*Joint Department of*

# BIOMEDICAL ENGINEERING

UNC CHAPEL HILL

NC STATE UNIVERSITY

## SPRING / SUMMER 2017

# IN THIS ISSUE

# LETTER FROM THE CHAIR

Nancy Allbritton

## DEAR BME ALUMNI AND FRIENDS:

A major milestone set for UNC/NC State BME at the 2014 conclusion of the six-month strategic planning project was to create and execute a UNC/NC State Joint Department of Biomedical Engineering Charter. I am thrilled to announce that this crucial milestone was achieved as 2016 came to a close, when the Chancellors and Provosts of both UNC-Chapel Hill and NC State University approved and signed the Joint BME Charter. The Joint BME Charter presents a unified and compelling picture to our many stakeholders by establishing a documented protocol for how to make all of the joint-institutional activities of this unique department function.

The BME strategic plan, implemented in 2014, made clear the need for a Joint BME Charter that articulates the long-term framework for a successful operation. BME is a single department embedded in three colleges/schools within the two universities: the UNC School of Medicine, the UNC College of Arts and Sciences, and the NC State College of Engineering. To ensure that BME serves its students properly and maximizes faculty research output, all BME members must work together seamlessly to achieve the Department's goals, irrespective of which university provides the payroll appointment. The Charter establishes the principle of eliminating administrative boundaries that impede the fully integrated operation of BME across the universities. The Charter consists of an introduction articulating the Department's guiding principles along with a series of appendices comprised of memoranda of agreements (MOA) covering specific aspects of BME's operation, which may be amended from time to time as deemed appropriate by each institution. It is envisioned that the guiding principles will be constant over time but that the MOAs will be modified to evolve as the BME Department grows.

The following critical issues are addressed by the Charter:

- Faculty standing at both universities including access to institutional resources and assets;
- Equal access to all facilities, systems, and services at both universities for all BME students with all administrative processes, procedures, and policies supporting that principle;
- Standard operating procedures for BME sponsored projects, overhead distribution, limited submission proposals, and development of intellectual property;
- Cohesive approach to fundraising in collaboration with all relevant foundations of the two universities; and
- Administration by the BME leadership team (initially comprised of the Provosts, Deans, and Chair/Head of BME) to facilitate successful and efficient operation across two universities and three colleges/schools and to address and resolve any inter-university issues that may arise.

UNC/NC State BME combines medicine, science, and engineering to improve lives. Serving this mission, the Joint BME Charter provides a crucial stanchion that supports the bridge between UNC-Chapel Hill and NC State University by establishing interdisciplinary collaboration in all academic endeavors. This BME collaboration benefits both universities, the State of North Carolina and, ultimately, human health.

Sincerely,

Nancy Allbritton MD, PhD

Nancy Allbritton, M.D., Ph.D.
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Dr. Frances Ligler

# LIGLER HONORED AS GREAT INVENTOR BY TWO ORGANIZATIONS

**DR. FRANCES LIGLER**, Lampe Distinguished Professor in the department, has been inducted into the National Inventors Hall of Fame and named as a Fellow of the National Academy of Inventors.

Ligler is a member and past chair of the Bioengineering Section of the National Academy of Engineering. She has more than 400 full-length publications and 31 patents, which have led to 11 commercial biosensor products and have been cited more than 15,000 times. She is the winner of the National Drug Control Policy Technology Transfer Award, the Naval Research Laboratory (NRL) Technology Transfer Award, three NRL Edison Awards for Patent of the Year, and the national Women in Science and Engineering Outstanding Achievement in Science Award.

The National Inventors Hall of Fame recognized Ligler for her innovative application of emerging technologies in a variety of fields to make optical biosensors smaller, more versatile and more sophisticated. Thanks to her work conducted at the U.S. Naval Research Laboratory (NRL), biosensors have moved out of the lab and into use for food safety, disease diagnosis, pollution control and homeland security.

"I am humbled and honored to be in such great company," Ligler said. "As an innovator that enjoyed hands-on, STEM activities in my early childhood years, I look forward to partnering with the National Inventors Hall of Fame to inspire the next generation of STEM innovators, especially young women, who aspire to be inventors in their own right."

A biosensor is a device using biological molecules to detect a chemical or biological target. Ligler developed a new chemistry for attaching biomolecules on sensor surfaces that maintained their functionality far better than prior approaches and then integrated emerging technologies from a variety of fields to make optical biosensors smaller, more versatile and more automated. The resulting biosensors have moved out of the lab and into food production plants, clinics in developing countries, pollutant cleanup sites and areas of concern for military and homeland security.

> ***"I am humbled and honored to be in such great company"***
>
> - Professor Frances Ligler

In 1986, Ligler joined the NRL, where she and her colleagues developed automated biosensors, including point-of-use sensors for continuous monitoring. The biosensors were configured for manual addition of samples (sample in-answer out) or for automated sampling of air while flying on a drone or of water while deployed on an unmanned undersea vehicle. These biosensors provide quick results, identifying and quantifying pathogens, toxins, pollutants, drugs of abuse or explosives.

During Operation Desert Storm, Ligler was instrumental in producing tactical sensors for botulinum toxin and anthrax. Ligler's subsequent incorporation of microfluidic channels and miniaturized optics enabled portable devices into which users could simply inject a sample for testing. With the consequent small size and automation, the Ligler group demonstrated the first airborne biosensor for biological warfare agents. Ligler's group developed the underlying technology for the RAPTOR portable, automated biosensor, tested by NATO for use in analyzing biological toxins and pathogens, and used to test water deliveries to U.S. Navy ships in Bahrain. A more advanced system incorporated an array of biological detector molecules to identify pathogens in food or indicators of disease in clinical samples.

Ligler joined the faculty at UNC and NC State in 2013.

The academic inventors and innovators elected to the rank of NAI Fellow are named inventors on U.S. patents and were nominated by their peers for outstanding contributions to innovation in areas such as patents and licensing, innovative discovery and technology, significant impact on society and support and enhancement of innovation.

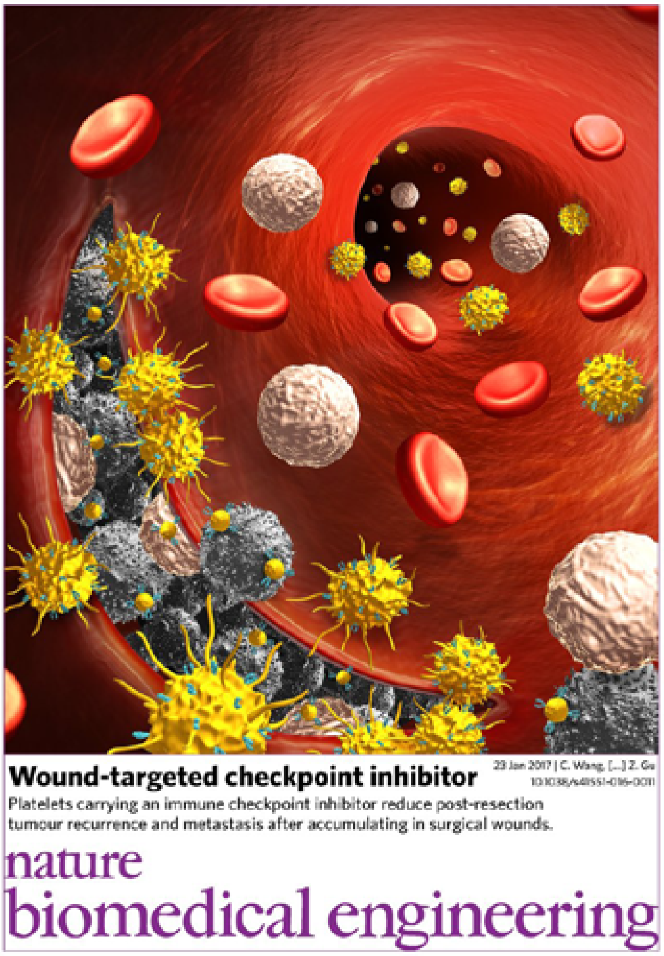
Founded in 1973 in partnership with the United States Patent and Trademark Office, the National Inventors Hall of Fame is a nonprofit organization dedicated to recognizing inventors and invention.

The NAI elects Fellows currently working in academia and nonprofit agencies across the country in order to foster academic invention and has 757 Fellows total. The National Inventors Hall of Fame selects approximately 15 new members/year for inventions that have had a major impact on life in the U.S. since the first U.S. patent in 1790, without regard to whether or not the inventor is still living. There are slightly more than 100 living members, including the seven selected this year. •


Ligler working in the lab with Matt Rich.

# On target

## BME researcher arms platelets to deliver cancer immunotherapy




The research is described in a paper published in *Nature Biomedical Engineering*.

**AFTER SURGERY** to remove a cancerous tumor — even if the surgery is considered "successful" — it's nearly impossible to ensure that all microtumors have been removed from the surgical site. Cancer recurrence is always a major concern.

Meanwhile, tiny blood cells called platelets rush in to start the post-surgical healing process. What if platelets could carry anti-cancer drugs to wipe out any microtumors? UNC and NC State scientists have developed a way to do just that, and they have shown success in animal studies.

"Our goal was to study a new and effective way to treat cancer patients after they have surgery," said BME's Dr. Zhen Gu.

"There has been tremendous interest in developing new, effective strategies to prevent cancer recurrence after surgery. Among them, cancer immunotherapy has received considerable attention. But immunotherapeutic agents do not directly attack the tumor; they use the body's immune system to kill cancer cells."

However, immune cells may be blocked by inhibitory molecules, which serve as checkpoints to alleviate or "turn off" the immune system response, Gu explained. Cancer cells can leverage such mechanisms to escape the immune system response. The cancer cells' defense strategy can be overcome by immune checkpoint inhibitor agents, including anti-PD-1/PD-L1 antibodies - several kinds of which have received fast-track approval from the U.S. Food and Drug Administration (FDA).

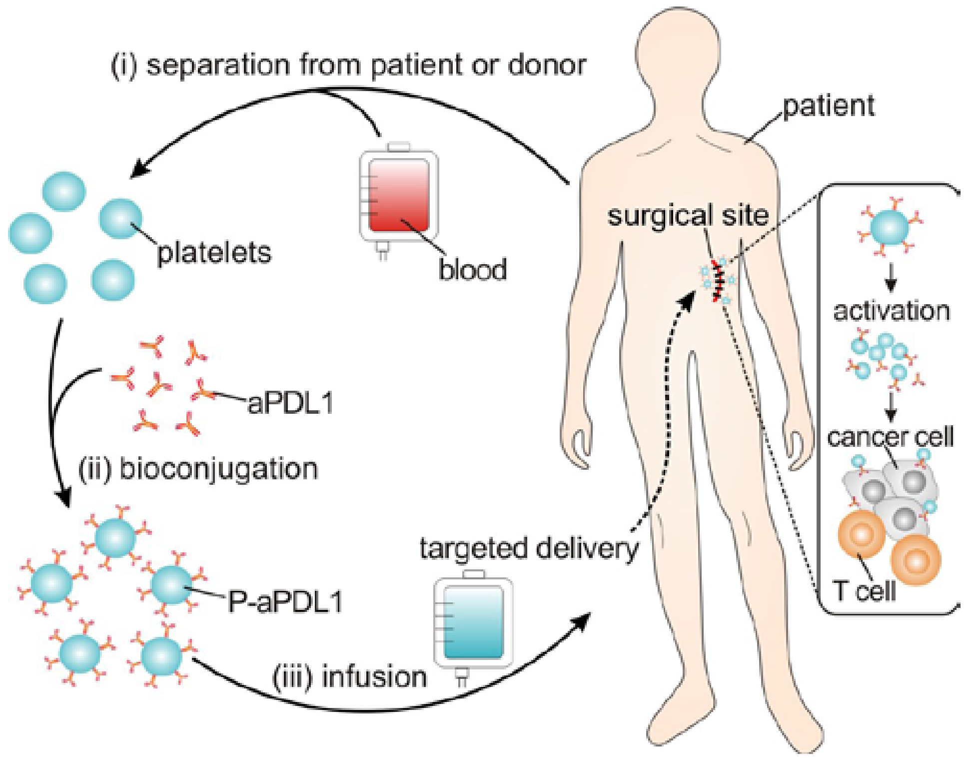
"But challenges remain in order for these inhibitor antibodies to be used effectively in patients," said Chao Wang, Ph.D., the paper's lead author and a postdoctoral researcher on Gu's team. "Currently, the antibodies cannot target the tumor site effectively. The off-target antibodies and overdose usage of antibodies can cause side effects like autoimmune disorders, which can damage normal tissue cells."

To overcome these problems, Gu's research team directly targeted post-surgical residual tumors using immunotherapy, rather than using immunotherapy to nonspecifically bolster the immune system as is the current standard practice. To achieve this, the team engineered a new method of attaching specific cancer-fighting antibodies to the surface of platelets, which then travel to the wound site to kill cancerous microtumors or circulating tumor cells. This way, the negative side effects can be avoided.

Cancer can become deadly after surgery to remove a primary tumor because of the possibility of recurrence at the surgery site and in other parts of the body. There is also a possibility that tumor cells will continue to circulate through the body after surgery.

"We wanted to utilize platelets' intrinsic tendencies to accumulate at wounds and to interact with circulating tumor cells — for targeted delivery of immune checkpoint inhibitors," said Gu. "Interestingly, we found the antibody can be promoted to release from activated platelets in the surgical site, due to generation of small platelet-derived microparticles upon the platelet activation. Also, aggregated platelets can help attract and boost immune cells in the surgical site."

Using animal models (some mice had melanoma tumors; some had triple-negative breast cancer tumors), Gu's team set out to target the tumors with checkpoint inhibitor-laden platelets, which were drawn to the surgical bed to attack the remaining microtumors. To mimic metastasis, Gu's team introduced circulating tumors to the mice, which they were also able to combat.



Schematic of aPDL1 delivery to a patient.

The team used atezolizumab, an anti-PDL1 inhibitor that was recently fast-tracked by the FDA. For the mice that received the treatment — compared to their placebo counterparts — the treatment "significantly" prolonged overall survival after surgery by reducing the risk of cancer regrowth and metastatic spread.

"It's going to be a broader technology to treat a variety of tumors. That's why we applied different cancer types — not just for solid tumors, but for cancers like leukemia," Gu said. "Leukemia is a liquid, circulating tumor, while breast tumors and melanoma are solid tumors - so this is going to be a very broad technology."

In addition to anti-tumor responses, immune checkpoint inhibitors have also been associated with long-term remission in a subset of patients.

"Dr. Gu's work represents an exciting and elegant technological advance in targeted therapeutics for cancer," said Melina Kibbe, M.D., professor and chair of the department of surgery at UNC. "Engineering platelets to release PDL1 via microparticles overcomes several challenges currently facing cancer therapeutics. Specifically, Gu's approach could avoid off-target systemic side effects by allowing for concentrated drug delivery at the site of interest. While much remains to be elucidated with this technology, there is great potential to have a dramatic impact on the care of patients with cancer."

Even after removing the primary tumor, cancer can still be a deadly disease; however, Gu and his team are adamant about helping to negate the risks of post-surgical cancer recurrence.

"We need new approaches to address cancer metastasis and circulating tumors after surgery, and we think we're on the right track using platelets laced with antibodies to kill various types of cancers," Gu said. •


# PRODUCT DEVELOPED BY BME SENIOR DESIGN STUDENTS SEES **SUCCESSFUL COMMERCIAL LAUNCH**

Dr. Andrew DiMeo

**FEW CLASSES** offer real opportunity for students to make a difference, but Dr. Andrew DiMeo's senior design course has proven time and time again that it does just that.

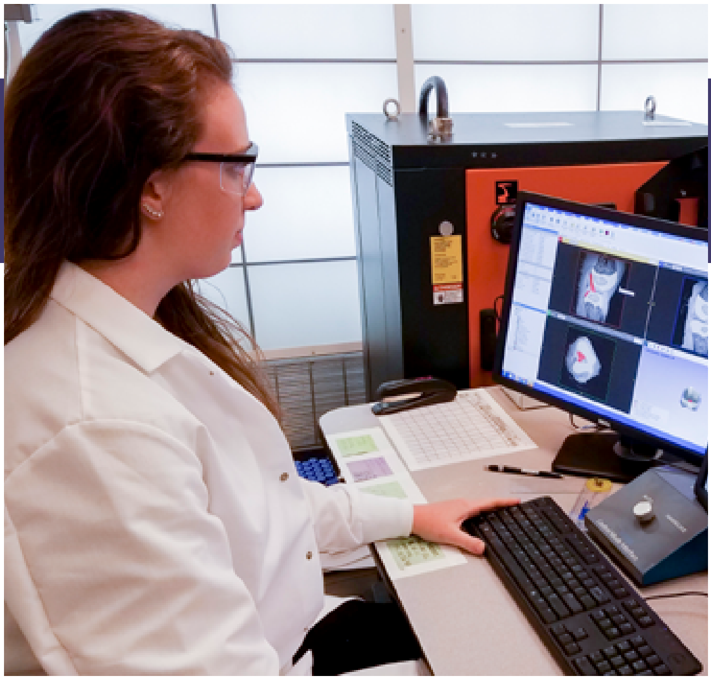
During this course, teams of students develop new and innovative products after shadowing medical professionals and studying real-world biomedical needs. This year, one of those teams saw their class project launch commercially: local company 410 Medical has launched LifeFlow, a rapid infuser used in the resuscitation of critically ill patients.

Denise Witman, Laura Rucker, Ashley Hayes, Alex Eller, and Lizz Davenport made up the five-woman team that shadowed Dr. Mark Piehl (WakeMed Hospitals) in order to develop the first prototype. Once done, Dr. Piehl accelerated development of a commercially viable version, which cleared the FDA in 2016 and has since been used in a variety of local hospitals and doctor's offices. As a result of the positive feedback from these local institutions (the product has been described as "amazing" by users), 410 Medical is expanding its market nationwide.

Not unexpectedly, the launch has attracted the attention of University leaders and news outlets alike. "It's not every day that we get to celebrate the launch of a product that is truly going to save lives," said Kelly Sexton, assistant vice chancellor for technology commercialization and new ventures at NC State. "We are launching, supporting and funding companies that improve our lives and support economic growth here in North Carolina."

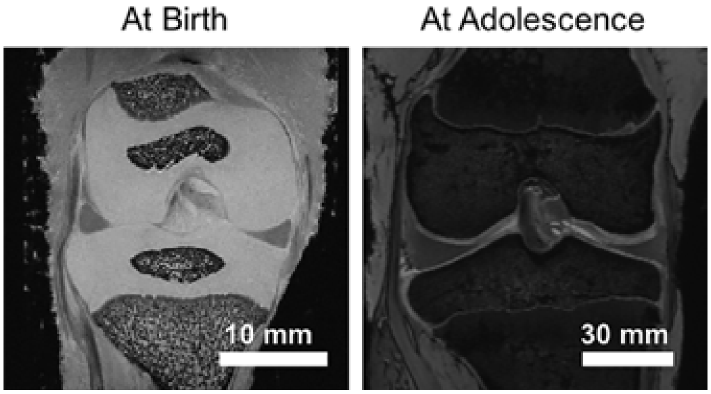
NC State Chancellor Randy Woodson took the opportunity to highlight DiMeo's role in championing the University's Think and Do attitude, calling the achievement "outstanding." In the news, MedGadget and PR Newswire have both run articles about 410 Medical and its life-saving LifeFlow technology.

Denise Witman is now a product manager at Ottobock Health Care in London. Laura Rucker and Ashley Hayes are R&D engineers at Cook Medical. Alex Eller is an associate product manager at Bioventus. Lizz Davenport is a post-doctoral researcher at the University of Texas Southwestern in Dallas. •



Stephanie Cone examines MRI images of pig knees.

# **PIG MODEL** TO HELP RESEARCH ON HUMAN KNEE GROWTH, INJURY TREATMENT




Researchers compared MRI images of pig knees at birth and at adolescence.

**BME RESEARCHERS** and colleagues from UNC and NC State have published research on how the knees of pigs compare to human knees at various stages of maturity — a finding that will advance research by this group and others on injury treatment in young people.

"There's a lot we still don't know about how human knees work at different stages of maturity," says Matthew Fisher, corresponding author of a paper on the research.

"What we've developed is a model that will allow us — or any research team — to study changes in the knee joint using pig knees," says Fisher, an assistant professor in the department.

"Our ultimate goal is to improve clinical treatment of joint injuries in children and teens, given the increased participation in sports and rise of injuries, such as to the anterior cruciate ligament or ACL," Fisher says. "We're specifically focused on changes that take place during the growth process — such as changes in the placement and orientation of ligaments during growth."

Previous research had established that adult pig knees serve as a good model for research into adult human knees. However, less was known about how comparable pig and human knees were at various stages of growth.

For this study, researchers examined pig knees at six stages of growth, between birth and 18 months — which is comparable to early adulthood in humans. The researchers then compared the growth stages found in pigs to the available data on human knee growth.

"We focused on how the orientation of knee ligaments changes over time," says Stephanie Cone, lead author of the paper and a Ph.D. student in the Joint Department of Biomedical Engineering. "And we found that the transitions in ligament orientation we saw in pig knees at various stages of maturity mapped very closely to the existing research on humans at comparable stages of maturity."

"We're excited about the potential for this model, but tracking ligament orientation using MRIs is really only a starting point," Fisher says. "Our next steps include testing the pig knees mechanically in order to help us better understand how they move at various stages of growth: which joint components bear load, how these elements interact, and so on. A number of things change as we mature, but we are still trying to clarify the details — and those details can eventually inform future clinical practice. In fact, surgeons can use the pig model to test new surgical approaches for children and adolescents."

The work was a collaborative effort involving the Joint Department of Biomedical Engineering, College of Veterinary Medicine, and the Comparative Medicine Institute at NC State and the departments of orthopaedics and radiology in the UNC School of Medicine.

"Being able to form a team with expertise in engineering, comparative biology, pediatric imaging and orthopaedics has been extremely valuable to this research and will continue to be important as we move forward," Fisher says. •

Blood thinners are the latest drug being delivered using Gu's micro-needle patch.

# MICRONEEDLE PATCH **SUCCESSFUL** AT PREVENTING THROMBOSIS IN ANIMAL MODEL

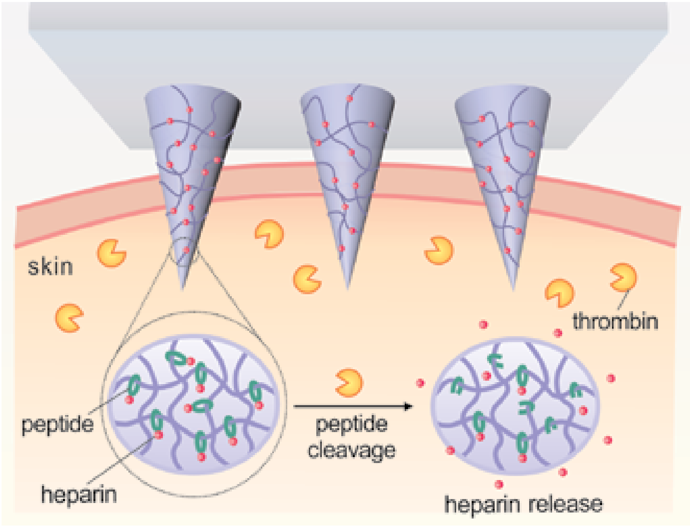
**BME'S DR. ZHEN GU** has been hard at work creating and studying the uses of his "smartpatch" — a patch with hundreds of micro-needles that, when applied to the skin, feels like a band-aid and can deliver drugs directly into the bloodstream.

So far, Gu has been successful at delivering anti-cancer therapeutics and diabetic insulin with varying versions of this patch. Now, he and co-investigators Drs. Caterina Gallippi and Yong Zhu have developed yet another use: delivering blood thinners to prevent thrombosis, or blood clots.

Current methods of blood thinner delivery are far from perfect, as they require regular injections, blood testing, and constant dosage adjustment. Over-medicating could lead to disastrous hemorrhaging, while under-medicating would make the drug ineffective at combating clots. To create a more effective and stable delivery system, the research team created a microneedle patch using a polymer that reacts to the amount of clotting enzyme in the blood. Inside the polymeric microneedles is the drug Heparin, a blood thinner.

When the microneedles are bombarded with elevated levels of clotting enzyme, they begin to break down and release Heparin into the blood stream. Co-leads on the project and subsequent paper are Yuqi Zhang and Jicheng Yu, both Ph.D. students in Gu's lab. According to Zhang, "...the more thrombin there is in the bloodstream, the more Heparin is needed to reduce clotting."

Importantly, a recent animal study model illustrated that the patch was more effective at preventing thrombosis than the traditional method of Heparin delivery (injection). The next steps in the study will be more preclinical testing, for which the team is hopeful.




Schematic of Heparin release into the body.

"We will further enhance the loading amount of drug in the patch. The amount of Heparin in a patch can be tailored to a patient's specific needs and replaced daily, or less often, as needed," says Yu. "But the amount of Heparin being released into the patient at any given moment will be determined by the thrombin levels in the patient's blood."

Effectively, the team has created a self-regulating anti-clotting delivery system — the next step in personalized medicine. •

# SYNTHETIC STEM CELLS COULD **OFFER THERAPEUTIC BENEFITS,** REDUCED RISKS

**RESEARCHERS FROM** NC State, UNC and First Affiliated Hospital of Zhengzhou University have developed a synthetic version of a cardiac stem cell.

These synthetic stem cells offer therapeutic benefits comparable to those from natural stem cells and could reduce some of the risks associated with stem cell therapies. Additionally, these cells have better preservation stability and the technology is generalizable to other types of stem cells.

Stem cell therapies work by promoting endogenous repair; that is, they aid damaged tissue in repairing itself by secreting "paracrine factors," including proteins and genetic materials. While stem cell therapies can be effective, they are also associated with some risks of both tumor growth and immune rejection. Also, the cells themselves are very fragile, requiring careful storage and a multi-step process of typing and characterization before they can be used.

Ke Cheng, associate professor of molecular biomedical sciences at NC State, associate professor in BME, and adjunct associate professor at the UNC Eshelman School of Pharmacy, led a team in developing the synthetic version of a cardiac stem cell that could be used in off-the-shelf applications.

Cheng and his colleagues fabricated a cell-mimicking microparticle (CMMP) from poly (lactic-co-glycolic acid) or PLGA, a biodegradable and biocompatible polymer. The researchers then harvested growth factor proteins from cultured human cardiac stem cells and added them to the PLGA. Finally, they coated the particle with cardiac stem cell membrane.

> ***"We are hoping that this may be a first step toward a truly off-the-shelf stem cell product."***
>
> \- Assocate professor Ke Cheng

"We took the cargo and the shell of the stem cell and packaged it into a biodegradable particle," Cheng says.

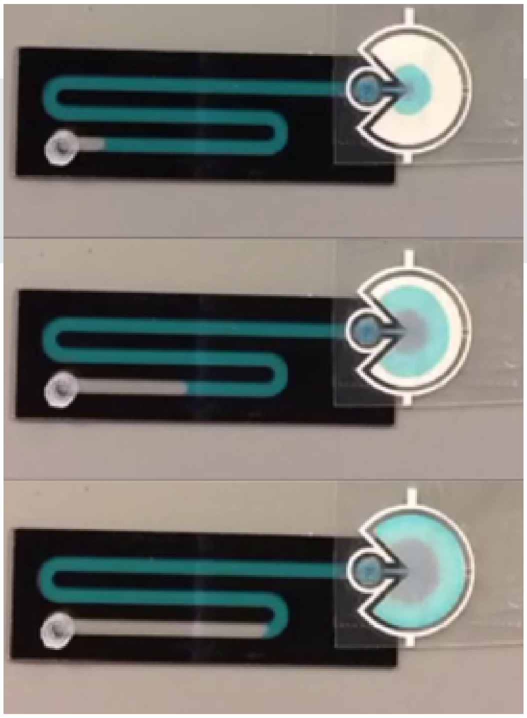
When tested in vitro, both the CMMP and cardiac stem cell promoted the growth of cardiac muscle cells. They also tested the CMMP in a mouse model with myocardial infarction, and found that its ability to bind to cardiac tissue and promote growth after a heart attack was comparable to that of cardiac stem cells. Due to its structure, CMMP cannot replicate, reducing the risk of tumor formation.

"The synthetic cells operate much the same way a deactivated vaccine works," Cheng says. "Their membranes allow them to bypass the immune response, bind to cardiac tissue, release the growth factors and generate repair, but they cannot amplify by themselves. So, you get the benefits of stem cell therapy without risks."

The synthetic stem cells are much more durable than human stem cells, and can tolerate harsh freezing and thawing. They also don't have to be derived from the patient's own cells. And the manufacturing process can be used with any type of stem cell.

"We are hoping that this may be a first step toward a truly off-the-shelf stem cell product that would enable people to receive beneficial stem cell therapies when they're needed, without costly delays," Cheng says. •

# PAPER PUMPS **POWER** PORTABLE MICROFLUIDICS, BIOMEDICAL DEVICES



A hydraulic battery pumping fluid through a simple microchannel.

**BME RESEARCHERS** have developed inexpensive paper pumps that use capillary action to power portable microfluidic devices, opening the door to a range of biomedical tools.

Microfluidic devices are devices that manipulate fluids that have a volume of one microliter or less — volumes substantially smaller than a single teardrop. These devices hold promise for use in applications ranging from biomedical diagnostic tools to drug testing technologies.

"One longstanding challenge to the development of portable, real-world microfluidic device technologies has been the need to find a cost-effective way to pump fluids through the device when outside of the lab," says Glenn Walker, co-corresponding author of a journal article on the work and an associate professor in the department. "Portability is important, because it makes new applications possible, such as diagnostic tools that can be used in the field. Electric pumps, and tubing to connect them, are fine for a laboratory environment, but those aren't easy to take with you."

Now Walker and his collaborators have developed a new way to not only pump fluids through microfluidic devices, but to exert substantial control over that flow. They can stop and re-start the flow, control the rate of the flow, and control how long the flow lasts.

"And, because our approach is a new twist on an age-old technology, our pumps are extremely cost effective," Walker says.

The age-old technology he's referring to is paper.

The researchers call their pumping system a hydraulic battery, but it doesn't involve electricity in any way. Instead, the "battery" draws its pumping power from capillary action.

If you've ever seen a paper towel soak up a spill, you've seen capillary action at work. Broadly speaking, capillary action is the tendency of liquids to be drawn into small spaces by surface tension. In the context of the hydraulic battery, it is the tendency of water — and aqueous liquids, such as blood — to be drawn into the pores found in a piece of paper.

"Our system uses pieces of paper that are 125 microns thick, little more than the width of a single hair," Walker says. "Capillary action pulls a liquid into the paper. And by changing the shape of the paper, we are able to control how much liquid is pulled through an attached device — and how quickly that happens."

The shape can be changed in two dimensions by simply cutting out the paper. But it can also be manipulated in three dimensions by stacking multiple pumps on top of each other.

"By stacking the paper we are able to create more complex flow profiles, depending on the needs for any given application," Walker says. "And any one of these hydraulic battery pumps costs less than a dime."

There are other portable means for pumping liquid through a microfluidic device, but Walker feels that the paper pumps his team has developed hold several significant advantages.

"Our hydraulic battery is small, lightweight, very inexpensive, easy to connect to a device and disposable," Walker says. "In addition, our paper pumps could be saved for later evaluation, such as to run secondary, lab-based tests to confirm on-site diagnoses."

The researchers have filed a patent application on the paper pump technology and are currently looking for industry partners to help bring it to the marketplace.

"We're optimistic that it could make a difference in both public health and advancing fundamental research," Walker says. •

ALUMNI NEWS

# WE WANT TO HEAR FROM YOU

### Former BME undergraduate receives 2017 Gates Cambridge Scholarship

Adriano Bellotti

Adriano Bellotti, former BME undergraduate and current UNC graduate student, has been named as a 2017 Gates Cambridge Scholar. This prestigious program provides full support to the top non-UK students who wish to undertake graduate study at the University of Cambridge. A core tenet of the Gates Scholarship is having a keen interest in social leadership and responsibility, and Bellotti is no exception: while at Cambridge, he plans to study neurophysiology through computational modeling.

"It is wonderful to see Adriano selected for this outstanding award that will help him advance his studies in the development and application of mathematical models to create new biomedical engineering solutions leading to breakthrough clinical treatments and technologies," said UNC Chancellor Carol L. Folt. "I am very excited for Adriano and know his studies at Cambridge will provide an excellent opportunity for him to continue his studies."

### 2016 Journal of Biomechanics award presented to BME graduate Dr. Ben Robertson

Ben Robertson, Ph.D., a former doctoral student working with Dr. Greg Sawicki in the Human PoWeR Lab and now a postdoctoral fellow at Temple University, won the 2016 Journal of Biomechanics Award given by the American Society of Biomechanics for his work conducted at NC State entitled "An in vitro approach for directly observing muscle-tendon dynamics with parallel elastic mechanical assistance."

This award recognizes substantive and conceptually novel mechanics approaches explaining how biological systems function. The awardee is selected by a committee from all submitted abstracts for the 2016 ASB Annual Meeting. It is sponsored by Elsevier Science, Ltd., publisher of the *Journal of Biomechanics*, and comes with an award check and spot to highlight the work as a full article published in the *Journal of Biomechanics*.

### Department spin-off company SonoVol receives NIH grant

SonoVol, a company run by BME Ph.D. graduate Ryan Gessner, was awarded a $1.8 million SBIR grant titled "Development of a mobile and automated platform for multiplexed multi-modality imaging" from the National Institutes of Health. This grant will enable the development of a photoacoustics imaging system and will contribute to the company's continuing development of novel 3D imaging products in the preclinical oncology, cardiology, and tissue engineering space. SonoVol, which has licensed technology out of BME faculty member Paul Dayton's lab, is located at the First Flight Venture Center in Research Triangle Park and has six full time employees, five of which are graduates of UNC or NC State.

### Robin Queen wins Kappa Delta Young Investigator Award

Dr. Robin Queen

The Kappa Delta Sorority, along with the Orthopaedic Research and Education Foundation, has honored 2004 BME graduate Dr. Robin Queen with this year's Young Investigator Award.

The KD/OREF awards are given to musculoskeletal researchers who focus on advancing patient treatment and care for related diseases or injuries. Queen, associate professor of biomedical engineering at Virginia Tech University, was chosen for her outstanding work on the impact of ankle osteoarthritis on balance and gait mechanics.

Kappa Delta established the first-ever award to honor achievements in orthopaedic research in 1947, a tradition that has carried on to include four total awards. •

**Please share your personal and professional milestones with us!**

**To submit an item for the newsletter, send your information to UNCBME@unc.edu. Be sure to include your name and class year.**

# FACULTY NEWS

### Department featured by University System of North Carolina

The BME department has once again been featured by a major educational institution - this time, by the University of North Carolina System.

The feature, found on the system's web site at **northcarolina.edu/news/2017/01/Pioneering-future**, talks in detail about how the marriage between UNC's top-ranked medical school and NC State's blockbuster engineering school has created a first-of-its-kind opportunity for students and faculty members alike.

Having full access to facilities at both locations has allowed for a flurry of innovation and collaboration, all while keeping a focus on patient-centered outcomes. The arrangement has been so successful that universities from across the nation are seeking our advice on how to implement their own joint programs.

Dr. Zhen Gu

### Zhen Gu named 2017 Health Care Hero by *Triangle Business Journal*

Dr. Zhen Gu is brilliant, kind and personable, and is arguably one of the most innovative biomedical scientists in the nation today. *The Triangle Business Journal*, a local publication with a large presence, has taken notice of this and has named Gu as a 2017 Rising Star Health Care Hero.

The Health Care Heroes Awards, now in their 16th year, honor Triangle individuals and organizations for putting innovation and compassion to work to improve the human condition. Gu, along with the other winners, were honored at the annual awards banquet in March.

### UNC Chancellor Carol Folt excited about "biomedical juggernaut"

The Higher Education Works Foundation recently interviewed Dr. Carol Folt, chancellor at the University of North Carolina at Chapel Hill, about the current state of UNC research and what excites her about it. Folt's first response? "There has been a push in the last three years in areas like biomedical — where it's a biomedical juggernaut."

She also praised the UNC Lineberger Cancer Center, which partners with many BME faculty members to produce leading therapeutic research. "We've become a real innovation center, with students, faculty, staff, the community all interested," she said. "We've seen powerful results."

Watch the interview at **higheredworksfoundation.org/2016/10/unc-research**.

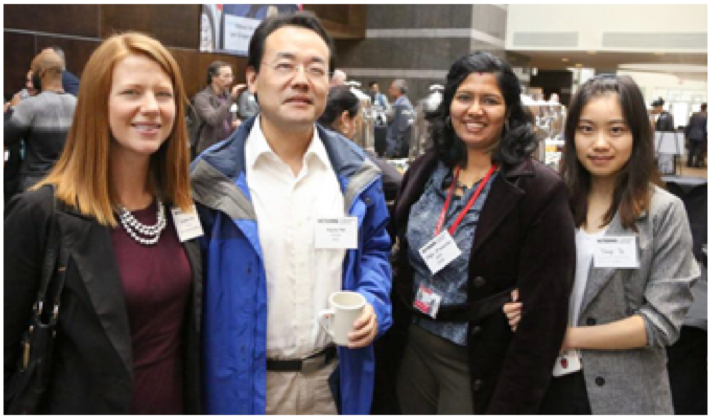
### BME presents lectures, wins awards at NC Tissue Engineering and Regenerative Medicine Symposium

BME Industrial Advisory Board member Peter Johnson chaired the NC Tissue Engineering and Regenerative Medicine Symposium (NCTERMS), a one-day meeting aimed at fostering collaborations in tissue engineering.

Dr. Fran Ligler highlighted the activities of the joint BME department, while Dr. Danny Freytes provided a lecture describing not only his work, but the broader issues surrounding the role of the immune system in tissue regeneration.

Not to be outdone, five BME students won poster awards for their excellent and innovative research. Those students were: Stephanie Cone (principal investigator: Matt Fisher); Seema Nandi (PI: Ashley Brown); Paul Warren (PI: Matt Fisher); Jhon Cores (PI: Ke Cheng); and Amber Hochstapler (PIs: Ashley Brown and Thom LaBean — NC State Department of Materials Science and Engineering). Only 12 awards were given in total.

Dr. Danny Freytes



Erin Sproul, Teng Su, Shilpa Sivashankar, and Yanqi Ye enjoy networking between sessions.

## Game-Changing Research Incentive Program (GRIP) winning team features BME faculty members

Dr. Matt Fisher

NC State announced the winners of its prestigious Game-Changing Research Incentive Program (GRIP), a program dedicated to enhancing forward-thinking and collaborative research. We are excited to report that a team including Drs. Matt Fisher and Fran Ligler was chosen to receive this distinguished award. GRIP was created to spur NC State faculty members to think outside of the box and to stimulate collaborations across college and institutional boundaries. This year, more

Dr. Fran Ligler

than 59 pre-proposals from all 10 NC State colleges were received, accounting for more than 300 NC State faculty members. Six finalists were chosen to give oral presentations to the GRIP scientific and administrative review panel, and just four of these groups were chosen to receive awards based on the merits of the proposed project.

Drs. Fisher and Ligler and collaborators at NC State and UNC-Chapel Hill plan to extend recent innovations in 3D printing and bioprinting by developing a fiber-based printing system that underpins the essential need for mass customization technologies. As an example, Dr. Fisher's focus is on developing patient-specific replacements for the knee meniscus.

"Engineered replacements for tissues, such as the meniscus, require the ability to match the overall size and shape of the tissue as well as microscopic structural features," Fisher said. "Combining 3D printing with traditional nonwovens techniques to make custom fibrous scaffolds allows a unique opportunity to do just that."

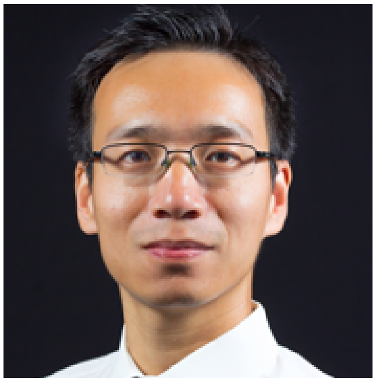
This vision would open up new interdisciplinary areas of research for healthcare and engineering, and can be easily extended to many other applications.

## NC State names Zhen Gu, Ke Cheng as University Faculty Scholars

Dr. Zhen Gu

NC State Chancellor Randy Woodson has announced the 2016-17 class of University Faculty Scholars, and two BME faculty members, Drs. Zhen Gu and Ke Cheng, have been named to this prestigious group of academics.

The University Faculty Scholars program is comprised of top



Dr. Ke Cheng

early- and mid-career faculty members who work to solve society's most pressing problems. Gu and Cheng were nominated by the College of Engineering and were selected by a committee of senior faculty members who evaluated their research and scholarship productivity, excellence in teaching and mentoring and leadership initiatives. They will keep their title for a five-year period and will receive an annual monetary award to support their research.

### American Heart Association honors Ashley Brown with 2016 Scientist Development Grant

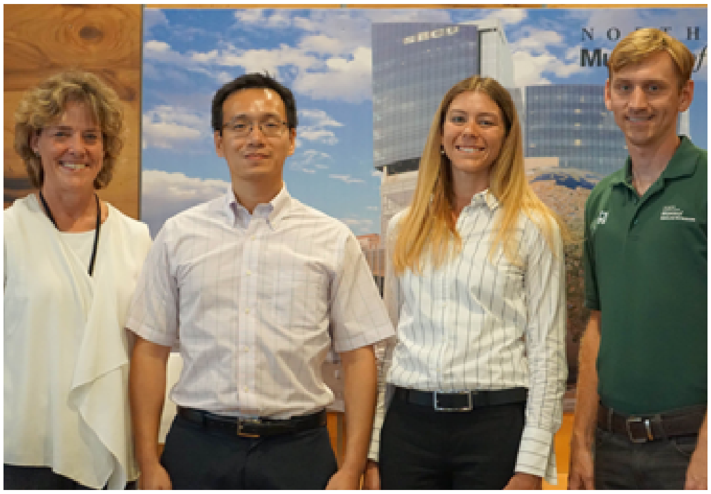
Dr. Ashley Brown

Dr. Ashley Brown, BME's resident heart expert, has received a 2016 Scientist Development Grant from the American Heart Association (AHA). Her proposed study — developing an anti-microbial platelet that fights hemorrhaging, prevents infection and enhances wound healing — has the potential to positively impact millions as bleeding out (with or without infection) is the major cause of death in both civilian and battlefield traumas. The award is given in support of highly promising early-career scientists in cardiovascular and stroke research.

### Ashley Brown and Ke Cheng headline Science Cafe Event at NC Museum of Natural Sciences

The North Carolina Museum of Natural Sciences is known for its public outreach events that make it possible for scientists to speak with the public about their area of expertise. The Science Cafe series is one such example, and recently Drs. Ashley Brown and Ke Cheng were the stars of the show.

On behalf of the Comparative Medicine Institute, an NC State-based collaborative focused on bridging the gap between basic research and clinical applications, Brown and Cheng took the stage and spoke to more than 60 people about their work in regenerative medicine. Specifically, they spoke about the pioneering technologies they are developing to aid in the restoration of cardiac function following a heart-related event (including heart attack and hemorrhaging). Participants at the event were excited about the innovative research, which was evident from the many follow-up questions for the team.



NC Museum of Natural Sciences' Katey Ahmann (left) and Chris Smith (right) welcome Drs. Ke Cheng (center left) and Ashley Brown (center right).

### Department Head Nancy Allbritton featured on National Institutes of Health director's blog

Dr. Nancy Allbritton

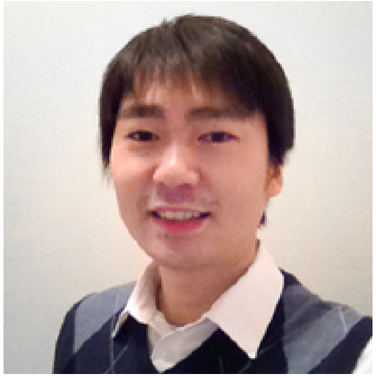
In September, BME Department Head Dr. Nancy Allbritton found herself the subject of the director's blog on the National Institutes of Health (NIH) website.

The post, written by NIH Director Dr. Francis Collins, highlights Allbritton's incredible vision and work on creating a miniature replica colon — a feat considered impossible until very recently. Allbritton and her team, BME faculty members Drs. Shawn Gomez and

Scott Magness and Dr. Scott Bultman (UNC), are first developing a structural matrix in which they will be able to produce highly specialized intestinal cells. In so doing, they will be able to effectively recreate the environment of a human colon. But the team is always focused on the ultimate goal: building a working miniature colon simulacra.

Once this replica colon is fully realized, we will be able to get a behind-the-scenes look into the colon's response to both internal and external stimulations. To modern-day medicine, this means that exploring the side effects of a drug can become a part of a personalized medicine plan; it means that we will be able to study how a patient's body reacts to all types of factors (including dietary changes). The blog post, available at **directorsblog.nih.gov/2016/09/22/creative-minds-making-a-miniature-colon-in-the-lab**, has been shared thousands of times across social media, a testament to just how much impact this research could have on the lives of millions.

### Postdoctoral associate Kota Takahashi published in *Nature's Scientific Reports*


Dr. Kota Takahashi

Dr. Kota Takahashi, a former postdoctoral associate in Dr. Greg Sawicki's Human PoWeR lab, has been published in *Nature's Scientific Reports*. His research into how shoe stiffness impacts the amount of energy required to walk had a surprising outcome: Takahashi and his team found that, on average, a stiff shoe required the wearer to use 13 pounds more energy effort than if the shoe was flexible. He expected to find that stiff shoes required less energy from the wearer, since increased shoe stiffness has been shown to improve athletic performance. Now a faculty member at the University of Nebraska at Omaha, Takahashi is continuing his research into human movement analysis and would like to study different shoe components in order to present a more complete picture of the relationship between shoe structure and gait. The paper, "Adding Stiffness to the Foot Modulates Soleus Force-Velocity Behaviour during Human Walking," was published in July 2016.


Dr. Danny Freytes

### NC TRaCS pilot grant awarded to BME faculty member Dr. Danny Freytes

The NC Translational and Clinical Sciences Institute (NC TRaCS) has recently announced the winners of its 2016 Pilot Grant cycle, and BME's Dr. Danny Freytes has been awarded one of the few grants given this year. His proposal to develop a testing platform to study the interaction between inflammation agents and repair cells is just the first step to bettering our response to muscle injuries (cardiac and skeletal). The NC TraCS Institute Pilot Grant Program was created to facilitate the transfer of research findings to clinical practice in order to improve the health of North Carolinians, and encourages novel clinical and translational research.

### Jason Franz featured on cover of *Exercise and Sports Sciences Reviews*


Dr. Jason Franz

Recently published work from BME faculty member Jason Franz has been selected as the feature publication in the fall issue of *Exercise and Sports Sciences Reviews* (ESSR), a preeminent journal of the American College of Sports Medicine. The paper, titled "The age-associated reduction in propulsive power generation in walking," proposes a paradigm change in our understanding of mechanisms governing mobility decline in old age and novel directions for more effective clinical countermeasures.

As the feature publication and issue cover, the article is accompanied by a video abstract, accessible at **http://bit.ly/2rwrfE1**

## Divers Alert Network grant awarded to Virginie Papadopoulou

Dr. Virginie Papadopoulou

The Divers Alert Network (DAN) has selected BME postdoctoral researcher Dr. Virginie Papadopoulou as the 2017 recipient of the R.W. Bill Hamilton Memorial Dive Medicine Research Grant. The program was begun in honor of Dr. Bill Hamilton, a world-renowned physiologist, and seeks to fund projects that advance diving science and reduce the incidence of decompression sickness.

Papadopoulou will use this funding to refine how ultrasound can be used to monitor diving decompression stress. She hopes that this line of research will help the development of new personalized decompression models that could account for individual physiology. The project expands upon her current research in the Dayton Lab, which addresses ultrasound imaging and cancer therapies using special microbubble contrast agents. For more information on Papadopoulou's research, visit **virginiepapadopoulou.com/research.html**.

## Naji Husseini receives 2017 Gertrude Cox Award for innovative teaching

Dr. Naji Husseini has been chosen as one of three recipients of the 2016-2017 NC State Gertrude Cox Award for Innovative Excellence in Teaching and Learning with Technology. Husseini, a lecturer in BME since 2015, was nominated by the department for his commitment to creative and innovative teaching and learning practices. His students rave about his BME 201 lab, in which they learn how to program using MATLAB software. Instead of using mostly simulated data, as most MATLAB courses do, Husseini uses real-time data with the help of Raspberry Pi, a small computer. The Raspberry Pi allows for easy data acquisition and input, so now his students can capture real-time data, process it in MATLAB, then use it for real biomedical applications.

Husseini, left, receives the Gertrude Cox Teaching Award.

This approach makes the labs more interactive and bridges the gap between data acquisition, processing, and output; most labs do one or two of those, but real-life applications do all three. It also allows for students to be introduced to more advanced biomedical applications earlier in their careers, meaning they are more equipped to handle complex biomedical problems than most of their peers. And, since the equipment for this lab is so cost-effective, Husseini is able to teach more students than ever before.

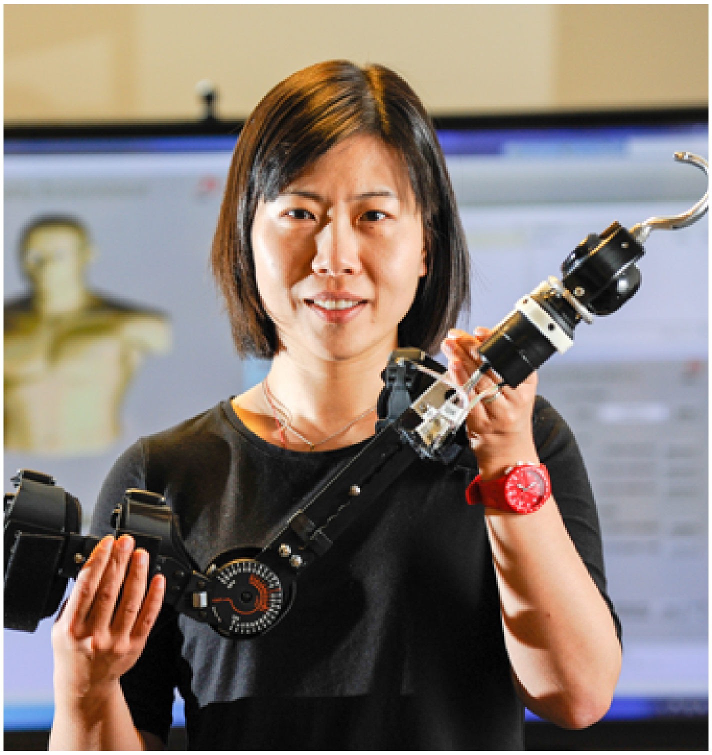
This is the first time a BME faculty member has received this award, and the first time in eight years that the College of Engineering has had a winner. Provost Warwick Arden presented the award at a celebratory event in April.

## Nancy Allbritton honored as 2017 UNC Chapel Hill Inventor of the Year

Dr. Nancy Allbritton

On April 20, 2017, Department Head Dr. Nancy Allbritton was honored as the 2017 Inventor of the Year at the Celebration of Inventorship at UNC Chapel Hill. Her academic research has resulted in technological advancements that address a multitude of unmet needs in biomedical applications such as cell sorting, cell cloning, organ on a chip and cell signaling evaluation. As a result of commercializing a number of these advancements, she has launched no fewer than four start-up companies in the Research Triangle. Allbritton is an avid proponent of interdisciplinary and collaborative research, and as such has developed an industry-leading department that reflects these same values.

## Science Cafe features Neuromuscular Rehabilitation Engineering Lab



Dr. Helen Huang

Every week, the NC Museum of Natural Sciences holds the Science Cafe, an event that showcases the state of science in today's society.

Dr. Helen Huang and Neuromuscular Rehabilitation Engineering Lab members Andy Brandt and Stephanie Huang were invited to present "The Bionic Human: Making Fantasy a Reality." Their talk delved into the fantasy world of bionic humans and how close we are today to achieving prosthetics that mimic these superhuman-like qualities, especially for amputees. The hour-long event was applauded as "one of the best Science Cafe events" yet.

Watch their talk at **livestream.com/naturalsciences/Cafe/videos/152487648**.

## Gu receives Alcoa Foundation Engineering Research Award

Dr. Zhen Gu, center, receives the Alcoa Foundation Engineering Research Achievement Award from Dr. Louis Martin-Vega, left, and Dr. Douglas Reeves, right.

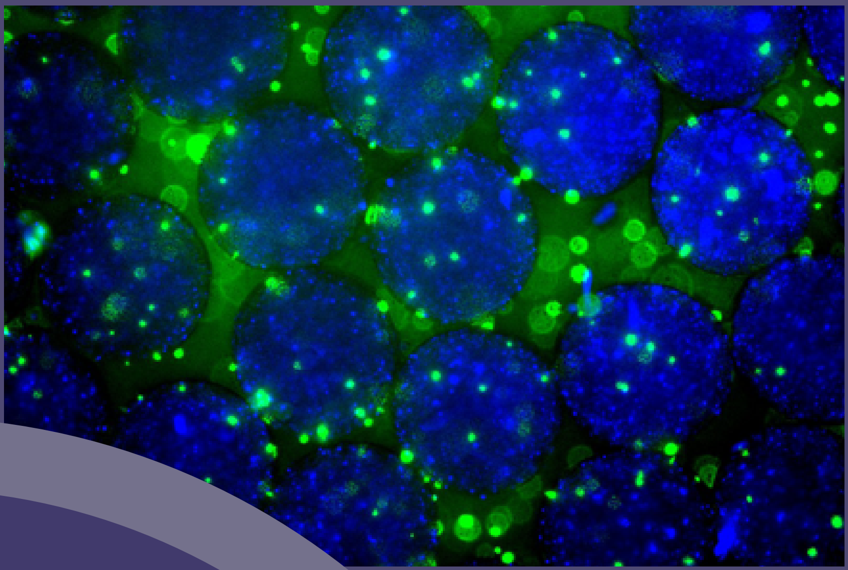
Dr. Zhen Gu received a 2017 Alcoa Foundation Engineering Research Award during the spring faculty meeting of the College of Engineering at NC State.

Gu was awarded the Alcoa Foundation Engineering Research Achievement Award, which recognizes young faculty members who have accomplished outstanding research achievements during the preceding three years.

Gu's accomplishments in developing novel material and biological chemistry tools to address important questions in controlled drug delivery are impressive and internationally known. His groundbreaking contributions at the interface between drug delivery and materials science have resulted in inventions including a smart insulin patch, liquid metal nanomedicine and immune blockade platelets. Focused on developing new stimuli-responsive drug delivery systems, such as glucose-responsive insulin delivery and tumor microenvironment-triggered programmable anticancer drug delivery, he has independently published around 70 research papers in high-profile journals, such as *Nature Communications* and *Nature Biomedical Engineering*. Most recently, he was selected as a TR35 Global Young Innovator by *MIT Technology Review*.

Dr. Michael Dickey, professor in the Department of Chemical and Biomolecular Engineering, received the Alcoa Foundation Distinguished Engineering Research Award, made to a senior faculty member for research achievements over a period of at least five years at NC State. •

# YANQI YE WINS **BEST PAPER AWARD** AT ANALYTICAL INSTRUMENTATION FACILITY SYMPOSIUM



Pancreatic cells in microcapsules.

**YANQI YE**, a BME graduate student working with Dr. Zhen Gu, accepted the Best Paper Award given by the NC State Analytical Instrumentation Facility (AIF) at the Joint AIF Symposium.

The paper, published in *Advanced Materials*, is titled "Microneedles integrated with pancreatic cells and synthetic glucose-signal amplifiers for smart insulin delivery" and discusses the use of a microneedle patch that allows for diabetic drug delivery. •

### Jeremy Nortey receives Cato T. Laurincin Travel Fellowship

Jeremy Nortey

The Society for Biomaterials (SFB) has selected BME junior Jeremy Nortey to receive this year's Cato T. Laurincin Travel Fellowship, a program that supports under-represented minorities in the field of biomaterials. Nortey has more than illustrated his deservedness for this award while working under the mentorship of Dr. Ashley Brown in the Advanced Wound Repair Lab at NC State.

The fellowship includes registration to the SFB Annual Meeting and Exposition in Minneapolis, airfare, hotels, transfers and meals. In addition, Nortey will be given a complimentary membership to the Society and will be assigned a mentor to guide him through the annual meeting, who will also help him pursue his advanced degree and career goals.

### Undergraduate team selected to compete in global health competition

H3 Global, a team of BME undergraduates, has been selected to attend and compete in the Seventh Annual Undergraduate Global Health Design Competition. Hosted by Rice University, this event will feature student-developed technologies that address the pressing global health challenges of our time.

Each team is required to enter both oral and poster presentations relating to their technology design. Entries will be judged on the quality of problem definition, the effectiveness and potential impact of the design solution, and the likelihood that the solution can be successful in improving healthcare delivery in low-resource settings.

### NC State BME undergraduates earn Office of Undergraduate Research grants

Two BME undergraduate students have been awarded NC State Office of Undergraduate Research Grants.

Elizabeth Easter, a senior housed in the Department of Materials Science and Engineering, will be working with Dr. Jacque Cole on her project entitled "Validating laser Doppler flowmetry for in vivo longitudinal measurements of bone blood perfusion."

Elizabeth Easter



Harsha Pinnamaraju

Harsha Pinnamaraju, a senior based in BME, will also be working with Dr. Cole on the project "Characterizing osteovascular structure and function in murine bone post-stroke."

These awards are intended to help students offset the cost of equipment, supplies, software, publications and transportation as they work toward completing student research.

### BME team selected as finalists for international venture competition

News from BME's Senior Design studio continues to impress. Christopher Lynch, Erica Lenzen, Gabrielle Hochu, Hannah Kausche and Wyatt Robinson have been selected as finalists for the 2017 Richards Barrentine Values and Ventures Competition.

The mission of this program is to help develop "ethical leaders with a global perspective by encouraging student entrepreneurs to develop for-profit enterprises that impact society in meaningful ways." The team traveled to Texas Christian University in April to compete against teams from schools around the world in order to win start-up funding for their proposed venture.

In the United States, two million people are intubated for breathing assistance in intensive care units (ICU) every year. Of these patients, 540,000 develop ventilator-associated pneumonia (VAP), a potentially

From left, Wyatt Robinson, Gaby Hochu, Erica Lenzen, Hannah Kausche and Chris Lynch.

lethal and highly expensive illness, extending hospital stays and cost. NovaNervus aims to reduce the incidence of VAP through redesigning the endotracheal tube used for intubation.

Specifically, NovaNervus will redesign the balloon-like cuff at the end of the tube. Currently, the endotracheal tube is guided into the throat and, once fully inserted, the balloon-like cuff is inflated. This balloon holds the tube in place and attempts to prevent micro secretions from slipping down the throat and into the lungs. If the secretions make it into the lungs, the microbes in these secretions can cause pneumonia.

The new design by NovaNervus will remove the balloon, replacing it with a 3D-printed cup and attempting to prevent secretions from passing into the lungs. NovaNervus is targeting 15 percent of the market share for endotracheal tubes used in emergency rooms and ICUs in the United States, reducing cost for patients and hospitals.

## BME students take home 2017 National Science Foundation fellowships

Two BME students have received National Science Foundation (NSF) fellowships and two more received honorable mentions.

Graduate student Kathryn Moore, along with former undergraduate Michaela Rikard, have both been awarded a 2017 NSF Graduate Research Fellowship. Emily Mihalko and Kristina Rivera, both current graduate students, received honorable mentions.

The program is the oldest graduate fellowship of its kind, recognizing outstanding graduate students in science, technology, engineering and mathematics disciplines who are pursuing research-based master's and doctoral degrees.

Only 2,000 fellowships are awarded each year. Fellows benefit from a three-year annual stipend along with an allowance for tuition and fees, opportunities for international research and the ability to conduct research at any U.S. institution they choose.

## Jicheng Yu honored with inaugural UNC Horizon Award

BME graduate student Jicheng Yu has been selected as a recipient of the inaugural Horizon Award given by the UNC Graduate School.

The award recognizes an outstanding graduate student who holds extremely high potential for making a significant contribution to the educational, economic, physical, social or cultural well-being of North Carolina citizens and beyond. Yu, mentored by BME faculty member Dr. Zhen Gu, worked on the 'smart' insulin patch for diabetes management. The Horizon/Impact Awards Selection Committee, comprised of faculty members from across the UNC campus, chose Yu's project due to its exceptional quality and impact.

Yu was honored at the Graduate Student Recognition Celebration in April 2017, where he had the opportunity to present his work to the campus community and visiting state legislators. He also received a plaque commemorating the remarkable achievement. •

*Joint Department of*
# BIOMEDICAL ENGINEERING

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## UNC/NC State Private Giving Opportunities

The UNC/NC State Joint Department of Biomedical Engineering seeks private investment to capitalize on the collegial and fertile inter-institutional environment between UNC-Chapel Hill and NC State to become the best BME department worldwide. Private gifts will enable the Department to make strategic investments to bring in and keep the best people, launch bold new research and academic programs, and seed a culture of innovation through state-of-the-art labs on both campuses. With this investment, UNC/NC State BME will expand three core Department-wide initiatives.

### INITIATIVE 1: Be the world-renowned leader in research

We have created an unprecedented collaborative environment that promotes seamless exchange among engineers, clinicians and scientists.

PROMOTE COLLABORATION AND RESEARCH

To attract world-class scientists and engineers to North Carolina and expand our high-impact research and training programs, the Department seeks to add six endowed professorships (three at NC State and three at UNC). The Department will also showcase its research and faculty, the universities and the state by sponsoring an international scientific meeting (held in North Carolina), as well as a distinguished lecture series.

### INITIATIVE 2: Recruit and educate exceptional students

BME is committed to educate a new generation of biomedical engineers expressly equipped to meet the complex yet vital societal challenges impacting the health of our nation.

INVEST IN EDUCATION AND ENTREPRENEURSHIP

To increase educational competitiveness, BME seeks funds to provide graduate and undergraduate fellowships and scholarships to students. Funds supporting our international exchange program will support our students to gain global experiences so that they are "market ready" upon graduation. BME seeks the infrastructure to provide continuing education to the citizens of North Carolina through the creation of a Professional Science Master's degree in medical technologies.

### INITIATIVE 3: Translate technology into economic growth

Our goal, which permeates every function of BME, is to create and translate practical solutions to health care needs. Students are taught not only the skills of the life sciences and engineering, but are also provided with hands-on experience in interdisciplinary teamwork. Faculty members collaborate with companies and also start new ones.

### Seed technology transfer

To enhance technology translation and speed the transition of new technologies to the marketplace, BME seeks funding to increase the department's capacity to move new product designs out of the laboratories and to encourage greater entrepreneurship among faculty and students. In addition, a new BME Innovation Fund will be endowed to fund new faculty members and student research projects, departmental initiatives including international conferences, student and faculty professional development and ongoing department-wide strategic planning.

For more information about these and other opportunities to invest in UNC/NC State BME's mission to unite engineering and medicine to improve lives, please contact Jack O'Daly at **jpodaly@ncsu.edu** or **919.513.7889** or **919.843.6338**.