers, and clinical practitioners work side by side and have done so for decades. They are developing ways to track and measure nerve regeneration; use targeted photosensitizers for photodynamic cancer therapy; incorporate novel PET approaches for imaging lung inflammation; and enhance navigation in pancreatic cancer surgeries with a molecular imaging probe.

A big effort involves developing less invasive ways to investigate brain function and pathology.

Earlier this year, for example, a large team led by VUIIS Director John Gore, Hertha Ramsey Cress University Professor of Radiology and Radiological Sciences and professor of biomedical engineering, found that a commonly used brain scanning technique can map electrical activity under the skull as precisely as more invasive methods that rely on probes or electrodes.

The study supports the potential usefulness of the technique, high-field functional magnetic resonance imaging (fMRI), for diagnosing and monitoring treatment of brain injuries, tumors and conditions ranging from epilepsy to psychiatric disorders. Findings of the animal study were published in May 2017 in the *Proceedings of the National Academy of Sciences*.

They found that the technique can accurately map functional connectivity—synchronous fluctuations in the electrical frequencies of two parts of the brain that suggest they are working together—both when the brain is at a resting state and when it is actively engaged.

Gore said the study clarified an uncertainty in the field because fMRI "actually does directly reflect electrical activity—not only where it is but how strong it is."

For surgeons and patients, that means fMRI use may help improve the precision of neurosurgery and monitoring of recovery from spinal cord injuries and brain injuries such as stroke.

VUIIS has its own four-level facility, with multiple dedicated centers of study, including human imaging, small animal imaging, computational imaging, molecular probes and radiochemistry, and analytic software and mobile technology.

Collaborations include developing new MRI technologies to track nerve recovery for patients who've had reconstructive surgery and mapping software for white matter brain regions. VUIIS researchers also have released open-source instructions for focused ultrasound to treat bone metastases, uterine fibroids and prostate tumors.

"It takes a lot of different things coming together for this type of research to be possible," said Mark Does, professor of biomedical engineering and director of the Center for Small Animal Imaging. "Some of the ideas that are being used here have been around for a long time, but you have to have the ideas, the right kind of equipment available and the right collaborators. It's the nature of Vanderbilt."

GPS-911, a partnership of current and former law enforcement officers, sponsored a team of engineering students that devised a sensor-filled bulletproof vest that calls for backup when injured officers cannot.

Company partner and former New York Police Department officer Jim Shepherd wanted a way to keep colleagues safer. He had carried out the grim task of finding fellow officers' bodies in the wreckage of the Twin Towers after the 9/11 terrorist attacks. In many cases, ballistic vests, their names printed neatly inside, were the only identifying feature that survived.

"I thought about how we can get that vest to do something more?" Shepherd said.

The biometric ballistic vest, called HERMES—Health Evaluation and Real-time Monitoring-based Emergency Signaling, monitors the wearer's heartbeat and breathing and calls for backup when it senses an officer has been shot or fallen on the ground. Sensors also indicate the presence of blood, as opposed to sweat or other liquid, by detecting blood sugar.

In a simulation, "our glucose sensor was triggered suggesting the officer was bleeding," said Vivek Shah (BE '17). "The combination of those biometric signals would result in the system alerting central dispatch."

The seven-student team included biomedical, electrical and chemical engineering seniors. Shepherd applauded the work, noting every second matters when an officer's life is at stake.

# Undergrads design ballistics vest that calls for help when police can't


GPS-911 hopes to make the make the vest available to law enforcement officers and departments within the next few years. The goal is a cost of about $100 with a $5 monthly subscription fee per office for the web application.

Demand clearly exists. After several Nashville news outlets featured the project in Design Day coverage, Middle Tennessee police departments began calling students and company reps to inquire when they could place orders.

In an ICU, shrill, frequent alarms disrupt patient sleep, exacerbating stress and disorientation.

What if an in-ear device could block a specific alarm sound—in this case, the "red" crisis alarm from ICU patient monitors—yet not interfere with speech and normal environmental noise?

Three biomedical engineering majors, now Vanderbilt School of Engineering 2017 graduates, tackled the problem. Working under the direction of Joe Schlesinger, a critical care physician and assistant professor of

# BME undergrads, physician team up on ICU alarm-blocking device to improve patient sleep

anesthesiology at Vanderbilt University Medical Center, they used real-time audio signal processing and filters to create a workable in-ear device.

Next, the team simulated an ICU environment using recorded alarms and background noise and then measured quantitative as well as qualitative reactions from classmates who had agreed to be test "patients."

In the simulated ICU, the device produced clinical and statistical improvement in filtering out the alarms and improving participants' ability to hear speech.

Schlesinger and the trio—Elizabeth Reynolds, Brittany Sweyer and Alyna Pradhan—presented their work in June 2017 at Pennsylvania State University to the largest audio research conference in the world. The team's paper, with all three listed as Schlesinger's coauthors, had been accepted as a full presentation at the 23rd International Conference on Auditory Display.

That the BME students achieved such significant results in such a short time and had their work accepted to the premier global auditory conference is impressive, Schlesinger said.

"It far exceeded my expectations," he said. "We wanted to create a way that clinicians would still be alerted to necessary patient alarms, while providing a better environment for the patient's healing process."

The 2016-2017 design team was the third group of biomedical engineering seniors to work with Schlesinger. A new team will continue the work, focusing on a production prototype.

The ongoing nature of the research appealed to Reynolds.

"I really liked the idea of getting to continue and refine a project that is based on a large-scale topic with far-reaching applications," she said. "I also appreciated how the project was easily understood outside the medical field—anyone who has been in the ICU, as either a patient or a visitor, knows that medical alarms are both incessant and irritating."

# Alumnus brings passion, purpose to WiseWear's stylish health tech

WiseWear founder and CEO Jerry Wilmink didn't set out to make jewelry, but once he'd discovered the underlying technology, it made sense.

Wilmink (BE '02, MS '04, PhD '07) had started the first lab to study the biological effects of terahertz

radiation at the Air Force Research Laboratory in San Antonio. It was an extension of his doctoral work applied to a new problem.

More personal—and painful—applications became clear after Wilmink's grandfather died from a fall.

"I got obsessed with solving a problem, and it was a problem much bigger than I initially thought," he said.

More than 27,000 U.S. adults aged 65 and older die from falls each year, and Wilmink started with a biosensing hearing aid that would alert the wearer a fall was imminent based on changes in gait, balance and hydration.

"I got obsessed with creating solutions to prevent seniors from falling—that is what drove me as I converted from 'mad scientist' to an entrepreneur with a vision," he said.

The underlying technology allowed sensing information to be transmitted through metal. With the goal of developing a family of wearable tech devices that improved safety, security, and peace of mind, the leap to jewelry wasn't that big.

A line of "smart" bracelets—WiseWear's first commercially available products—wowed the 2016 Consumer Electronics Show for combining high style with high function.

The screen-free metal bangles have embedded technology for distress messaging, mobile notifications, and detailed health and wellness activity tracking. The bracelet pairs with either Android or iOS, where users get all data. Discreetly tapping it notifies a preapproved list of emergency contacts with a geotagged location.

The metal bracelet itself acts as the wireless antenna. Engineers of all stripes will appreciate what's inside: a haptic motor that creates touch patterns for communication; a custom lithium polymer battery optimized for space and energy density; and an energy efficient microcontroller integrated with tracking sensors.

WiseWear's business model is equally robust. The company's partnership program includes distress messaging for e-911, location services, private security, and asset tracking. In August, a partnership with RapidSOS was announced that will send alerts a data directly to 911 call centers. More is on the way. Next generation products will focus on child safety and be independent of commercial cellular networks. A collection of men's belt buckles with the same features as WiseWear bracelets is envisioned, too.

Wilmink credits Vanderbilt for giving him the foundation it took to invent the tech and become an entrepreneur. He earned his bachelor's and master's degrees in biomedical engineering here, as well as his doctorate.

And he has clear ideas about where technology is headed.

"We want the technology to empower people but not make you stand out—we want it to become invisible," said Wilmink, who also is a member of the new BME External Advisory Board.

## BME FACULTY

### FACULTY

**Adam Anderson,** Professor

**Franz Baudenbacher,** Associate Professor

**Brett Byrum,** Assistant Professor

**Mark Does,** Professor

**Craig Duvall,** Associate Professor

**Todd Giorgio,** Professor

**John Gore,** Hertha Ramsey Cress University Professor of Radiology*

**William Grissom,** Assistant Professor

**Frederick Haselton,** Professor

**E. Duco Jansen,** Professor

**Michael King,** J. Lawrence Wilson Professor; Chair, Biomedical Engineering

**Anita Mahadevan-Jansen,** Orrin H. Ingram Professor of Engineering

**David Merryman,** Associate Professor

**Michael Miga,** Harvie Branscomb Professor

**K. Arthur Overholser,** Professor

**Cynthia Paschal,** Associate Professor

**Cynthia Reinhart-King,** Cornelius Vanderbilt Professor

**Yuankai (Kenny) Tao,** Assistant Professor

**John Wikswo,** Gordon A. Cain University Professor, A.B. Learned Professor

### TEACHING FACULTY

**Amanda Lowery,** Assistant Professor of the Practice

**Christina Marasco,** Assistant Professor of the Practice

**Matthew Walker,** Associate Professor of the Practice

### RESEARCH FACULTY

**Nicholas Adams,** Research Assistant Professor

**Cyndi Clark,** Research Assistant Professor

**Yurui Gao,** Research Assistant Professor

**Mukesh Gupta,** Research Assistant Professor

**Kevin Harkins,** Research Assistant Professor

**Dmitry Markov,** Research Assistant Professor

**Patricia Russ,** Research Assistant Professor

**Veniamin Sidorov,** Research Assistant Professor

**Eric Spivey,** Research Assistant Professor

**Jared Weis,** Research Assistant Professor

### AFFILIATED FACULTY

**Leon Bellan,** Assistant Professor, Mechanical Engineering

**Daniel Brown,** Professor, Radiology*

**Amanda Buck,** Instructor, Radiology*

**Charles Caskey,** Assistant Professor, Radiology*

**James Cassat,** Assistant Professor, Pediatrics

**Eduard Chekmenev,** Associate Professor, Radiology*

**Andre Churchwell,** Levy Watkins, Jr., M.D. Professor of Medicine

**Rebecca Cook,** Assistant Professor, Cancer Biology

**Bruce Damon,** Associate Professor, Radiology*

**Benoit Dawant,** Cornelius Vanderbilt Professor, Electrical Engineering

**Andre Diedrich,** Research Professor, Medicine

**Zhaohua Ding,** Research Associate Professor, Electrical Engineering

**Edwin Donnelly,** Associate Professor, Radiology*

**Richard Dortch,** Assistant Professor, Radiology*

**Dario Englot,** Assistant Professor, Neurological Surgery

**William Fissell,** Associate Professor, Medicine

**Daniel France,** Research Associate Professor, Anesthesiology

*and Radiological Sciences

**Scott Guelcher,** Professor, Chemical and Biomolecular Engineering

**Paul Harris,** Professor, Biomedical Informatics

**S. Duke Herrell,** Professor, Surgery

**Karen Joos,** Ellis Family Professor of Ophthalmology

**Robert Labadie,** Professor, Otolaryngology

**Bennett Landman,** Associate Professor, Electrical Engineering

**Ethan Lippmann,** Assistant Professor, Chemical and Biomolecular Engineering

**H. Charles Manning,** Professor, Radiology*

**Victoria Morgan,** Associate Professor, Radiology*

**Gregor Neuert,** Assistant Professor, Molecular Physiology and Biophysics

**Jeffry Nyman,** Associate Professor, Orthopaedic Surgery and Rehabilitation

**Reed Omary,** Carol D. & Henry P. Pendergrass Professor and Chair, Radiology*

**Aron Parekh,** Assistant Professor, Otolaryngology

**Wellington Pham,** Associate Professor, Radiology*

**David Piston,** Professor, Molecular Physiology and Biophysics

**Jeff Reese,** Professor, Pediatrics

**Baxter Rogers,** Research Assistant Professor, Pharmacology

**Teresa Sanders,** Research Associate Professor, Pharmacology

**Joseph Schlesinger,** Assistant Professor, Anesthesiology

**Seth Smith,** Associate Professor, Radiology*

**Julie Sterling,** Assistant Professor, Medicine

**Wesley Thayer,** Associate Professor, Plastic Surgery

**Eric Tkaczyk,** Assistant Professor, Medicine

**Justin Turner,** Associate Professor, Otolaryngology

**E. Brian Welch,** Assistant Professor, Radiology*

**James West,** Professor, Medicine

**John Wilson,** Assistant Professor, Chemical and Biomolecular Engineering

**Junzhong Xu,** Assistant Professor, Radiology*

**Karl Zelik,** Assistant Professor, Mechanical Engineering

*and Radiological Sciences

## AWARDS AND HONORS SPOTLIGHT

**W. David Merryman,** associate professor, received a $5.3 million R35 Emerging Investigator Award from the National Heart, Lung and Blood Institute. He also was named a 2017 Chancellor Faculty Fellow, a two-year title that includes research funding.

**Craig L. Duvall,** associate professor, received a 2017 Presidential Early Career Award for Scientists and Engineers (PECASE). CMBE named him to its list of Young Innovators of Cellular and Molecular Bioengineering in 2016.

**Michael Miga,** Harvie Branscomb Professor, was appointed to a four-year term on the Bioengineering, Technology, and Surgical Sciences Study Section of the National Institutes of Health Center for Scientific Review.

**Todd Giorgio,** professor, was named Chair of the BMES Public Affairs Committee in fall 2016.

**Michael King,** department chair and professor, was awarded the J. Lawrence Wilson Professor Chair of Engineering.

**Cynthia Reinhart-King,** professor, was named a Cornelius Vanderbilt Endowed Chair and Fellow of the Biomedical Engineering Society.

**William Grissom,** assistant professor, had one of the top five most downloaded articles of 2016 in the *Journal of Magnetic Resonance*: "gr-MRI: A software package for magnetic resonance imaging using software defined radios."

**Megan Poorman,** PhD candidate, won 1st place in the 2017 ISMRM Interventional MR Study Group poster session. She also won a 2016 Whitaker International Summer Award, which supported travel and research at University Medical Center Utrecht.

**Xinqiang Yan,** radiology instructor and PhD candidate, won three awards for his abstracts at the 2017 ISMRM Meeting.

**Meghan Bowler,** PhD candidate, won the Allan D. Callow Young Investigator Award for best poster presentation at the 15th biennial meeting of the International Society of Applied Cardiovascular Biology.

**Francois Bordeleau,** a postdoctoral scholar, was awarded a K99 from the NIH and a scholarship for the Next Generation of Scientists from the Cancer Research Society.

# ADMISSIONS

## UNDERGRADUATE

The Vanderbilt Office of Undergraduate Admissions manages admission to this program. Admissions staff can answer questions, arrange campus tours, provide additional information about degree programs and more.

**Office of Undergraduate Admissions**
Vanderbilt University
2305 West End Avenue
Nashville, TN 37203-1727
Phone: (615) 322-2561 or (800) 288-0432
Website: *admissions.vanderbilt.edu*

**Anita Mahadevan-Jansen**
Director of Undergraduate Studies
Department of Biomedical Engineering
Office: 308, Photonics Center, Keck Laser Center
Email: *anita.mahadevan-jansen@vanderbilt.edu*
Phone: (615) 343-4787
Fax: (615) 343-7919

## GRADUATE

To apply for admission to the biomedical engineering graduate program, you must first meet general requirements for admission by the Vanderbilt University Graduate School. Application may be made electronically here: *vanderbilt.edu/gradschool.* The Graduate School Catalog is here: *vanderbilt.edu/catalogs.*

**Vanderbilt University Graduate School**
117 Alumni Hall
2205 West End Avenue
Nashville, TN 37240 USA
ATTENTION: Biomedical Engineering
(615) 343-2727

**Cynthia Reinhart-King**
Director of Graduate Studies
Department of Biomedical Engineering
Office: 440 Engineering and Science Building
Email: *cynthia.reinhart-king@vanderbilt.edu*
Phone: (615) 875-8309
Fax: (615) 343-7919

# FINANCIAL AID

## UNDERGRADUATE

Vanderbilt is committed to enrolling talented, motivated students from diverse backgrounds. About 65 percent of Vanderbilt students receive some type of aid. Our admissions process is need-blind for U.S. citizens and eligible non-citizens, which means the ability to pay for a Vanderbilt education is not a factor in the admissions process. All need-based aid packages now include scholarships, grants (gift assistance), and employment opportunities in place of need-based loans. This initiative does not involve income bands or income cutoffs that limit eligibility. More information can be found at *vanderbilt.edu/financialaid.*

## GRADUATE

Students wishing to be considered for financial awards administered by the Graduate School should check the appropriate box under "Financial Information" on the online application and make certain that a complete application is received by January 1. Prospective applicants are urged to apply for fellowships or grants from national, international, industrial, or foundation sources. More information can be found at *vanderbilt.edu/gradschool.*

Graduate students in the Department of Biomedical Engineering seeking the Ph.D. degree receive a competitive stipend, tuition waiver, health insurance and reimbursement for some incidental fees. This financial aid can be in the form of a Teaching Assistantship or a Research Assistantship.

Assistantships may be supplemented by a departmental, service-free scholarship or fellowship.

## SUPPORT VANDERBILT BME

Your financial support of the Vanderbilt BME Department can help us advance our mission of producing cutting-edge biomedical engineering research, education, and improvements to human health outcomes. Some initiatives that private gifts make possible include:

- Advanced laboratory equipment for hands-on student design experiences
- Graduate research fellowships to increase diversity and train the next generation of researchers
- Distinguished lectures from leading biomedical engineers
- Student travel awards to enable participation in national conferences

Every gift of every amount is greatly appreciated. For more information about making a gift or pledge to the Vanderbilt University Department of Biomedical Engineering, please contact the School of Engineering Development Office by e-mail (*alumniengineering@vanderbilt.edu*) or at 615-322-4934.

Gifts may also be made directly online at the following link: *vu.edu/supportbme*

**Thank you for your support!**

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