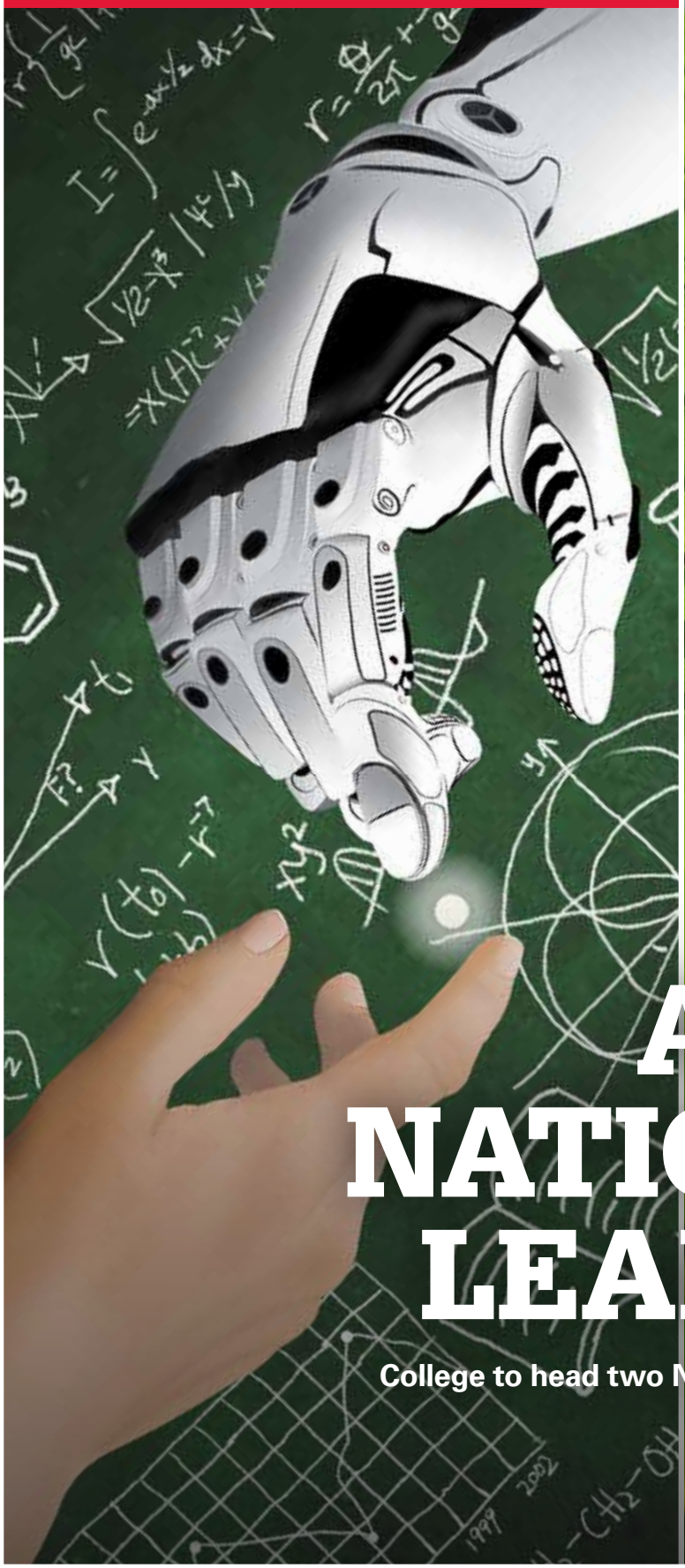
NC STATE Engineering

MAGAZINE FALL / WINTER 2021



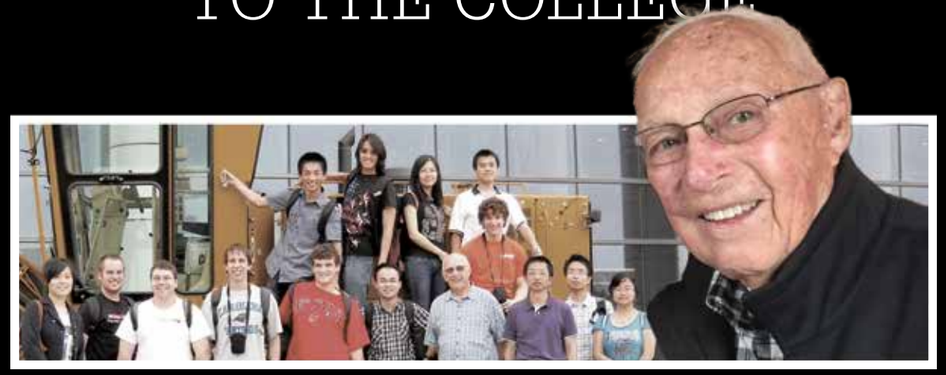
A NATIONAL LEADER

College to head two NSF research centers

Celebrate our College during the dedication of the new Fitts-Woolard Hall on Oct. 29

HOMECOMING • PAGE 32

ZOROWSKI ESTABLISHED A LEGACY OF SERVICE TO THE COLLEGE



ZOROWSKI SHOWN WITH AN ENGINEERING STUDY ABROAD GROUP AT A CATERPILLAR, INC., FACILITY IN SUZHOU, CHINA.

Carl Zorowski, Reynolds Professor Emeritus in the Department of Mechanical and Aerospace Engineering (MAE) at NC State, passed away on Monday, April 5, 2021.

During a nearly 60-year career in the College of Engineering at NC State, Zorowski was an influential figure in the classroom, in the laboratory, in the halls of the College's administration and in the business community. His lifelong love of learning and innovation and his dedication to his students served as a shining example for faculty members in the College.

"Carl's impact on MAE and on our College was very significant over the five-plus decades that he served as a faculty member and administrative leader at NC State," said Louis Martin-Vega, dean of the College. "He was a very warm, generous and caring person who will be missed greatly by those of us in COE who were fortunate to have gotten to know him as a dear colleague and friend."

In 2015, Zorowski was the inaugural winner of the College's Faculty Distinguished Service Award.

A three-time graduate of the Carnegie Institute of Technology (now Carnegie Mellon University), Zorowski joined the NC State faculty in 1962.

He was an innovator for the College from the start, bringing with him experience with senior design competitions that allowed graduating students a chance to gain real-world experience by designing and building a prototype.

Zorowski served as head of MAE, as the College's associate dean for academic affairs and as co-founder and director of the Integrated Manufacturing Systems Engineering Institute (IMSEI), along with work as a consultant to industry. In 1993, he assumed direction of Southeastern University and College Coalition for Engineering Education, a multi-million-dollar National Science Foundation program geared toward revitalizing undergraduate education.

Zorowski co-founded IMSEI in 1983 to offer multi-disciplinary education and practical training opportunities in the theory and practice of integrated manufacturing systems engineering at the master's level.

In 2007, he started a study-abroad program for engineering students in partnership with Zhejiang University in Hangzhou, China. Students in the program are able to take engineering, international relations and Chinese language courses during a five-week stay. They also work on a design project with Caterpillar, Inc. at one of the company's manufacturing facilities nearby.

In retirement, he was able to spend more time on his twin passions for amateur motorsports and travel with his wife, Louise.

MAE has created a new lecture series in mechanical engineering design. After a delay because of the COVID-19 pandemic, the first Zorowski Lecture was held on September 10, 2021, with Michael Sutton, distinguished professor at the University of South Carolina. Subsequent lectures will be held annually in April. ■

Chancellor's Innovation Fund supports research commercialization

Research breakthroughs from the College of Engineering lead to society-changing products and startups. To help faculty members move their research project to the market, the Chancellor's Innovation Fund (CIF) provides funding to short-term, commercially focused projects. For every dollar awarded, almost $20 has been generated in additional funding or investment.

This year, all six projects that received grants have ties to the College or its affiliated departments.

From the UNC / NC State Joint Department of Biomedical Engineering, **Yevgeny Brudno**, assistant professor, and **Michael Williams**, professor of practice, are shortening the production time of developing Chimeric Antigen Receptor T cells that are used to treat cancer — lowering the cost of the treatment.

In the COE-affiliated Department of Forest Biomaterials, **Lokendra Pal**, associate professor, and **Lucian Lucia**, professor, are conducting pilot and commercial trials of a wood-based alternative to plastic.

Cheryl Xu, an associate professor in the Department of Mechanical and Aerospace Engineering, aims to reduce the thickness of and simplify the manufacturing process of the tougher material she developed to coat stealth jets.

In the Department of Chemical and Biomolecular Engineering (CBE), Ph.D. student **Scott Collins** and his advisor **Chase Beisel** are furthering their new CRISPR editing technique that could make gene therapies safer.

Milad Abolhasani, associate professor in CBE, will develop the next generation of his "Artificial Chemist" technology, which uses machine learning to more quickly manufacture quantum dots.

A microfluidic device developed by **Michael Daniele**, associate professor in the Department of Electrical and Computer Engineering, might be able to mimic the blood-brain barrier and more accurately predict whether drugs that treat brain diseases can cross that barrier. ■

FROM THE **DEAN**

The beginning of this new year has brought back some of the joy, energy and annual traditions that those of us on campus so look forward to as a fall semester begins, along with a number of continued challenges.

We were delighted to welcome back our students in August with first-year students moving into dormitories and most of our instruction taking place in the classroom. While our campus is the busiest that it's been since February 2020, the impact of the Delta variant of COVID-19 has also required our University leaders to implement a number of ongoing safety protocols. You can learn more by visiting **ncsu.edu/coronavirus**.

Notwithstanding the many unprecedented challenges we have faced over the last 18 months, I am very proud of how our students, faculty members and staff members have not only persevered, but thrived.

That applies especially to our research efforts. We've long made planning and leading major research institutes and centers a priority for our faculty. Your College leads more than 20 such centers and institutes and is one of only two engineering schools in the United States to ever take the lead role in two National Science Foundation (NSF) Engineering Research Centers at the same time.

I'm very pleased to tell you that those efforts have continued despite the challenges of the pandemic, and to great success. This year, NSF has announced that two new major research centers will be led by members of our faculty.

Jacob Jones, a Distinguished Professor in the Department of Materials Science and Engineering, and Ross Sozzani, an associate professor in the Department of Plant and Microbial Biology, are the director and one of the co-deputy directors, respectively, on an NSF Science and Technology Center — Science and Technologies for Phosphorus Sustainability (STEPS) — award. Thanks to an initial five-year, $25 million grant from NSF, this joint College of Engineering and College of Agriculture and Life Sciences effort will bring together a multidisciplinary team from NC State and eight partner institutions to strengthen the nation's food security and improve water quality by charting a path toward sustainable use of phosphates in agriculture.

Our Department of Computer Science has long been a global leader in research on the use of artificial intelligence to further personalized learning. Now, a five-year, $20 million grant from NSF will establish the NSF AI Institute for Engaged Learning. James Lester, Distinguished University Professor of Computer Science and director of our Center for Educational Informatics, will lead this effort to create new AI-based technologies that transform education.

These outstanding successes don't happen overnight. Landing major research grants requires vision and meticulous planning. It takes the right people, supported by state-of-the art infrastructure in place to do the work. I am grateful for your steadfast support of the College of Engineering and would like to acknowledge the significant role that our alumni and friends have played in getting us to where we are today. With your continued support, I know that we will be able to achieve even more.

I hope that you are staying safe and that you will please stay in touch with us.

Louis A. Martin-Vega, Ph.D., NAE
Dean

NC STATE
Engineering

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DEAN
Louis A. Martin-Vega

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FEATURES

ON THE COVER

The National Science Foundation tapped NC State to lead two nationwide research centers. Read more on **pages 16** and **18**.

Q&A

QUESTIONS FOR **ANA SOFIA UZSOY**

Ana Sofia Uzsoy (computer science, physics '21) is the third-ever Churchill Scholar to be selected from NC State. She will study at the University of Cambridge for a year, along with Nikhil Milind (computer science, genetics '21), who was announced as the University's fourth scholar in July.

Why did you choose NC State?

The biggest attraction was the Park Scholarships program, which provides not only financial support, but also enrichment opportunities and a wonderful community. I also appreciated that NC State accepted all of the credits I earned during high school, which was critical for me to complete my double major and two minors in four years.

What drew you to your two majors, and do you want to continue pursuing research in both fields?

As a kid, I was fascinated by outer space and thought I wanted to study astronomy. When I got to high school, I started taking physics classes, and found that it was something I enjoyed and seemed to be decent at. A lot of it does not come easily at first, but it's taught me the value of perseverance and hard work.

I was pretty late to the game in computer science — in high school, I knew other students who coded, and it seemed so elusive and complicated. But, I took CSC 116, the introductory programming class at NC State, and I was hooked and went on to complete the entire major. I love how versatile computer science is — it can be used to solve problems in every field.

I would like to continue developing my skills in both areas. While my main research interests lie in astrophysics, a significant amount of programming is needed to perform data analysis and conduct simulations.

How did you become interested in machine learning?

I had been hearing about machine learning and the amazing things it was capable of, but I didn't really understand what it was or how it worked. I was lucky to be able to intern at NASA in the summer of 2019, where I learned the ropes of machine learning and used it to analyze data from the International Space Station. In the summer of 2020, I interned at Google and continued developing my machine learning skills by creating natural language processing models. These experiences helped me understand not only how powerful machine learning can be, but also how much there is left to learn about it.

What are you most looking forward to about studying abroad in Cambridge?

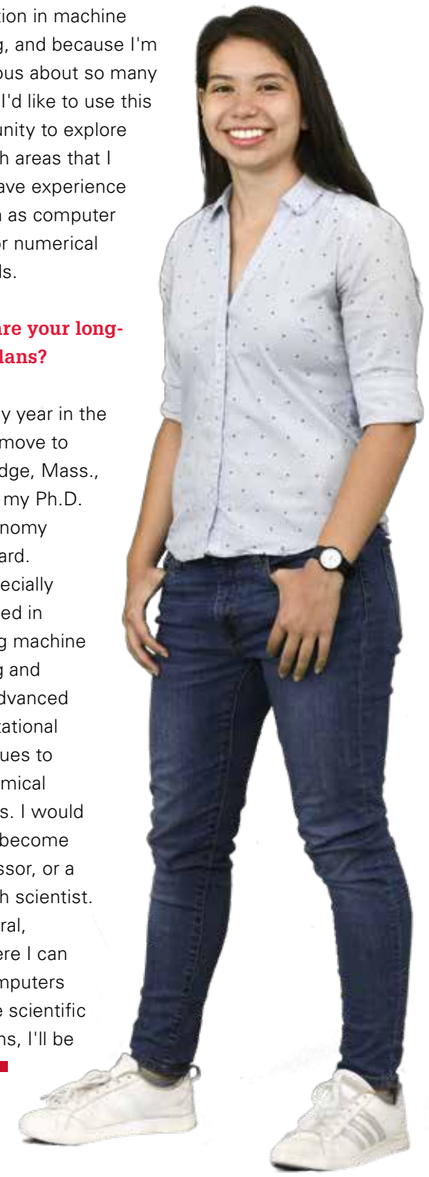
I am looking forward to meeting people from all over the world and experiencing life in another country. I'm sure I will make so many memories and grow so much from the experience.

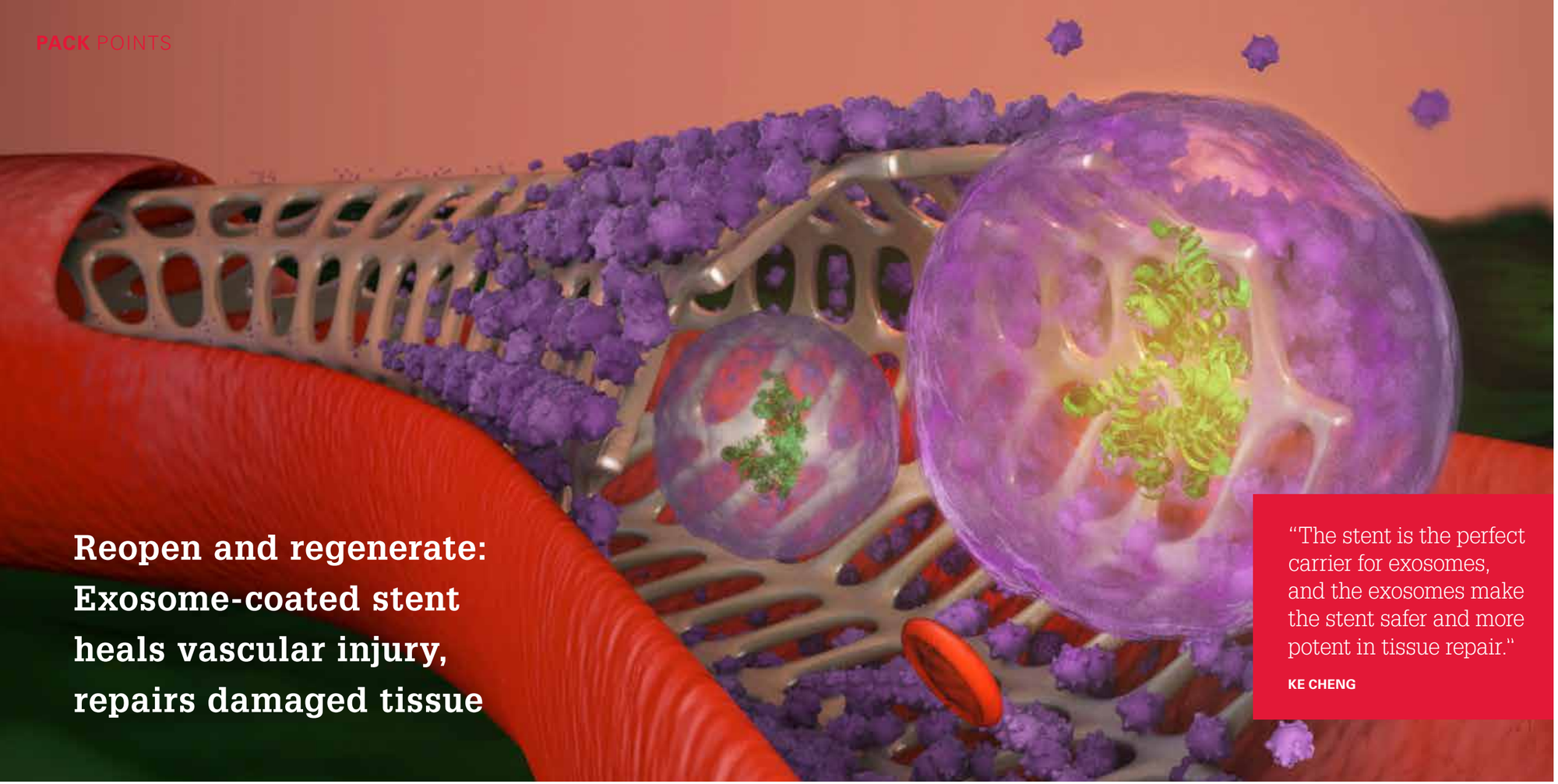
How do you plan to spend your year there?

The degree I'm doing is half coursework, half research. I'm looking forward to the coursework because it will help me develop a solid foundation in machine learning, and because I'm so curious about so many things! I'd like to use this opportunity to explore research areas that I don't have experience in, such as computer vision or numerical methods.

What are your long-term plans?

After my year in the UK, I'll move to Cambridge, Mass., to start my Ph.D. in astronomy at Harvard. I'm especially interested in applying machine learning and other advanced computational techniques to astronomical datasets. I would love to become a professor, or a research scientist. In general, anywhere I can use computers to solve scientific problems, I'll be happy. ■





Reopen and regenerate: Exosome-coated stent heals vascular injury, repairs damaged tissue

PACK POINTS

RESEARCHERS FROM NC STATE have developed an exosome-coated stent with a "smart-release" trigger that could both prevent reopened blood vessels from narrowing and deliver regenerative stem cell-derived therapy to blood-starved, or ischemic, tissue.

Angioplasty — a procedure that opens blocked arteries — often involves placing a metal stent to reinforce arterial walls and prevent them from collapsing once the blockage is removed. However, the stent's placement usually causes some injury to the blood vessel wall, which stimulates smooth muscle cells to proliferate and migrate to the site in an attempt to repair the injury. The result is restenosis: a re-narrowing of the blood vessel previously opened by angioplasty.

"The inflammatory response that stents cause can decrease their benefit," said Ke Cheng, corresponding author of the research. "Ideally, if we could stop smooth muscle cells from over-reacting and proliferating, but recruit endothelial cells to cover the stent, it would mitigate the inflammatory response and prevent restenosis." Cheng is the Randall B. Terry, Jr. Distinguished Professor in Regenerative Medicine at NC State and a professor in the UNC / NC State Joint Department of Biomedical Engineering.

There are drug-eluting stents currently in use coated with drugs that discourage cell proliferation, but these anti-proliferative drugs also delay stent coverage by endothelial cells — which are the cells healthcare providers want to coat the stent.

To solve this problem, Cheng and his team developed a stent coating composed of exosomes derived from mesenchymal stem cells. Exosomes are tiny nano-sized sacs secreted by most cell types. The idea behind the coating was two-fold: first, since the exosomes are composed of materials not much different from cell membranes, they "camouflage" the stent to trick smooth muscle cells and the body's immune system. Second, the exosomes promote coverage of the stent by endothelial cells and, in the case of injury, travel downstream to the site to promote tissue repair.

To prevent premature depletion of the therapy, the stent releases exosomes when it encounters reactive oxygen species (ROS) — which are more prevalent during an inflammatory response.

"Think of it as a smart release function for the exosomes," Cheng said. "Ischemic reperfusion injuries, which occur when blood flow is diminished and then reestablished, create a lot of ROS. Let's say the heart is damaged by ischemia. The enhanced ROS will trigger the release of the exosomes on the stent, and regenerative therapy will travel through the blood vessel to the site of the injury."

The research team performed in vitro testing to ensure biocompatibility and test the release mechanism. They found that in the presence of ROS, the exosomes released up to 60 percent of their secretions within 48 hours post-injury.

In a rat model of ischemic injury, the researchers compared their exosome-eluting stent (EES) to both a bare metal stent (BMS) and a drug-eluting stent (DES). They found that in comparison to the BMS, their stent performed better in both decreasing stenosis and promoting endothelial coverage. While the DES performed similarly to the EES in preventing restenosis, the EES was less injurious to the vessel wall and had better endothelial coverage overall. In addition, the exosomes released from the EES promoted muscle regeneration in rats with hind limb ischemia. The researchers plan to test the stent in a large animal model with an eye toward eventual clinical trials.

> "The stent is the perfect carrier for exosomes, and the exosomes make the stent safer and more potent in tissue repair."
>
> **KE CHENG**

"This bioactive stent promotes vascular healing and ischemic repair, and a patient wouldn't need additional procedures for regenerative therapy after the stent is in place," Cheng said. "The stent is the perfect carrier for exosomes, and the exosomes make the stent safer and more potent in tissue repair."

The research appears in *Nature Biomedical Engineering* and was supported by the National Institutes of Health and the American Heart Association. NC State postdoctoral research scholars Shiqi Hu and Zhenhua Li are co-first authors. ■

HUBERT WINSTON

College's first African American faculty member is still a part of the department that he loves

HUBERT WINSTON, associate professor emeritus of chemical and biomolecular engineering, has been affiliated with NC State for more than 45 years. First, as a student, then in the roles of faculty member, administrator and (now) a retiree working part-time for his University "home," the Department of Chemical and Biomolecular Engineering (CBE).

He was both the first African American to earn a Ph.D. in chemical engineering from NC State and the first to serve as a faculty member in the College of Engineering.

"One of the best decisions of my life was to enroll at NC State," he said. "I've spent far more than half of my life here and it's something that I continue to benefit from."

Winston enrolled as a freshman at NC State in the autumn of 1966. In a student population of 10,203, he was one of 33 undergraduate African American students. At the time, there were no African American faculty members in the College of Engineering and only a handful of African American faculty and staff members in the University.

In 1975, after earning B.S., M.S. and Ph.D. degrees in chemical engineering, Winston made history when he was hired as an assistant professor of chemical engineering and became the first African American faculty member in the College. After a stint with Exxon Production Research Company, in 1983, Winston returned to the (then) Department of Chemical Engineering as an associate professor. After a few years, he moved to the COE dean's office, where he served as the assistant dean for academic affairs for 11 years. He believes some of the projects he worked on during those years have benefitted many students across the University. Those include helping to establish the Benjamin Franklin Scholars Program, the Contractual Readmission process for undergraduates and the system of undergraduate academic minors.

In 2003, after a three-year hiatus from NC State, Winston returned to the campus and was involved in an effort led by Peter Kilpatrick, the CBE head at the time, that secured $28 million in initial funding to design and build the Golden LEAF Biomanufacturing Training and Education Center on Centennial Campus.

After a national reckoning in 2020 on the state of racial equity in the United States sparked by the killings of George Floyd, Breonna Taylor and others, COE Dean Louis Martin-Vega called on leaders in the College to redouble their efforts to recruit and retain outstanding faculty members from underrepresented groups.

Winston thinks that the College's academic departments should make tangible commitments to do just that and that a fair metric should be established to ensure that the commitments lead to concrete actions. He also believes the departments should make similar commitments for the process of recruiting their new graduate students. ■

Plant patch enables continuous monitoring for crop diseases

A NEW PATCH that plants can "wear" monitors continuously for diseases and other stresses, such as crop damage or extreme heat.

"We've created a wearable sensor that monitors plant stress and disease in a noninvasive way by measuring the volatile organic compounds (VOCs) emitted by plants," said Qingshan Wei, co-corresponding author of a paper on the work. Wei is an assistant professor of chemical and biomolecular engineering at NC State.

Current methods of testing for plant stress or disease involve taking plant tissue samples and conducting an assay in a lab. However, this only gives growers one measurement, and there is a time lag.

Plants emit different combinations of VOCs under different circumstances. By targeting VOCs that are relevant to specific diseases or plant stress, the sensors can alert users to specific problems.

"Our technology monitors VOC emissions from the plant continuously, without harming the plant," Wei said. "The prototype we've demonstrated stores this monitoring data, but future versions will transmit the data wirelessly. What we've developed allows growers to identify problems in the field — they wouldn't have to wait to receive test results from a lab."

The rectangular patches are 30 millimeters long and consist of a flexible material containing graphene-based sensors and flexible silver nanowires. The sensors are coated with various chemical ligands that respond to the presence of specific VOCs, allowing the system to detect and measure VOCs in gases emitted by the plant's leaves.

The researchers tested a prototype of the device on tomato plants to monitor for two types of stress: physical damage to the plant and infection by *P. infestans*, the pathogen that causes late blight disease in tomatoes. The system detected VOC changes associated with the physical damage within one to three hours.

Detecting the presence of *P. infestans* took longer. The technology didn't pick up changes in VOC emissions until three to four days after researchers inoculated the tomato plants.

"This is not markedly faster than the appearance of visual symptoms of late blight disease," Wei said. "However, the monitoring system means growers don't have to rely on detecting minute visual symptoms. Continuous monitoring would allow growers to identify plant diseases as quickly as possible."

"Our prototypes can already detect 13 different plant VOCs with high accuracy, allowing users to develop a customized sensor array that focuses on the stresses and diseases that a grower thinks are most relevant," said Yong Zhu, co-corresponding author of the paper and Andrew A. Adams Distinguished Professor of Mechanical and Aerospace Engineering.

Co-first authors of the paper are Zheng Li, a former postdoc at NC State, and Yuxuan Li, a Ph.D. student at NC State. The paper was co-authored by Jean Ristaino, William Neal Reynolds Distinguished Professor of Plant Pathology at NC State; Oindrila Hossain, Rajesh Paul and Shuang Wu, who are Ph.D. students at NC State; and Shanshan Yao, a former postdoc at NC State. ■

College looks to expand Grand Challenges Scholars program

OLGHA QAQISH

THE COLLEGE of Engineering's Grand Challenges Scholars program is growing — and a new position will help to manage and expand it.

On June 7, Olgha Qaqish, a lecturer, researcher and advisor for the College, became the coordinator of the Grand Challenges Scholars program, a position created by the College's Academic Affairs unit.

Started in 2008, the Grand Challenges Scholars program is designed to inspire engineering students to address one of 14 challenges designated by the National Academy of Engineering that need to be solved to improve and maintain quality of life. The approximately 80 students now enrolled start the program in their sophomore year, taking classes and working with a faculty member to complete activities that prepare them to solve these challenges.

David Parish, assistant dean of academic affairs for the College, said he saw Qaqish as the best choice for the position, recognizing her as an excellent instructor.

"Her knowledge with research and her ability to work with students will enhance this side of the program," said Parish. "While the program itself lets students be autonomous, she is good at getting groups to work together for a common goal."

As the program's coordinator, Qaqish will manage program processes and logistics. This includes overseeing recruitment, application management and program execution, while also serving as a mentor and a liaison between students and faculty members.

STUDENTS LEARN ABOUT THE 14 GRAND CHALLENGES IN E102: ENGINEERING IN THE 21ST CENTURY IN A SECTION TAUGHT BY DAVID PARISH.

Qaqish believes that her background as an engineering lecturer, curriculum developer and academic advisor will enable her to ensure the program's overall success while inspiring individual student success.

"The program is important as it enriches the student experience with hands-on application of engineering world problems," said Qaqish.

As an NC State alumna and staff member since 2005, Qaqish is excited to give more back to the Wolfpack.

"To me, it's a fun and exciting job that you want to wake up in the morning for," said Qaqish. "I have felt such a strong sense of community to be a part of the faculty and staff after having been a student here. Now I feel like I am able to give back to my mentors while also inspiring students to get them ready and excited to be a part of the Pack."

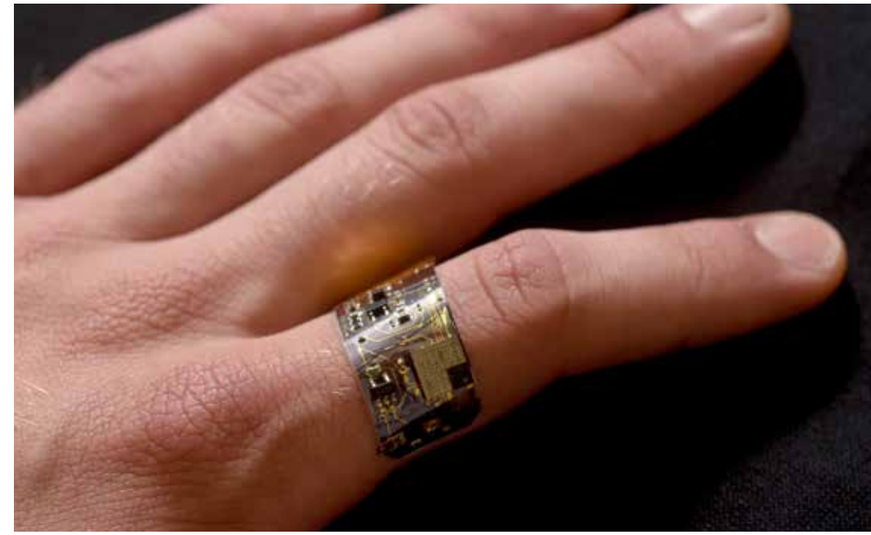
Going forward, while Qaqish is getting used to her new role, she hopes to expand the program to get more students involved and to implement further collaboration in the program both internally and externally.

"With my experience in grant writing, I'm working with funding agencies to see how we could possibly supplement and expand the program so that graduate students and even alumni could participate in the program, not just undergraduates," said Qaqish. "We're also looking to expand the program's partnerships to include other units at NC State and businesses and industries throughout North Carolina." ■

ASSIST Center looks to a self-sufficient future

NINE YEARS IN, the Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) has continued to lead the way in developing flexible, self-powering and wearable devices that will help both physicians and patients in monitoring human health across fields.

ASSIST, started in 2012, is an Engineering Research Center (ERC) led by collaborators at NC State, Florida International University, Penn State University and the universities of Michigan, Notre Dame, Virginia, Utah and North Carolina. About to graduate from its 10 years of National Science Foundation (NSF) funding, ASSIST has developed a self-sufficiency plan to continue its work, with an emphasis on industry engagement and new partnerships, large grant proposals and non-research sources of revenue.



A FLEXIBLE CIRCUIT FOR A PHOTOPLETHYSMOGRAM (PPG) SENSOR, WHICH WAS INTEGRATED INTO ASSIST'S WEARABLE CHEST PATCHES AND WRISTBANDS, HAS BEEN RECENTLY MINIATURIZED INTO A RING FORM FACTOR BY UTILIZING CUSTOM CIRCUIT BOARD MATERIALS.

"The plan focuses on sustaining ASSIST's leadership in ultra-low-power electronics, self-powering technologies, ultra-low-power sensors and flexible materials integration," said Veena Misra, director of ASSIST and Distinguished Professor in the Department of Electrical and Computer Engineering at NC State.

Over the last year, ASSIST has identified 15 clinical partnerships, received five grants, initiated a collaboration with UNC to support Alzheimer's research and worked on developing partnerships with the U.S. Army's 82nd Airborne Division to make sensors for paratroopers.

Researchers have made strides in improving some of the center's core technologies, which include a health and environmental tracker (HET) that helps people with asthma and a HET that monitors diet and wound healing. These HETs are both being used in clinical and behavioral research.

As part of these improvements, researchers built a new biochemical and biophotonic platform that can measure tissue oxygenation. At the University of Miami, clinicians continuously monitored wounds over a period of seven days using the ASSIST platform. The platform can be adapted to detect other biomarkers, and ASSIST is working with East Carolina University to submit proposals on monitoring kidney transplants to the National Institutes of Health.

These technologies are the two closest to becoming more widely used and commercialized. ASSIST launched two more companies last year, bringing its total to 10 startups.

"ASSIST continues to be highly entrepreneurial, with spinouts representing its most successful technology transfer and commercialization avenue to date," Misra said.

Other accomplishments over the last year include progress in developing novel flexible materials properties for thermoelectric generators (TEGs), which are now more flexible than ever with record-high power levels. TEGs convert the small difference between body and ambient temperature into electricity. With a recent NSF Partnerships for Innovation grant, ASSIST will focus on manufacturing TEGs.

As it moves into its final year of NSF funding, ASSIST has an H-index higher than its sister ERCs, Misra said. "We are being recognized as leaders in self-powered systems." ■

New law of physics helps humans and robots grasp the friction of touch

ALTHOUGH ROBOTIC DEVICES are used in everything from assembly lines to medicine, engineers have a hard time accounting for the friction that occurs when those robots grip objects — particularly in wet environments. Researchers have now discovered a new law of physics that accounts for this type of friction, which should advance a wide range of robotic technologies.

"Our work here opens the door to creating more reliable and functional haptic and robotic devices in applications such as telesurgery and manufacturing," said Lilian Hsiao, an assistant professor of chemical and biomolecular engineering at NC State and corresponding author of a paper on the work.

At issue is something called elastohydrodynamic lubrication (EHL) friction, which is the friction that occurs when two solid surfaces come into contact with a thin layer of fluid between them. This would include the friction that occurs when you rub your fingertips together, with the fluid being the thin layer of naturally occurring oil on your skin. But it could also apply to a robotic claw lifting an object that has been coated with oil, or to a surgical device that is being used inside the human body.

"Understanding friction is intuitive for humans — even when we're handling soapy dishes," Hsiao said. "But it is extremely difficult to account for EHL friction when developing materials that control grasping capabilities in robots."

To develop materials that help control EHL friction, engineers would need a framework that can be applied uniformly to a wide variety of patterns, materials and dynamic operating conditions — which is what the researchers have discovered.

"This law can be used to account for EHL friction, and can be applied to many different soft systems — as long as the surfaces of the objects are patterned," Hsiao said.

In this context, surface patterns could be anything from the slightly raised surfaces on the tips of our fingers to grooves in the surface of a robotic tool.

The new physical principle, developed jointly by Hsiao and her graduate student Yunhu Peng, makes use of four equations to account for all of the physical forces at play in understanding EHL friction. The research team demonstrated the law in three systems: human fingers; a bio-inspired robotic fingertip; and a tool called a tribo-rheometer, which is used to measure frictional forces. Peng is first author of the paper.

"These results are very useful in robotic hands that have more nuanced controls for reliably handling manufacturing processes," Hsiao said. "And it has obvious applications in the realm of telesurgery, in which surgeons remotely control robotic devices to perform surgical procedures."

Co-authors of the paper include Christopher Serfass, a Ph.D. student at NC State, and Catherine Hill, an undergraduate student at NC State. ■

> "Our work here opens the door to creating more reliable and functional haptic and robotic devices... "
>
> **LILIAN HSIAO**

Using liquid metal to turn motion into electricity — even underwater

NC STATE RESEARCHERS have created a soft and stretchable device that converts movement into electricity and can work in wet environments.

"Mechanical energy — such as the kinetic energy of wind, waves, body movement and vibrations from motors — is abundant," said Michael Dickey, corresponding author of a paper on the work and Camille & Henry Dreyfus Professor of Chemical and Biomolecular Engineering (CBE). "We have created a device that can turn this type of mechanical motion into electricity. And one of its remarkable attributes is that it works perfectly well underwater."

The heart of the energy harvester is a liquid metal alloy of gallium and indium. The alloy is encased in a hydrogel — a soft, elastic polymer swollen with water.

The water in the hydrogel contains dissolved salts called ions. The ions assemble at the surface of the metal, which can induce charge in the metal. Increasing the area of the metal provides more surface to attract charge. This generates electricity, which is captured by a wire attached to the device.

"Since the device is soft, any mechanical motion can cause it to deform, including squishing, stretching and twisting," Dickey said. "This makes it versatile for harvesting mechanical energy. For example, the hydrogel is elastic enough to be stretched to five times its original length."

In experiments, researchers found that deforming the device by only a few millimeters generates a power density of approximately 0.5 mW m-2. This amount of electricity is comparable to several popular classes of energy harvesting technologies.

"However, other technologies don't work well, if at all, in wet environments," Dickey said. "This unique feature may enable applications from biomedical settings to athletic wear to marine environments. Plus, the device is simple to make.

"There is a path to increase the power, so we consider the work we described here a proof-of-concept demonstration."

The researchers already have two related projects under way.

One project is aimed at using the technology to power wearable devices by increasing the harvester's power output. The second project evaluates how this technology could be used to harvest wave power from the ocean.

First author of the paper is Veenasri Vallem, a Ph.D. student in CBE. Co-authors include Erin Roosa and Tyler Ledinh, who were undergraduates at NC State when the work was done; Sahar Rashid-Nadimi and Abolfazl Kiani, who were visiting scholars at NC State and are now at California State University, Bakersfield; and Woojin Jung and Tae-il Kim of Sungkyunkwan University in South Korea, who worked on the project while visiting NC State. ■

From the Olympics to MIT

FOR ANTON IPSEN, industrial and systems engineering '19, competing in the Olympics for the second time was no less exciting than the first. But he thought he'd go into the 2020 Games with a better idea of what to expect — until COVID-19 hit.

Ipsen, who was a successful swimmer for NC State and swam internationally for his home country of Denmark, competed in the 800m and 1500m men's freestyle. While he did not advance to the final for either event, he was grateful for the experience and for the people who helped get him there.

"It was really special in this Olympics compared to (the 2016 Games in Rio de Janeiro) to be able to see and interact with so many people, because for the past year-and-a-half, most people haven't been able to travel or see other cultures, so that was really amazing," he said.

Ipsen took 30 COVID-19 tests during his 30 days in Tokyo, which were spent first at a holding camp with his Danish teammates to ensure they didn't pick up the virus during travel. He spent the rest of the time in the Olympic Village.

"The atmosphere felt more normal in the village," he said. "We had a really great view of Tokyo, and it was sad to not be able to experience that. It was like walking past a candy store every day and not being allowed to go inside."

Despite that, he appreciated the efforts of Japanese volunteers who helped make it a good experience, and ultimately was glad to get to compete.

Less than a month after the Games, Ipsen is back in the U.S., where he is pursuing graduate studies at the Massachusetts Institute of Technology. Accepted in 2019, he deferred twice due to the Olympics — a record, he jokes.

Ipsen sees a lot of connections between his engineering studies and swimming.

"Optimization is the biggest part of any engineering program, and it also is important when you're training at a world-class level," Ipsen said.

He has analyzed hours of film to improve his form and technique, and he recognizes the influence of his engineering degree in his long-term approach to swimming success.

Ipsen isn't sure if he'll continue swimming at the same level. School will come first as he works toward a master's in business analytics with a focus on data science. His research interests are in using machine learning and artificial intelligence in healthcare, and he has spent the last 18 months gaining experience at Novo Nordisk.

"I think this is a super exciting field because there are so many complex interactions between patients and medicine, and so forth. I see a lot of optimizations being made, which ultimately means better drugs and also lower drug costs for patients," he said. "That's my purpose and my 'why,' and I really hope I can expand this further in my career, and in that way, make my impact on the world." ■

'A force for good in the world': Veronica Cateté honored with 2020 Erskine B. Bowles Staff Service Award

VERONICA CATETÉ, a research scientist in the Department of Computer Science (CSC) at NC State, received the most prestigious honor awarded by the UNC Staff Assembly — the 2020 Erskine B. Bowles Staff Service Award.

The Erskine B. Bowles Staff Service Award recognizes the achievements of employees through their professional interactions, extraordinary service to their respective campus and outstanding service to the greater community.

The award is just one of several Cateté has received for her outstanding work; she has also been previously recognized with an Award for Excellence, Pride of the Wolfpack Award and a 2017 Equity for Women Award.

Cateté was nominated by Tiffany Barnes, a CSC Distinguished Professor at NC State and Cateté's faculty supervisor, who said that Cateté is "a force for good in the world."

"As a research scientist in my lab, she has gone above and beyond to make sure that the work that she does makes an impact," said Barnes. "From a local to global level, she has gotten involved to promote STEM education. Here at NC State, she is a mentor and makes significant efforts in improving the department and overall community climate."

Cateté received her B.S. and Ph.D. from NC State. She has worked in the CSC department since 2018 and has been focused on educational programming and course development with culturally responsible pedagogy in mind, helping students from all backgrounds to see themselves in the curricula that they are participating in. Cateté works under Barnes in the Game2Learn Lab, a facility associated with the Center for Educational Informatics and the Digital Games Research Center.

As the second Latina Ph.D. graduate from the CSC department, addressing accessibility and equity problems has remained at the core of Cateté's research and service at NC State. This includes creating an environment where young women and minority students feel a sense of belonging and can make informed professional decisions.

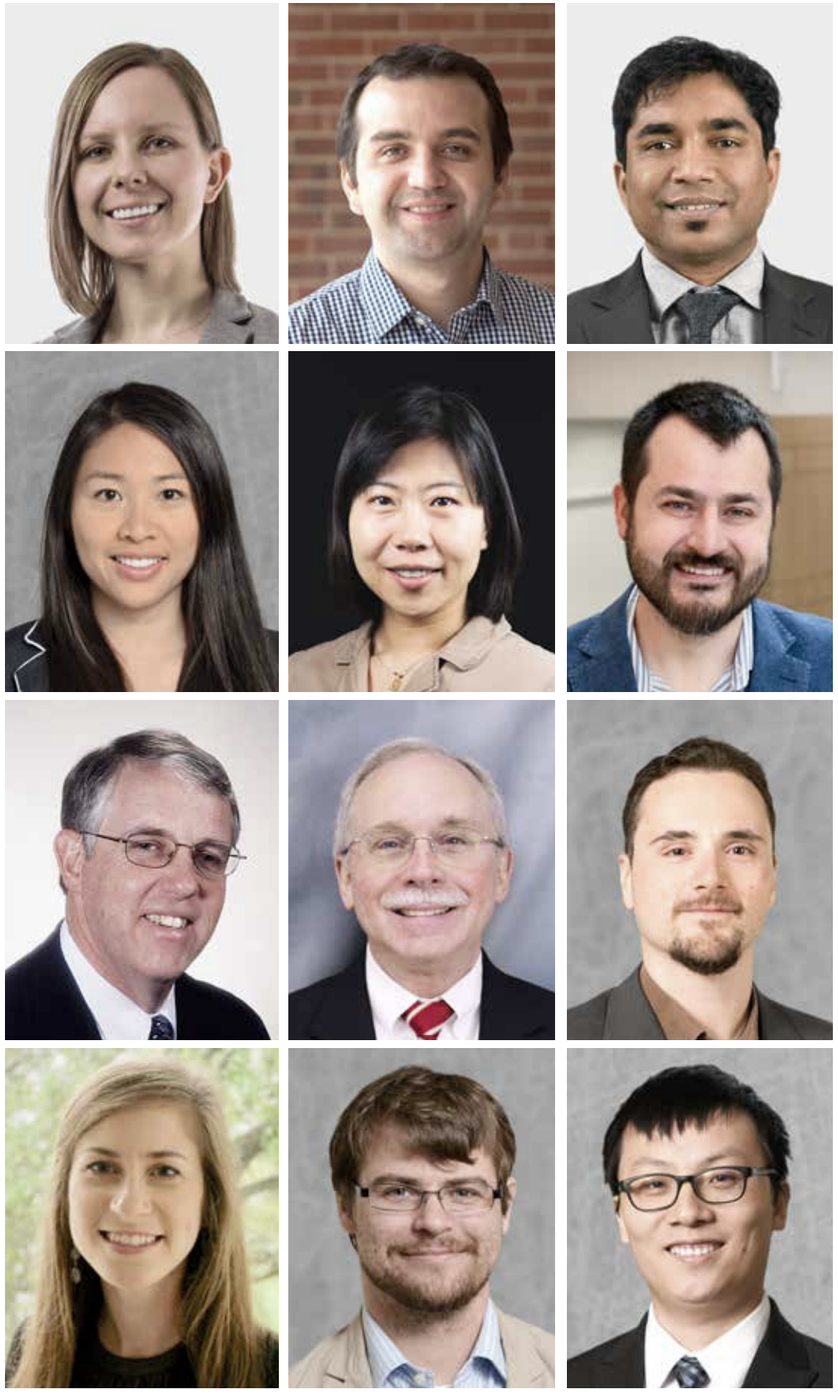
"There are places where decisions are happening where there isn't always representation, so I try to put my nose in these places," Cateté said.

She has mentored five graduate researchers, 10 undergraduates, approximately 50 high school students and a vast number of protégés. Additionally, Cateté serves as a co-advisor for the NC State student chapter of the STARS Computing Corps, a service organization that aims to engage K-12 students in computer science.

"I want to make an easier path that enables students to better figure out what they want to do while also opening the field to innovators and catalysts," said Cateté. "We aim to be a welcoming environment with many representatives being from different spaces and showing aspiring students what the faces of computer science look like and that they can be here, too." ■

"I want to make an easier path that enables students to better figure out what they want to do while also opening the field to innovators and catalysts."

VERONICA CATETÉ



TOP, LEFT TO RIGHT, VERONICA AUGUSTYN, FERNANDO GARCIA MENENDEZ, RAJEEV GUPTA, LILIAN HSIAO, HE (HELEN) HUANG, ALEXANDROS KAPRAVELOS, ROBERT KELLY, DICK KELTIE, STEFANO MENEGATTI, NATALIE NELSON, CHRISTOPER PARNIN AND RUOZHOU YU.

FACULTY HIGHLIGHTS

Six receive **NSF CAREER Awards**

Six faculty members from the College and affiliated engineering departments in other colleges at NC State received Faculty Early Career Development (CAREER) awards from the National Science Foundation (NSF). The NSF CAREER Award is one of the most prestigious awards in support of junior faculty members who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations. They receive their funding over five years from NSF.

Rajeev Gupta, associate professor in the Department of Materials Science and Engineering (MSE), will receive $500,000 for his project, "Towards High Strength Corrosion-Resistant Magnesium Alloys."

Lilian Hsiao, assistant professor in the Department of Chemical and Biomolecular Engineering (CBE), will receive $648,553 for her project, "Elastohydrodynamic lubrication of soft patterned interfaces."

Alexandros Kapravelos, assistant professor in the Department of Computer Science (CSC), will receive $561,188 for his project, "Web evolution and emerging threats."

Natalie Nelson, assistant professor in the Department of Biological and Agricultural Engineering, will receive $500,000 for her project, "Characterizing the Unseen Water Quality Consequences of Sunny-Day Floods in Nearshore Waters."

Christopher Parnin, assistant professor in CSC, will receive $555,882 for his project, "Understanding and supporting programmer cognition."

Ruozhou Yu, assistant professor in CSC, will receive $505,702 for his project, "WolfPack: An application-network co-design framework for performance-guaranteed real-time applications at the network edge." ■

Kelly receives **Holladay Medal for Excellence**

Robert Kelly, Alcoa Professor of Chemical Engineering in CBE, was one of two faculty members selected to receive the Alexander Quarles Holladay Medal for Excellence, the highest honor bestowed by NC State and the University's Board of Trustees.

Kelly has trained more than 90 master's, Ph.D. and postdoctoral scholars in areas related to life sciences and engineering. He has been the director of NC State's Biotechnology (BIT) Program for the past 20 years, and he is an elected Fellow of the American Association for the Advancement of Science and of the American Institute for Medical and Biological Engineering. ■

Huang, Menegatti receive **Alcoa Foundation Awards**

The 2021 Alcoa Foundation Awards were given to He (Helen) Huang, professor in the UNC / NC State Joint Department of Biomedical Engineering (BME), and to Stefano Menegatti, assistant professor in CBE.

Huang received the Alcoa Foundation Distinguished Engineering Research Award, given to a senior faculty member for research achievements over a period of at least five years at NC State. Recognized internationally for her work in rehabilitation engineering, Huang has led the way in research of neural control of robotic upper- and lower-limb prostheses.

Menegatti 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. Menegatti has built an internationally renowned research group that has made seminal contributions to biological drug manufacturing through its work on the biopurification of therapeutic proteins. ■

Keltie receives **Faculty Distinguished Service Award**

Dick Keltie, professor emeritus in the Department of Mechanical and Aerospace Engineering (MAE), received only the second Faculty Distinguished Service Award given by the College. The late Carl Zorowski, Reynolds Professor Emeritus in MAE, received the inaugural award in 2015.

During his long career at NC State, Keltie served as associate dean for research and graduate programs; director of the Center for Sound Vibration in mechanical and aerospace engineering; and associate head of the MAE department. He is a member of the NC State Academy of Outstanding Teachers, and he is a Fellow in the American Society of Mechanical Engineers. ■

Augustyn, Garcia Menendez receive **Blessis Awards**

Veronica Augustyn, assistant professor in MSE, and Fernando Garcia Menendez, assistant professor in the Department of Civil, Construction, and Environmental Engineering, have been announced as the winners of the George H. Blessis Outstanding Undergraduate Advisor Award.

The award recognizes faculty members who consistently and willingly give their time and effort to advising, counseling and mentoring students and assisting student groups. It is also a continuing memorial to George H. Blessis, a faculty member whose interest in undergraduate education and advising serves as an example today. ■

STEPS
TOWARD SUSTAINABILITY

RIGHT, ROSS SOZZANI.
BELOW, JACOB JONES.

Faculty members in the College of Engineering and across NC State will lead a national research effort to reduce both dependence on mined phosphates and the amount of phosphorus that leaches into soils and water. The research, funded by the National Science Foundation (NSF), will focus on issues relevant to both food security and environmental quality.

The NSF Science and Technology Center (STC) — Science and Technologies for Phosphorus Sustainability (STEPS) — will be headquartered on NC State's Centennial Campus. The center is funded by an initial five-year, $25 million grant that is renewable for an additional five years.

Jacob Jones, Distinguished Professor of Materials Science and Engineering, will be the center's director. College of Engineering faculty members will lead efforts within the center related to materials design, utilization of diverse forms of data, and water quality measurements and modeling, in cooperation with faculty and staff members from the College of Agriculture and Life Sciences and across the University, and at eight partner institutions. Ross Sozzani, an associate professor of plant and microbial biology at NC State, will serve as a center co-deputy director.

Phosphorus sustainability is an important and urgent societal problem. An essential chemical element, phosphorus plays a critical role in fertilizers used in food systems. But there are problems with supply — the industry relies on mined, non-renewable phosphates that could soon be depleted — as well as system inefficiencies and downstream effects on the environment.

The center's ambitious goals include facilitating a 25 percent reduction in human dependence on mined phosphates and a 25 percent reduction in phosphorus losses to soils and water resources within 25 years, leading to enhanced resilience of food systems and reduced environmental damage.

Current food production systems rely heavily on phosphorus fertilizers, most of which originate from non-renewable phosphate deposits that are mined outside of the United States. Once in the food system, only 20 percent of the input phosphorus is ultimately incorporated into the human diet due to multiple system losses and inefficiencies. The "lost" phosphorus accumulates in soils and freshwater sources.

"Phosphorus-driven algal blooms impair safe drinking water and marine life, and the increasing flux of phosphorus to oceans also leads to an expansion of coastal dead zones," Sozzani said. "Without intervention, the environmental, economic and sustainability issues involving phosphorus will escalate as the world's human population grows by another 2 billion people by 2050."

"STEPS develops the materials, technologies and best management practices to recover, recycle and reuse phosphorus," said Jones. "Recycling and reusing phosphorus means developing technologies and methods to capture 'lost' phosphorus in soils and surface waters — as well as in animal and human waste — and then reusing that recycled phosphorus in fertilizers."

STEPS will be an interdisciplinary center, integrating contributions across the physical, life, social and economic sciences.

The center's headquarters will be housed in the new Plant Sciences Building, home of the University's Plant Sciences Initiative, on Centennial Campus.

> "Without intervention, the environmental, economic and sustainability issues involving phosphorus will escalate as the world's human population grows by another 2 billion people by 2050."
>
> **ROSS SOZZANI**

Researchers will draw from a wide variety of academic disciplines — ranging from agricultural engineering, biomolecular and chemical engineering, and materials science to chemistry, crop sciences, economics and sociology — to develop materials and technologies that can be deployed at the human scale while considering regional and global issues.

Jan Genzer, S. Frank and Susan Culberson Distinguished Professor of Chemical Engineering, and Yaroslava Yingling, professor in the Department of Materials Science and Engineering (MSE), will lead the center's research on materials that will underpin the new technologies that will come out of the effort. Yingling and Rada Chirkova, professor in the Department of Computer Science, will be co-leads on a convergence informatics initiative that will help put STEPS data and analytics to use. Maude Cuchiara, research associate professor in MSE, is STEPS' acting managing director.

In the Department of Civil, Construction, and Environmental Engineering (CCEE), Douglas Call and Daniel Obenour, associate professors, and S. James Ellen Distinguished Professor Detlef Knappe will conduct research on phosphorus in a variety of environments and materials, including waterways, wastewater and animal manures. New environmental engineering labs in Fitts-Woolard Hall, the College of Engineering's newest building on Centennial and the new home of CCEE, will play a critical role.

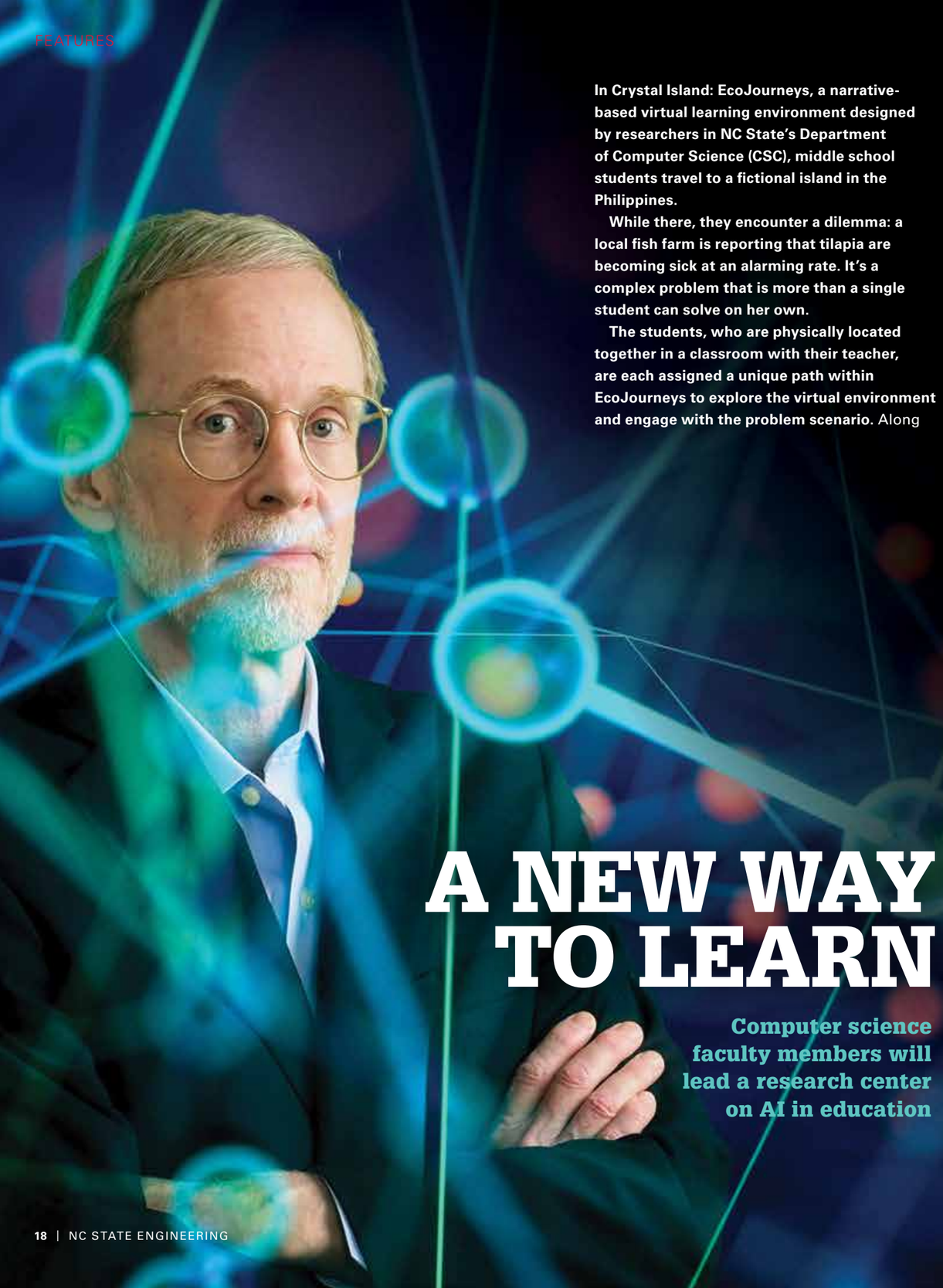
AN INCLUSIVE VISION

STEPS has a strong inclusivity goal. STEPS will foster progress toward a goal of more than 50 percent participation by members of underrepresented minority groups, including more than 50 percent pre-baccalaureate participation to further broaden and develop the STEM pipeline.

"This strong commitment to inclusivity and diversity is a testament to beneficial partnerships with organizations and institutions that allow us to recruit talented participants while strengthening new research collaborations," said Louis Martin-Vega, dean of the College of Engineering. "Diversity in thought, culture, experience and approach toward problem solving is truly required to address a societal issue that no single discipline or group can solve on its own."

STEPS partner institutions include Arizona State University, Appalachian State University, the Joint School of Nanoscience and Engineering at North Carolina Agricultural and Technical State University and the University of North Carolina Greensboro, the University of Florida's Institute of Food and Agricultural Sciences, Marquette University, RTI International and the University of Illinois.

The College of Engineering leads more than 20 research centers and institutes and is one of only two engineering schools to ever lead two NSF Engineering Research Centers at once. STEPS is the first NSF STC for which NC State has been named as the lead institution. ■



A NEW WAY TO LEARN

Computer science faculty members will lead a research center on AI in education

In Crystal Island: EcoJourneys, a narrative-based virtual learning environment designed by researchers in NC State's Department of Computer Science (CSC), middle school students travel to a fictional island in the Philippines.

While there, they encounter a dilemma: a local fish farm is reporting that tilapia are becoming sick at an alarming rate. It's a complex problem that is more than a single student can solve on her own.

The students, who are physically located together in a classroom with their teacher, are each assigned a unique path within EcoJourneys to explore the virtual environment and engage with the problem scenario. Along the way, they learn about ecosystems and the impacts cyanobacterial algal blooms are having around the world. They also gain valuable experience in working collaboratively toward a solution.

NC State researchers have been working for years on using artificial intelligence (AI) capabilities to enhance the field of education by supplementing human teacher-pupil interactions in a way that is customizable and scalable. Through the Center for Educational Informatics (CEI), housed in CSC, interdisciplinary teams of faculty members design and develop next-generation adaptive learning environments like EcoJourneys and conduct foundational research on technology-rich learning.

Now, the National Science Foundation (NSF) is furthering that effort with a five-year, $20 million grant that will establish a new research initiative that is led by NC State and aimed at creating AI tools to advance human learning and education for a wide variety of audiences.

The investment is part of a broader effort by NSF to advance our understanding of AI technologies and how they can drive innovation to address real-world challenges; the agency has announced the creation of 18 National Artificial Intelligence Research Institutes over two years.

"We have been designing, developing and implementing AI technologies for education for many years," said James Lester, principal investigator of the new institute, director of CEI and Distinguished University Professor of Computer Science at NC State. "The new NSF AI Institute for Engaged Learning will leverage our work, and that of our collaborators, to develop new tools that radically improve human learning and education."

In addition to NC State, the new institute will include researchers from Indiana University, the University of North Carolina at Chapel Hill, Vanderbilt University and the educational non-profit organization Digital Promise.

The National Academy of Engineering named Advancing Personalized Learning as one of its 14 Grand Challenges for Engineering in the 21st century, recognizing a global need to personalize instruction in a way that is tailored to an individual student's learning needs.

COLLABORATIVE APPROACH

The institute will focus on three areas that complement each other.

First, the institute will create AI platforms that generate interactive story-based problem scenarios that foster communication, teamwork and creativity as part of the learning process.

Second, the institute will create AI characters capable of communicating with students through their speech, facial expression, gesture, gaze and posture. These characters, or "agents," will be designed using state-of-the-art advances in AI research to foster interactions that engage students effectively in the learning process.

Lastly, the institute will create a sophisticated analytics framework that analyzes data from students in order to make the tools truly interactive. In other words, the system will be able to customize educational scenarios and processes to help students learn, based on information the system collects from the conversations, gaze, facial expressions, gestures and postures of students as they interact with each other, with teachers, and with the technology itself.

Researchers involved with the institute will be working with a broad range of stakeholders, including schools, museums and non-profit organizations. Through prior projects, CEI researchers have built a broad network of collaborators and schools willing to participate in research and help implement new, cutting-edge technologies in the classroom.

This collaborative approach is designed to ensure that the institute creates tools that can be used to meet educational goals while also ensuring that its AI-driven learning environments are ethically designed and promote diversity, equity and inclusion.

"All of our activities in the new institute will include a strong focus on ethics," Lester said. "We create effective educational tools that are informed by considerations of fairness, accountability, transparency, trust and privacy.

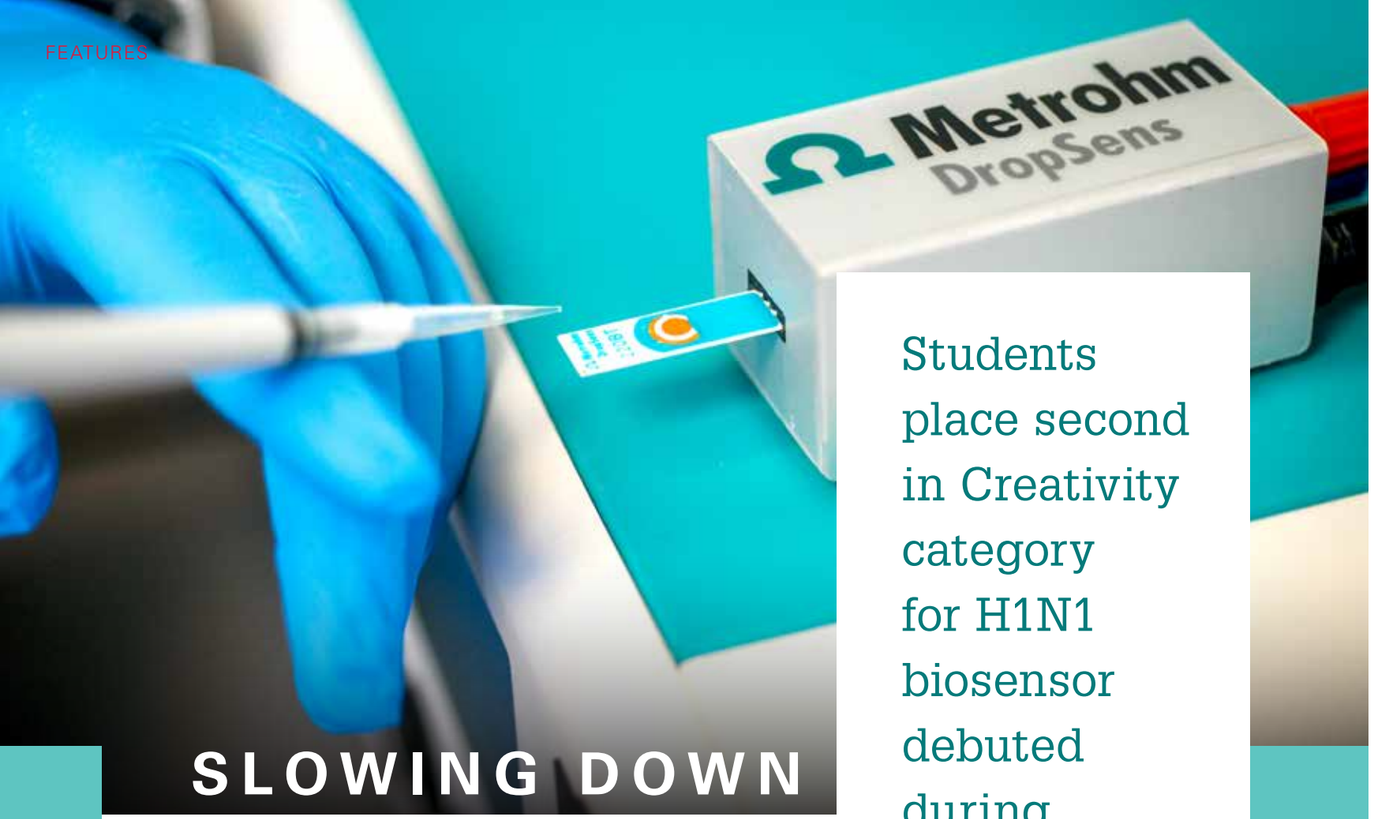
"Our work at the CEI has demonstrated that AI tools can be tremendously valuable in supporting education. But they do not exist in a vacuum, and we know how important it is to ensure that we are working with teachers, students and other community members to develop tools that meet their expectations in terms of safety, respect and privacy."

The goal is not to replace classroom teachers, but to enhance their work.

There is an enormous body of evidence showing that the best educational outcomes come from one-on-one interaction between a human tutor and a human learner. Unfortunately, that's not scalable.

With AI, students can receive that individual instruction with a virtual tutor. In the classroom, teachers using new technologies will have access to more information on how individual students are progressing and where they are getting stuck. Armed with this data, they can develop adaptive learning environments that are not one size fits all and offer individual attention in ways that weren't possible before.

"We're talking about providing powerful tools, along with training and professional development, that will allow teachers to really up their game in the classroom," said Eric Wiebe, a professor in STEM (science, technology, engineering and math) at NC State and a longtime CEI collaborator. ■



SLOWING DOWN TRANSMISSION

Students place second in Creativity category for H1N1 biosensor debuted during international competition

As viruses evolve and spread, delivering healthcare in a wide variety of settings within and far from traditional hospitals becomes more essential to ensure patients receive the care they need. To address this, a team of students across three different engineering disciplines debuted a novel H1N1 biosensor at the SensUs 2021 competition and won second place in the Creativity award category.

SensUs is an annual international competition started in 2015 that aims to accelerate the development of sensors for better healthcare through the involvement of students with industry experts and health partners. SenseNC, a multidisciplinary team of 10 College of Engineering students, was the only team from the United States.

This is the fifth year that SenseNC competed among more than a dozen teams from nations including China, Canada, Russia and Egypt.

SensUs 2021 focused on the detection of acute respiratory viruses and challenged teams to develop innovative biosensing systems to detect influenza A, or H1N1 — commonly referred to as swine flu — in saliva. Focus on H1N1 was related to the virus' rapid airborne transmission and its high rates of infection.

The competition was hosted virtually Sept. 3, where the team pitched, presented and tested their original biosensor work to attendees and judges by broadcasting from the Monteith Research Center in the ASSIST Center.

Judging was done by experts within academia, industry and healthcare in the categories of Creativity and Translation Potential.

The team was awarded second in the Creativity category due to the novelty of their sensor and its technical viability for deployment. Key factors included the device's ability to measure hemagglutinin — a protein antigen that is abundant on the surface of H1N1 and causes red blood cells to clump together — in saliva, to later adapt to detect the influenza virus, and to produce a test result in less than five minutes.

The team started their research in fall 2020 and divided into three sub-teams: the Chemical Team, the Electrical Team and the Business Team.

Led by Joshua Wilson, a senior electrical engineering major, the students of the 2021 team were: McKenna Downey, a senior chemical engineering major; Katie Kilgour, a fourth-year Ph.D. student in chemical engineering; Grace Maddocks, a first-year graduate student in electrical engineering; Sucheta Malladi, a senior electrical engineering major; Kaila Peterson, a second-year Ph.D. student in electrical engineering; Shannon Pinnell, a senior electrical engineering major; Meredith Robbins, a junior industrial engineering major; Sydney Stine, a senior chemical engineering major; and Brendan Turner, a fourth-year graduate student in biomedical engineering.

Building the biosensor, the team focused on two characteristics: ease of transport and ability to rapidly test, recognizing that current solutions are limited in their ability to be transported and then provide at-home rapid testing.

The Chemical Team focused on methods for detecting H1N1 proteins while the Electrical Team developed the electronic hardware, or "brain," of the system and worked on how to make the system easily portable and usable for clinical or home usage. The Business Team focused on funding requests, product promotion and business model development.

The biosensor works by detecting the presence of very small amounts of hemagglutinin.

The electronic hardware is able to detect the H1N1 virus through electrochemical transduction, where H1N1 proteins bind with aptamers that are connected to a sensor interface device which transfers information through square wave voltammetry. Changes in current magnitude detected through square wave voltammetry signal the presence of significant levels of hemagglutinin.

SenseNC's sensor is an early example of using aptamers and square wave voltammetry as a transduction method to detect H1N1.

While this biosensor is specifically for the H1N1 virus, the team emphasized the relevance and importance this type of research has in developing rapid yet accurate virus tests going forward.

SenseNC is advised by Michael Daniele, an associate professor in the Department of Electrical and Computer Engineering and the UNC / NC State Joint Department of Biomedical Engineering, with Stefano Menegatti, an associate professor in the Department of Chemical and Biomolecular Engineering.

"Our team is made up of a variety of experience levels," said Daniele, noting that the team ranges from students who were sophomores when the research began to advanced graduate students, and includes students who had never before stepped into a lab.

Daniele is excited for the students to come out of the competition and year-long project with a better understanding of system design and the engineering cycle, having interacted with peers on a global scale to develop a product that can make a real-world impact among communities.

"It was a lot of fun working with these students as everyone was excited to try something new," said Daniele. "I'm here to coach these students toward a goal; I didn't necessarily know the answers, it was an instructional role so we were here together to see what the outcomes were."

Though the competition, originally to be held in Eindhoven, The Netherlands, was moved online, students appreciated the chance to work and learn in the lab together and to apply what they had learned in class to experience outside of the university setting.

"To me, being a part of SensUs means putting classroom knowledge and concepts to the test in a realistic way," said Maddocks. "I love that we get to practice these skills on a scale which will actually be able to help people once in its final form." ■

College of Engineering research has the potential to make global impacts. NC State has resources that can help.

FINDING FUNDING

The ORC offers several ways for research-based startups to receive initial funding to grow their company, continue innovating their product, hire employees and more:

- NC State's Lulu eGames: Startups that have licensed NC State intellectual property in the last three years can compete for up to $25k of Daugherty Endowment Funding during the annual entrepreneurship competition. $50k total is awarded each year, with the second- and third-place teams receiving $15k and $10k.
- Chancellor's Innovation Fund: Supports short-term, commercially focused research projects. Through 2021, the fund has awarded $3.7M to 57 projects.
- Capital: The Wolfpack Investor Network (WIN), Triangle Venture Alliance and Council for Entrepreneurial Development's Connection to Capital Program offer support to companies getting off the ground.

In 2021, all three Daugherty Award winners have ties to the College

20 projects with ties to COE and its affiliated departments received Chancellor's Innovation Fund awards 2015-21

WIN has invested $13M in NC State startups

INNOVATIVE IDEAS

College of Engineering faculty members and students work on groundbreaking research and projects that help improve human health, transportation, education and more. An idea that starts in a lab or classroom can turn into a product that improves the lives of millions.

SUCCESS STORIES

Bay Nano Technologies won the third-place 2021 eGames Daugherty Endowment Award and has developed a smart glass at a low cost that helps save electricity. Nano-crystal ink technology applied to glass makes it tint automatically. The startup is led by **Aram Amassian**, associate professor in the Department of Materials Science and Engineering.

From the lab to a startup

Innovations that come out of the College of Engineering make a lasting impact on North Carolina, the U.S. and around the world. NC State has launched the second-most startups of any university in the U.S. without a medical school and is number four among all universities. To help take ideas and research from the lab to the market, NC State's Office of Research Commercialization (ORC) provides resources, financial support and advising to faculty and staff members.

A NEW STARTUP IS LAUNCHED

Once NC State entrepreneurs have been issued the necessary patents and licenses, gone through rounds of approval, identified a market and raised funds, their startup is ready to launch. NC State-associated startups have made important impacts on the North Carolina economy and for people around the world. The ORC has supported more than 190 startups and spinoffs from NC State research. Since 1988, 106 startups with ties to the College of Engineering have been launched.

TURNING AN IDEA INTO A COMPANY

Faculty members reach out to the ORC to discuss licensing, patents and invention disclosures. Through the ORC, faculty members have access to startup attorneys, regulatory consultants from RTI International, grant writing and business plan specialists, creative services and a co-working space on Centennial Campus. Here, faculty members can get advice on working through details like Food and Drug Administration or Environmental Protection Agency regulatory processes, license reviews, product development analysis and market landscape analysis. The ORC also provides creative services to assist in developing logos, a website and branded materials. The National Science Foundation I-Corps Site offers training to help researchers take their ideas to the market.

Among universities without a medical school, NC State is:

- **4th** in total licenses issued
- **1st** in active licenses and options
- **5th** in invention disclosures

The College of Engineering has:

- **2,519** invention disclosures
- **401** currently issued patents

ImagineOptix, a Durham-based company, is commercializing a patented thin-film polarizing beamsplitter technology called HoloBright. The NC State startup company has commercialized several technologies developed by **Michael Escuti**, a professor in the Department of Electrical and Computer Engineering.

GridBridge is an early spinoff from the FREEDM Systems Center that was acquired by ERMCO in 2017. The company partners with electric utilities to introduce products that enable the adoption of green technology, optimize electricity flow on the grid, minimize the cost of overhauls and ensure customer satisfaction.

Return *on* investment

The Golden LEAF Biomanufacturing Training and Education Center helps drive a thriving industry

A subsidiary of Fujifilm Corporation, Fujifilm Diosynth Biotechnologies' Holly Springs site will bring a planned 725 new highly skilled positions to North Carolina's Research Triangle region by 2028 and represents a $2 billion investment in the state. It was a significant win for North Carolina economic developers, but is one of many notable biopharma announcements over the last couple of years.

As state leaders looked to transform the economy from one built on tobacco, textiles and furniture, they have made a significant investment in recent years in biotechnology — a broad field covering the use of living systems to make products with applications in healthcare, agriculture, food processing and more. That investment has reaped significant benefits: with more than 775 companies employing 67,000 people, North Carolina's biotech industry has grown 25 percent since 2010, according to the North Carolina Biotechnology Center.

One of those early investments led to the creation of the Golden LEAF Biomanufacturing Training and Education Center (BTEC), part of the College of Engineering and located on NC State's Centennial Campus. BTEC offers NC State students undergraduate and graduate minors and a master's degree in biomanufacturing, focused specifically on biopharmaceutical manufacturing. BTEC also offers specialized training for working professionals and analytical and bioprocess services to companies, all in a state-of-the-art facility. Access to those services, and the well-qualified NC State graduates who often stay in the area after finishing their studies, is a major selling point for biopharmaceutical companies that have North Carolina on their short list of places to invest.

"BTEC is one of the reasons that these companies are coming here, because of the NC State students that have gone through our programs," said **Gary Gilleskie**, the center's director. "They know that we are going to provide talent: trained and educated students."

BTEC is one of many parts of the College of Engineering that plays a key role in recruiting businesses to North Carolina and helping them once they are here. **Thomas White**, director of the University's Economic Development Partnership, often calls on faculty and staff members within the College for data on students and graduates and to provide information on research and expertise that might be relevant to a potential company. White said that Industry Expansion Solutions, the COE extension arm, and the NC Clean Energy Technology Center, also part of the College, are important assets as well.

"The College of Engineering, the brand that we have, I wouldn't trade it for anything," White said.

A changed economy

The Golden LEAF Foundation was established in 1999 to help create new economic opportunities using the state's proceeds from the 1998 Master Settlement Agreement with cigarette manufacturers. Investments of millions of dollars from the foundation in the early part of this century led to the creation not only of BTEC but also to the founding of a groundbreaking biomanufacturing training partnership called NCBioImpact. This partnership between industry, government, North Carolina's universities and community college system, NCBIO and the NC Biotechnology Center is the foundation of the state's flourishing biopharmaceutical industry.

BTEC's combination of undergraduate and graduate education plus training and facilities access for existing industry was unique when the center was established in 2007, and several states have tried to copy that blueprint with similar efforts, Gilleskie said. One of BTEC's distinct advantages is that the North Carolina legislature continues to provide millions of dollars in dedicated funding annually for operation of the center.

While North Carolina's biopharmaceutical industry was established and growing in 2007 when BTEC was founded, the industry has really taken off in the last few years, particularly in the area of gene therapy, Gilleskie said.

Just a few months after the FUJIFILM Diosynth Biotechnologies announcement, Amgen announced that it would also be coming to Holly Springs, NC, creating a new multi-product biopharmaceutical drug substance manufacturing facility and creating 355 jobs. The NC Biotechnology Center counts 37 biopharma manufacturing economic development announcements across the state totaling 7,131 new jobs just since spring 2017.

The industry's maturation in the state has only served to make BTEC stronger. Companies need highly skilled BTEC graduates. They also need specialized training for existing employees who have a background in biomanufacturing, but maybe not in the specific work that they have been hired to do. BTEC has the expertise to offer these short courses, which are in demand because companies nearby and throughout the United States have a need for specialized training.

The relationships that form between BTEC and the major players in the industry are also invaluable for economic development. Laura Rowley, director of life science economic development for the NC Biotechnology Center, always tries to schedule time for representatives of biomanufacturing companies considering an investment in North Carolina to see BTEC. The quality of the center's students, the capabilities of its facilities and the breadth of its offerings, along with the staff and faculty's obvious familiarity with and relationships with companies in the industry, make it a tremendous tool.

"It's those multiple touchpoints that make BTEC so unique and so valuable," she said. "It's just something that not everyone can do and it's something that sets BTEC and North Carolina apart."

staying close *to* home

NORTH CAROLINA NUMBERS

The state's life sciences industry includes more than **775** companies employing over **67,000** people, according to the North Carolina Biotechnology Center.

#3 in the United States in pharmaceutical and medicine manufacturing

15 percent growth in pharmaceutical manufacturing employment since 2010

1,600+ new pharmaceutical manufacturing jobs announced in 2021

The value for students earning an undergraduate or graduate concentration or a master's degree from the center is also obvious. Ninety-eight percent of students who earn a biomanufacturing minor or master's degree at BTEC are employed in the industry within six months of leaving NC State.

Young people in North Carolina can go to school and have a promising career without having to leave the state, Rowley said. And the work that they do can literally help to save lives.

"It's hard not to feel that this is a meaningful field to be involved in," she said.

Emily Barefoot graduated in spring 2021 from NC State with a bachelor's degree in chemical engineering and a biomanufacturing concentration. Thanks to BTEC's accelerated bachelor's-to-master's program, much of her senior-year coursework applied to her graduate studies, and she should complete her master's in biomanufacturing in just one additional year. As an undergraduate, she was connected through BTEC with Merck for two internships and has accepted a full-time position that will start after she graduates.

Barefoot is planning for a career in industry and is glad that there will be many opportunities for her to stay in the area. No matter what kind of work her employer is doing, Barefoot thinks that her NC State training will have her prepared.

"I can go into that role feeling confident," Barefoot said. "I might not know everything the first day that I walk in the door, but that foundation is really important." ■

SEEING STARS

— and atoms, and *everything in between*

Every day, we are surrounded by things we can't see — our individual cells, their molecules, the atoms making up those molecules. Then there are planets and stars, which are too far away for us to grasp just how large they really are.

Understanding the relative size of things too big or small for people to see or interact with is an important concept that can affect how well students grasp future concepts they come across in science, technology, engineering and mathematics (STEM) classes.

"While this phenomenon is everywhere, there's research data showing that, unfortunately, learners of all ages, and we all do this, hold on to inaccurate ideas about sizes of scientifically relevant entities," said Karen Chen, assistant professor in the Edward P. Fitts Department of Industrial and Systems Engineering.

That's where virtual reality (VR) comes in — if students are able to experience objects that are very small or very large in comparison to their own bodies, faculty members at NC State think their understanding of scale and relative size will improve.

Chen is the principal investigator (PI) of a $1.3 million grant from the National Science Foundation, "Virtual Reality to Improve Students' Understanding of the Extremes of Scale in STEM." Cesar Delgado, associate professor in the College of Education, and Matthew Peterson, assistant professor in the College of Design, are the co-PIs. Graduate students from each college will be assisting with the development and assessment.

The team is developing a program called Scale Worlds, creating 31 unique scientific entities that differ in size by powers of 10. In the immersive experience, a student will first see a human-scale scenario, with a human about their size, and other entities at their corresponding sizes. If students use the navigation panel to shrink to a tenth of their height, they will see a chipmunk that appears to be about their size, with a human that now looks like a giant. After shrinking further, they'll feel like the size of the honey bee beside them, with the chipmunk towering over them, and a table tennis-ball sized flea beside them.

These entities currently range from a molecule to the ocean liner SS United States. They will eventually go down to an atomic nucleus and all the way beyond stars to the Cat's Eye Nebula. In an early prototype, students are able to see one larger and two smaller entities at a time.

The project is interdisciplinary by its very nature. "We believe that this won't happen unless all three pieces are together," Chen said. "We really need the expertise in education, and we also want to make sure it's well-designed and aesthetically pleasing."

FROM LEFT TO RIGHT, MATTHEW PETERSON, CESAR DELGADO AND KAREN CHEN.

An interdisciplinary team is using virtual reality to help students understand scale

The study will assess how well middle school and undergraduate students understand scale cognition after using Scale Worlds. Middle school is when science curriculums introduce concepts and entities that are too small to see, explained Delgado. Scale cognition is a cross-cutting concept, meaning it is critical to students' success in a range of STEM subjects.

"Research shows that students have trouble in this area," Delgado said. "Anything we can do to improve students' understanding of these objects, and then in turn, the cross-cutting concept of scale, proportion and quantity, there will be a more robust understanding from students to make those interdisciplinary connections."

The navigational tools in Scale Worlds will show scientific exponential notation, helping students think about powers of 10 while shrinking or growing along with these entities.

The team wants the entities to look as realistic as possible and to ensure that the distinct scale worlds are easy to navigate.

"I think it will be great coming from the design side for Karen and I to work on the visual and technological development because we will have a very different way of seeing those things, and I expect it to be complementary," Peterson said.

Peterson is interested in how, at certain points, if a student was really becoming as large as a massive star, they could be growing faster than the speed of light. Multimodal cues, like sound effects or changing the background color, can help students recognize those thresholds.

"From a STEM-education perspective, a big part of it is trying to find these meaningful moments to make these transitions apparent to students so they can have a rich experience that they can map on to the scientific representations and concepts they're seeing," Peterson said.

For the research, there will be three different ways in which students experience Scale Worlds: a full immersion in the Cave Automatic Virtual Environment (CAVE) on Centennial Campus, head-mounted VR displays and a two-dimensional desktop version.

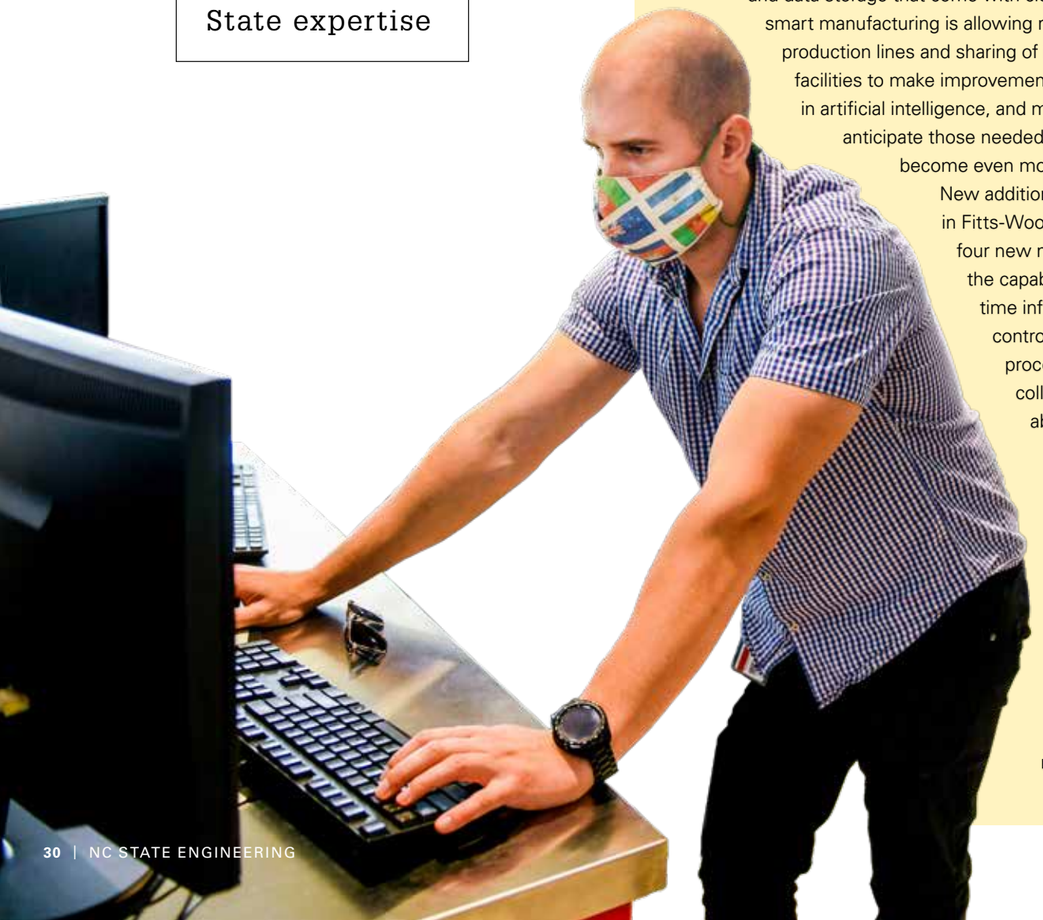
Each requires its own design approach, and each has its own limitations. While the researchers expect the CAVE to best improve student learning and the desktop version to be the least engaging, there might be an opposite pattern in terms of impact due to accessibility. The team wants to develop a version of Scale Worlds that is publicly available.

With advances in the technology, there is a lot of potential to use VR in STEM education, especially when approached from an interdisciplinary perspective, which Delgado, Peterson and Chen agree has been critical to this project.

One of the most natural ways of learning is to experience something first-hand, which isn't normally possible with an atom or a planet. Scale Worlds brings these entities that are extremely small or large where students can understand them best — right in front of their eyes. ■

BUILT WITH DATA

New smart manufacturing center provides access to NC State expertise



With the opening of Fitts-Woolard Hall in 2020, the College's smart manufacturing research and production facilities, already some of the best at an academic institution anywhere in the nation, underwent a transformation.

On the building's second floor, visible from the engineering oval outside through floor-to-ceiling windows, the new advanced manufacturing laboratory incorporates an "engineering on display" aesthetic that is an important part of NC State's newest engineering building on Centennial Campus. The innovative research being done inside is placed front and center with interpretive digital displays nearby, so that visitors have access that wasn't available in the College's previous facilities on North Campus.

Students and faculty members in the Edward P. Fitts Department of Industrial and Systems Engineering (ISE) are pushing forward smart manufacturing — think of making data an asset to take traditional manufacturing to the next level. Using cameras, sensors and the connectedness and data storage that come with cloud computing, smart manufacturing is allowing remote operation of production lines and sharing of information across facilities to make improvements in real time. Add in artificial intelligence, and machines begin to anticipate those needed changes and they become even more efficient.

New additions in the space in Fitts-Woolard Hall include four new machine tools with the capability to pull real-time information from controllers that can inform process improvements, collaborative robots able to work one-on-one with human partners efficiently and safely and even mobile robots that can move one of these collaborative robots from station to station on the manufacturing floor.

"There are just so many new advanced manufacturing tools coming out of their boxes every day," said Paul Cohen, Edgar S. Woolard Distinguished Professor in ISE. "It gives us the ability to mimic what people are doing in industry and to be able to add the smart manufacturing overlay to everything."

Now, because of a partnership with CESMII, the U.S. Smart Manufacturing Institute, American companies will have more ways to benefit from research expertise, facilities and tools across a broad range of manufacturing areas at NC State.

In 2020, CESMII named NC State as its first Smart Manufacturing Innovation Center (SMIC). Since then, three other such centers have been established around the country to provide a network of resources for the nation's manufacturers that stretches from coast to coast. The NC State SMIC covers the entire Southeast.

NC State manufacturing expertise has long been an asset for companies around North Carolina and the Southeast. Manufacturers can improve their operations by working with students and faculty members or with Industry Expansion Solutions, the College of Engineering's extension service. Undergraduate and graduate students benefit from the hands-on experience they receive and take that knowledge into the workforce, helping to push the local economy forward.

Now, through the CESMII partnership, more manufacturers can benefit from such partnerships. Cohen, along with Yuan-Shin Lee, director of the NC State SMIC and professor in ISE, and ISE James T. Ryan Professor Binil Starly, are excited about the additional exposure this will bring to their department, spreading the word about the strength of its programs.

"We are the leading university in the smart manufacturing area," Lee said.

UNIVERSITY-WIDE EFFORT

The NC State SMIC is unique in the breadth of its offerings. Along with the smart manufacturing work being done in the College of Engineering (COE), the center offers companies access to facilities and manufacturing expertise in the Golden LEAF Biotechnology Training and Education Center (BTEC), part of the COE, along with the paper manufacturing program in NC State's College of Natural Resources and in textile manufacturing through NC State's Nonwovens Institute, part of the College of Textiles.

Thanks to a new digital platform developed by CESMII called the SM Innovation Platform, manufacturers around the nation can gain remote access to NC State facilities from wherever they are.

"NC State is a 'Think and Do' nationally recognized university for research and innovation," Lee said. "With this partnership, the NC State SMIC will develop a world-class smart manufacturing demonstration facility through partnerships with industry and regional and national laboratories for sustainable workforce development and educational training. We are very excited about this new opportunity."

CESMII is the United States' national institute accelerating smart manufacturing adoption through the integration of advanced sensors, data, platforms and controls to radically impact manufacturing performance. CESMII's program and administrative home is with the University of California, Los Angeles in partnership with the U.S. Department of Energy's Advanced Manufacturing Office.

This national effort is a vital one, Cohen said, as the United States seeks to maintain and even improve its global standing as a leading manufacturer. As a member of a task force for the American Society for Engineering Education, the need among U.S. companies for a highly trained workforce that understands these new technologies is something that he hears about often.

That needs ranges from the community college level to the advanced work done by master's and Ph.D. graduates from four-year universities.

"The knowledge that is needed is so broad," Cohen said. "They need people with an overview of how processes, data and control fit together. We really don't produce those people, nationwide, right now." ■

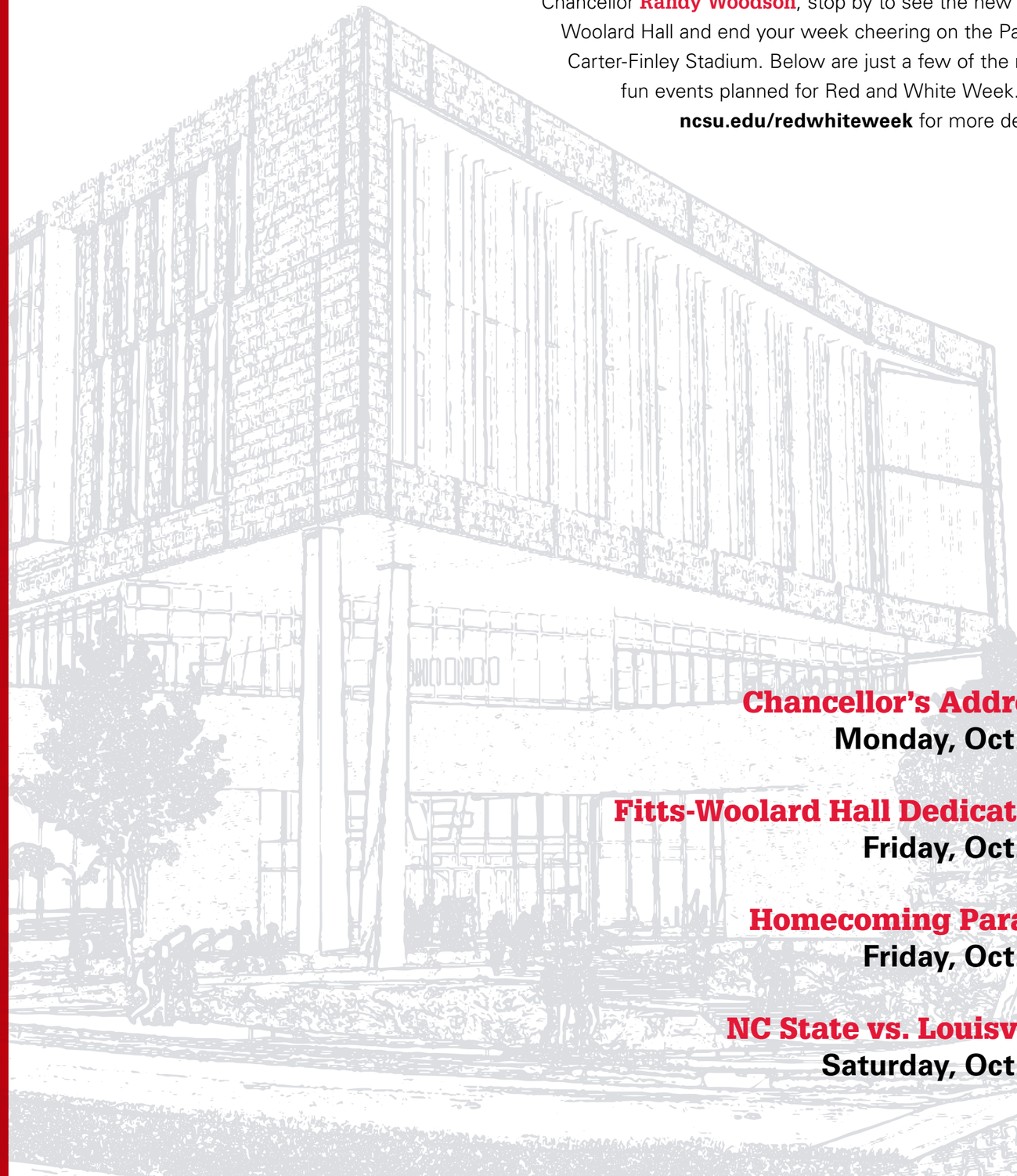
HOMECOMING 2021

A Community Celebration

This fall, join your fellow Wolfpack engineers and computer scientists for Red and White Week, Oct. 24-30. More than a traditional homecoming, it's a week that captures everything our students, faculty, staff, alumni and friends hold dear about NC State. As a community, we'll celebrate the dedication, resilience and generosity NC State alumni have shown to the University, especially to our College of Engineering.

Homecoming is particularly important this year for our alumni from the Department of Civil, Construction, and Environmental Engineering and the Edward P. Fitts Department of Industrial and Systems Engineering — their home departments have settled into their new home in Fitts-Woolard Hall. The state-of-the-art building officially opened in August 2020 with generous support from alumni and friends of the College.

All College of Engineering alumni are invited to a special dedication, celebration and tours of this extraordinary, state-of-the-art space that emphasizes "engineering on display."



This **Red and White Week**, start with an address from Chancellor **Randy Woodson**, stop by to see the new Fitts-Woolard Hall and end your week cheering on the Pack at Carter-Finley Stadium. Below are just a few of the many fun events planned for Red and White Week. Visit **ncsu.edu/redwhiteweek** for more details.

Chancellor's Address
Monday, Oct. 25

Fitts-Woolard Hall Dedication
Friday, Oct. 29

Homecoming Parade
Friday, Oct. 29

NC State vs. Louisville
Saturday, Oct. 30

2021

SAVE THE DATE

Friday ▪ Oct. 29 ▪ 1 p.m.

Join Chancellor Randy Woodson, Dean Louis Martin-Vega, colleagues and friends for a dedication ceremony followed by tours of the building.

Details: **engr.ncsu.edu/alumni-and-giving/homecoming**

GLENN FUTRELL WITH WIFE, PHYLLIS.

SUZANNE GORDON

Futrell, Gordon honored by the University with **Watauga Medals**

Two College of Engineering alumni received the Watauga Medal, NC State's highest nonacademic honor, for 2021. Glenn Futrell and Suzanne Gordon were honored by the University during a program on Sept. 9.

The Watauga Medal was established in 1975 by the Board of Trustees to honor people who have made significant contributions to the advancement of the University. The name derives from the Watauga Club, a progressive group founded in 1884 by young men under the age of 30 who wanted to promote the educational, agricultural and industrial development of the state.

A native of Wayne County, NC, Futrell graduated with bachelor's and master's degrees in civil engineering in 1963 and 1965, respectively.

Futrell founded Soil & Materials Engineers, which grew to be the fifth-largest geotechnical engineering firm in the U.S. before being sold in 1987 to Westinghouse. He moved into the real estate development business and began work on Pirates Cove — a residential community and marina in Manteo, NC — as well as developments in Zebulon, Cary and Chapel Hill, NC.

Futrell credits NC State with not only providing a solid classroom education, but with teaching him work ethic and the lifelong value of being good at what you do and enjoying it. He says a stroke of luck led him to a master's degree in soils and geotechnical engineering (instead of transportation or structures, which were his first choices but had no graduate student projects available when he was ready to start) and to his successful career.

He has supported the Department of Civil, Construction, and Environmental Engineering by endowing scholarships and two named professorships and has donated to support construction of Fitts-Woolard Hall, the department's new home on Centennial Campus. Futrell served on the NC State Engineering Foundation (NCSEF) board of directors for 20 years; two of those years were as president.

"I love the University and I've always wanted to give back," he said.

For Gordon, it's a culmination of years of service to her alma mater. She earned her bachelor's degree in computer science and mathematics in 1975 and master's degree in statistics in 1980. During her more than 30 years at SAS Institute, she held a variety of key leadership roles, rising to vice president of information technology, and eventually chief information officer, at the world's largest privately held software company.

She has served on the NCSEF board and was its first woman president. She has also been a member of the Board of Trustees, the Alumni Association Board of Directors and on the College of Management Advisory Board. She is a Distinguished Alumna of both the College of Engineering and the College of Physical and Mathematical Sciences.

"I'm humbled and honored because of all of the great people who have received it," Gordon said of the medal, citing several engineering alumni who have received the award in recent years.

She and her husband, Ralph Gordon, who holds bachelor's and master's degrees in civil engineering from NC State, have created multiple scholarship endowments at the University to help students in multiple disciplines. Both of their children and a daughter-in-law also attended the University.

"We're just an NC State family," she said. ■

FROM LEFT TO RIGHT, SAMI RIZKALLA, PAUL ZIA, MICHAEL CREED, DAVID JOHNSTON AND DON KLINE.

Friendships helped forge **successful career for alumnus** Michael Creed

Reflecting on where he is today, Michael Creed, civil engineering '73, is struck by the serendipity of some of the events that led him to NC State.

Creed co-founded McKim & Creed, is a long-time supporter of the College of Engineering and Fitts-Woolard Hall, and remains close with civil engineering students and faculty members he met at NC State.

But when he graduated in 1966 from Parkland High School in Winston-Salem, NC, he had little direction. On the advice of his guidance counselor, he started working at Salem Steel Company. He enrolled in an on-the-job training program, where he learned about the elemental building blocks of structural steel buildings and bridges.

"For a lackadaisical high school student, it was exhilarating to be gaining obviously important knowledge," he said.

In the four years he worked there, Creed took courses at local community colleges, got married and started a family. In 1970, he started at NC State.

Creed did well at NC State, joining the Engineering Honors Program. He worked on a research project developing ultra-high-strength concrete with Paul Zia, Distinguished University Professor Emeritus of Civil Engineering. Through this research, he also met Sami Rizkalla, a Ph.D. student at the time and now Distinguished Professor Emeritus.

"I have fond memories of working in the testing labs in the basement of Mann Hall. The aromas of damp cement and concrete specimens are still vivid in my mind," he said.

Creed was impressed by visiting professionals who later become friends and advisers. This included NC State alumnus Don Kline, who was a visiting lecturer and a structural engineer at Kimley-Horn.

In 1978, Creed and Herb McKim, another NC State alumnus, started their own structural engineering firm — McKim & Creed Engineers, PA — in Wilmington, NC.

During an early project in 1981, the firm had to make a controversial decision — it advised the City of Wilmington to close a downtown 500-space parking facility until structural problems could be thoroughly assessed. Creed enlisted the help of Zia and Kline to review their work.

"The people I met at NC State, both professors and students, provided me an extended network of trusted friends that I cherish to this day," he said.

McKim & Creed now has 24 offices in eight states. The Triangle office moved to Centennial Campus in the mid-2000s, and Creed started to become more involved as an alumnus. Creed has given guest lectures, served on the Paul Zia Distinguished Lecture Series committee, helped create the CCEE Industry Advisory Board and is on the Engineering Foundation Board of Directors.

Creed recently toured Fitts-Woolard Hall with some of the people who inspired him most, including Zia, Rizkalla and Kline, as well as David Johnston, Edward I. Weisiger Distinguished Professor Emeritus, who helped plan the building and led the tour.

"This is a truly first-class 21st century building," Creed said of the College's newest building on Centennial. "Our collective investment in Fitts-Woolard Hall combined with the outstanding CCEE faculty puts NC State on a much higher and impressive playing field than at any time in its history." ■

"I have fond memories of working in the testing labs in the basement of Mann Hall. The aromas of damp cement and concrete specimens are still vivid in my mind."

MICHAEL CREED

CREED, RIGHT, WITH HERB MCKIM IN THEIR FIRST OFFICE IN WILMINGTON IN 1978.

JANE AND JOHNNY FITCH.

Paving the way for adventures

For decades, Jane and Johnny ('76) Fitch each enjoyed successful careers that also allowed them to plan steadily for a future phase two of their lives: a retirement filled with travel adventures.

Then, the COVID-19 global pandemic gripped the world and interrupted those adventures. The couple found themselves at home and thinking again about their future — but also about their past and the institutions that shaped them. They began to talk about connecting all of that through philanthropic giving.

"During this time when we couldn't travel, we worked on taking care of a lot of paperwork and knew it was a good time to get our estate planning documents updated," Jane said. "That's when we put our heads together and decided that whatever is left when we're finished, we would like (that money) to go to the educational institutions that meant a lot to us and played a key role in our successes."

One of the Fitches' decisions was to establish the Jane and Johnny Fitch Endowment for Experiential Education at NC State's College of Engineering through their estate plans. Once fully endowed, the fund will support scholarships for experiential education experiences among students pursuing an undergraduate degree in the Department of Materials Science and Engineering. Those learning experiences could include conference attendance, study abroad, internship opportunities and more.

Their estate gift through NC State's Think and Do the Extraordinary Campaign also will create the Jane and Johnny Fitch Scholarship Endowment to support need-based scholarships for students pursuing an undergraduate degree in materials science and engineering, Johnny's degree program at NC State.

"I remember when I was a student, I worked my way through college," Johnny said. "I certainly didn't have any extras, but I could work part-time on the weekends and during the summer and pay for my schooling — you can't do that now."

He fondly recalls the impact NC State had on him and his future.

> "... My time [at NC State] taught me how to learn. Once you learn how to learn, then it makes life more interesting — whatever the challenge."
>
> **JOHNNY FITCH**

"The critical thing was, my time there taught me how to learn," he said. "Once you learn how to learn, then it makes life more interesting — whatever the challenge."

Johnny also spoke about his own journey as a first-generation college student and how, as an NC State senior, he was able to take a trip to Chicago, Ill., paid for by his department. The trip marked his first time on a plane and in a big city. He and Jane hope their support means other students can have those types of life-changing experiences.

"We want students to have experiences that enrich their education," he said.

For Jane, who spent her career in medical education, directing their resources toward student support made perfect sense. The Fitches have also chosen to make gifts to other higher-education institutions that have had an impact on their lives.

The two were dedicated to their careers. Johnny recalls Jane getting up at 4:30 a.m. for work, and he would join her as well. They often put in long hours, sometimes seven days a week.

Johnny worked as a metallurgist for more than a decade after NC State, doing failure analysis in the oil and gas industry. He received his MBA from Rice University in 1989 and spent the rest of his career developing managerial software. He calls himself a "problem solver," even having built Jane seven different software programs to help her in her own career.

The two are high school sweethearts who both grew up in Durham, NC, where they first met in the library at Northern High School. Jane attended nearby Duke University. Johnny, who still says today that his number-one goal has always been for his wife to be happy, moved around the country with Jane as she pursued a nursing degree, then a graduate program for nurse anesthesia, then a doctorate in medicine, followed by a residency and fellowship in cardiovascular and thoracic anesthesiology.

Jane retired from a career in academic anesthesiology, having served as residency director, fellowship director, division chief, vice chair and chair at four major academic institutions from the East Coast to the West Coast. In 2014, she served as president of her national specialty organization, only the second female president since the group's inception in 1905. She is also past president of her national academic organization, 2012-14.

All of that hard work paid off in successes and in their retirement thus far. Just before the pandemic hit, the two had traveled to eight countries in 2019 and three countries in early 2020. Destinations included Cuba, Peru, Ecuador, Cambodia and Thailand, among others. They also visited 30 state and national parks in that period.

"Our motto is, the world is our classroom," Jane said. "We love traveling; we did little bits of traveling while we were working, but we couldn't take long trips.

"Now we can be gone for weeks."

They'll pick back up where they left off as the pandemic eases, with plans to fit in the trips they missed out on in 2020 and 2021 as well as new adventures.

Being able to pursue those dreams is another part of what inspired the Fitches' philanthropy. Johnny talked about the couple's own modest middle-class beginnings and their desire for others from similar circumstances to be able to afford a complete college experience today.

"We're able to accomplish the things we have been able to accomplish because other people have made sacrifices so that we could," Johnny said. "This is our chance to give back." ■

Alumnus Jim Ellen and family **create scholarship for students** from eastern North Carolina

S. JAMES "JIM" ELLEN, JR.

From a young age, S. James "Jim" Ellen, Jr. knew how to work hard — first on a farm, then as a carpenter's assistant, and eventually as an entrepreneurial civil engineering student who went on to run his own companies.

Ellen was the first of three brothers to graduate from NC State with a degree in civil engineering, construction option. The 1959 alumnus, who is from Nash County, credits his mother, Bessie Morton Ellen, for his and his brothers' education and the success that it helped enable.

"None of us ever had one gap year, none of us ever failed, and we all graduated on time," he said. "She kept us straight. She was a fantastic mother."

His education at NC State paved the way for Ellen to start his own successful business, Capital Masonry Corporation, in 1971. Based in Richmond, Va., he eventually started another company and went into real estate. He led his company until his retirement in 2013.

Ellen has since returned his success, supporting both faculty members and students in the Department of Civil, Construction, and Environmental Engineering. In 2011, he endowed the S. James Ellen, Jr. Distinguished Professorship. He recently created the Samuel James Ellen, Jr. Family Scholarship Endowment, which will support students majoring in civil engineering, with priority for those from Nash County and other rural eastern North Carolina counties.

While an undergraduate student, Ellen received a scholarship when he won a contest for a paper he wrote — something he could hardly believe, as writing was not his strongest subject. The scholarship had a major impact on helping him pay his tuition for one year of college. As a focused, career-oriented student who spent most of his time studying or working, he had little extra time or money for extracurricular activities.

"With a scholarship, hopefully people can get a more well-rounded, enjoyable education," he said.

FROM CARPENTER'S ASSISTANT TO ENTREPRENEUR

To help bring in money for his family, Ellen started working on a farm as a child before landing a job as a teenager with a carpentry crew. He helped build barns, sheds and wood-frame farm equipment, and he decided then that he wanted to go into construction.

"That summer building farm buildings led me into construction, and that led me into civil engineering, construction option at NC State," he said. "I could see my way from that degree into my own company."

Ellen had never doubted that NC State was the school for him and was initially hooked by the school's basketball program. But coming from a small town with a high school graduating class of just 27 students, he decided to start at a smaller school. He spent two years at Mars Hill Junior College (now Mars Hill University) in western North Carolina, where he took pre-engineering courses and worked as a janitor before transferring to NC State in 1957. His younger brothers followed. Ed Ellen, who passed away in 2013, went to Mars Hill and then NC State two years after Jim Ellen, while his youngest brother, Bill Ellen, went straight to NC State. All three majored in civil engineering, construction option.

"I doubt they would admit it, but I'm sure I influenced them by going there first," he said.

After college, Ellen worked for 12 years in different parts of the construction industry before starting Capital Masonry, a commercial masonry contractor. He later started a second company, Capital Interior Corporation, which specializes in drywall, ceilings and floors and is still in business.

At the time in Virginia, subcontractors could bid lump sum for labor and materials, whereas in North Carolina, subcontractors bid piecework and were only paid for their labor.

"Virginia was the natural place for an entrepreneurial-type operation," Ellen said. "I became a complete turnkey contractor, not just a labor contractor."

IN THE FAMILY

While the three Ellen brothers never worked together at Capital Masonry, all three ended up in Richmond, just two hours from their mother in Rocky Mount. Ed Ellen and Bill Ellen started their own concrete construction companies, Dee Shoring and Elco Concrete.

And the three did eventually go into business together. While running his companies, Ellen also went into real estate. He specialized in renovating unused properties and turning them into usable rental properties.

"I thought we could do great things together in real estate," he said. "So I made them partners in some of my real estate, and we're still partners today."

Beyond the three brothers, NC State has remained an important connection in his family, with ties dating back more than a century. Ellen's great-uncle Jasper Hewitt graduated in 1913 with a degree in civil engineering. In his mother's family, there are seven NC State graduates. In one of his aunt's families, there are 26 NC State degrees among 22 people.

"I still have roots down there in North Carolina and Nash County," he said. "That's the reason the scholarship is angled toward where I got my start."

While Ellen's mother did not attend NC State — she completed a two-year degree at Cullowhee State Teachers College (now Western Carolina University) and later went back to school to earn her bachelor's degree from Atlantic Christian College (now Barton College) — he knows that much of his family's success is because of her guidance.

"She was the lynchpin that kept it all together," he said. "She made it happen." ■

THE ELLEN BROTHERS, STANDING FROM LEFT TO RIGHT, ED, BILL AND JIM, WITH THEIR MOTHER, BESSIE MORTON ELLEN.

Engineering Interest Circles connect students and alumni

JED TAN, LEFT, AND TIMOTHY CRAWFORD.

College of Engineering alumni and students shared networking tips, information on research positions and more through a new program launched last year to help NC State engineers make lasting connections.

The NC State Engineering Foundation and the College's Engineering Your Experience (EYE) Program started Engineering Interest Circles (EICs) as a virtual program to connect students with alumni in their fields to learn more about what potential careers look like for them and to find mentors.

Each circle had eight to 11 people and included students and alumni who were just a few years out of NC State and those with more than 20 years of experience. They met for three one-hour virtual sessions, followed by a celebration with all participants.

Jed Tan, a sophomore majoring in biomedical engineering, signed up for EICs to talk to alumni. Through his circle, he met an alumna who helped him get an undergraduate research position in a lab at NC State and made more connections on LinkedIn.

"One of the things I learned from the career fair is that networking is definitely really important," he said. "These connections gave me a lot of insight into the path that I'm taking."

Tan plans to continue participating in the EICs, which will eventually involve in-person meetings and video calls.

"These were very relaxed sessions, despite talking about serious topics," Tan said. "It was more like a conversation between alumni and students."

> "I told students to find what they're passionate about and apply their skills and interests to their classes."
>
> **TIMOTHY CRAWFORD**

EICs have also proven valuable for alumni. Timothy Crawford, who graduated with degrees in electrical and computer engineering in 2016, said he enjoyed making connections with current students and learning from older alumni.

Crawford is a controls and automation commissioning engineer at BP in Houston and has been able to travel to several countries through his work, which was a goal of his when he was a student. He decided on his career path when he met an alumnus who spoke about his own experiences at a campus event.

"While at NC State, no matter what step or direction I was taking, I had someone advising me," he said. "I feel like I've had mentors in every capacity, and they're all tied to NC State whether it was a professor, another student or alumni."

Crawford said many students talked about how they knew they wanted to study engineering but weren't sure what kind. He had initially wanted to major in mechanical engineering before realizing his mind was better suited for electrical engineering.

"I told students to find what they're passionate about and apply their skills and interests to their classes," he said. "Connecting the dots and relating it back to something I loved made it exciting."

The College plans to offer EICs again in the spring. For more information or to get involved, contact **Hannah Kunkel** at **heallen3@ncsu.edu**. ■

First-generation ECE **graduate returns success**

MAURICE PARTIN

> "I owe my good fortune to being able to start out at NC State. That kind of success needs to be returned."
>
> **MAURICE PARTIN**

Growing up in a blue-collar family in eastern North Carolina, Maurice Partin thinks his parents knew the only way he'd get to college was with a scholarship.

"They pushed me to do well in school," he said. "And I guess it worked."

Partin graduated valedictorian from his high school, and he was the first in his family to attend college. He received a need-based scholarship from NC State and a merit-based scholarship from the company his father worked for. He also received support from Reserve Officer Training Corps (ROTC), which he participated in for all four years of college, and took out National Defense Student Loans.

Partin remembers the pride his family had when he attended NC State. "My parents were always bragging about having a college student in the family."

Now, after a successful 53-year career with Westinghouse, later acquired by Northrop Grumman, he is helping support NC State students earning their degrees from the Department of Electrical and Computer Engineering. Partin established a scholarship that prioritizes first-generation college students and students who are veterans or participate in ROTC. He said a common theme he hears from students is stress about paying for their education and taking out loans — and he's glad he can help relieve that.

Drawn to building things and constructing electronic devices as a child, Partin took a high school senior elective course taught by an inspirational math and physics instructor who covered advanced concepts. He went into NC State knowing he wanted to major in electrical engineering.

Partin found stress relief from his coursework through music. He played clarinet for the NC State marching and symphonic bands. He was also a member of the ROTC marching band.

After graduating on June 1, 1963, and being commissioned as a second lieutenant, Partin started his first job only five days later at Westinghouse in Pittsburgh, Pa. Just four months after beginning his career, he left for Fort Benning in Georgia to fulfill his two years of active service in the Army Corps of Engineers required by ROTC. His service continued in the Maryland Army National Guard for 28 years, retiring as a colonel.

After his leave of absence, Partin returned to Westinghouse in Baltimore, Md., where he worked in radar design, microelectronics and on major air defense systems for countries around the world. Partin worked on six or seven large, multi-year programs over his 53-year career.

While he first retired at 60, he returned within a year following the 9/11 attacks, working at the same desk and computer until he retired again in 2016.

"I had a good career, and I'm a typical list maker who likes to plan things out," he said. "I owe my good fortune to being able to start out at NC State. That kind of success needs to be returned." ■

From **the board**

Learn more about the work of the NC State Engineering Foundation, Inc. Board of Directors

The NC State Engineering Foundation, Inc. was established in 1944 to aid and promote, by financial assistance and otherwise, engineering education and research at NC State. A board of directors made up of alumni and friends of the College of Engineering works with the Foundation staff and the dean of engineering to set the Foundation's agenda. The board is led by President Nelson Peeler, Jr. and Vice-President Deborah Young.

GET INVOLVED

To learn more about board service for the College of Engineering or to nominate someone, contact Sara Seltzer at skseltze@ncsu.edu.

INDUSTRY PARTNERS EVENT HIGHLIGHTS BIOMANUFACTURING'S POSITIVE IMPACT

The fifth annual Industry Partners Event, hosted by the NC State Engineering Foundation Board of Directors, emphasized how the Golden LEAF Biomanufacturing Training and Education Center (BTEC) has helped position the state at the forefront of the industry, which has brought in new jobs and billions of dollars.

NC Department of Commerce Secretary Machelle Baker Sanders, an NC State alumna and biotechnology executive, opened the June 2 event as the keynote speaker and noted that more than 8,000 jobs have been created in North Carolina by biomanufacturing companies since 2018.

The event featured four panelists who are helping North Carolina remain a leader in the biomanufacturing space.

Ruben Carbonell, Frank Hawkins Kenan Distinguished Professor of Chemical and Biomolecular Engineering and BTEC Distinguished Fellow, and Gary Gilleskie, executive director of BTEC, have helped guide and grow the center, which opened in 2007 with support from the Golden LEAF Foundation and the state legislature.

Chad Henry, corporate vice president / general manager, Novo Nordisk, emphasized the important role that BTEC has in filling a growing demand for biomanufacturing employees in the Triangle. Elice Kitchen-McKinley, a bioprocess engineer at Novartis Gene Therapies, was drawn to biomanufacturing when she saw the impact it has on improving human health, especially after her father was diagnosed with a neurodegenerative disease. She is one of the many students who minored in biomanufacturing through courses at BTEC and works in the Triangle.

At the heart of the discussion was the way in which biomanufacturing has become an economic driver for North Carolina. Both Pamela Townsend, chair of the Board of Directors' advocacy committee and moderator of the panel, and Anna Knight, director of development and advocacy committee member, noted there is a need for continued investment in BTEC.

"The purpose of this event is to highlight the value of the College of Engineering to the economy in North Carolina, and the world," said Townsend. "BTEC is a true collaborative public-private partnership that is now attracting more dollars to the state."

As more biomanufacturing companies seek to come to North Carolina, public and private investment is essential to grow BTEC's faculty, staff and lab space, in order to keep up with the increasing demand for educated workers, professional training and development of new manufacturing technologies. While NC State has long been at the forefront, new biomanufacturing centers are growing in other parts of the U.S. and world. BTEC aims to be a collaborator with these new centers, while also continuing to break new ground and draw economic investments to North Carolina. ■

SPOTLIGHT

YOUNG ALUMNI ADVISORY BOARD ADDS FIVE

New members

Formed in 2018 by the NC State Engineering Foundation, the Young Alumni Advisory Board (YAAB) aims to encourage support from the growing population of College of Engineering young alumni.

The College defines "young alumni" as students who are 0-15 years post-graduation from their last degree earned. Currently 36.2 percent, or 24,395, of graduates are young alumni.

Members of YAAB are drawn from various engineering disciplines and are divided into four committees: Events, Communications, College Relations and Development. The 2021-22 board has 31 members, including five new recruits.

"The board has grown in its diverse representation — through background, geographic location, departmental representation and ideas," said Hannah Kunkel, assistant director of development, alumni engagement and stewardship for the Foundation. "This has allowed us to attract more young alumni and create a board that represents the College we know today."

Alumni support is instrumental to the College through means including volunteering, financial contributions and representing NC State Engineering in their cities, communities and workplaces.

"The board is educating students on what private support is able to accomplish and that remaining involved does not have to start with financial giving, but can start with volunteering your time and ideas to help move the College forward," said Kunkel. "Being involved and seeing the growth inspires folks to financially support the College, allowing the College to move forward."

YAAB helps to connect recent graduates with the NC State Engineering Foundation Board to bring together generations of alumni.

"A culture of philanthropy and connection to the College from the time you graduate is one that both boards are working toward," said Kunkel.

Want to get involved in YAAB? Visit **engr.ncsu.edu/alumni-and-giving/ya** or contact **Hannah Kunkel** at **heallen3@ncsu.edu**. ■

TREVOR LAWSON

Chemical Engineering, '13
Financial Advisor, *Capitol Financial Solutions*
Events Committee
"I wanted to join the board to help continue growing our engineering network and to help promote the Foundation."

TREVOR LAWSON

SAM BROHAUGH

Civil Engineering, '20
Analyst, *Kimley-Horn*
"I wanted to get involved in YAAB because I got so much out of the connections I built in the College as a student and I hoped to continue to help provide those opportunities to other students as well as continue to grow my own professional network."

SAM BROHAUGH

KALENE HANSON

Industrial Engineering, '17, '19
Mission Assurance Engineer, *Northrop Grumman*
Development Committee
"I am excited for YAAB to connect with Wolfpack engineers, even when outside of Raleigh."

KALENE HANSON

THALIA ALLEN

Mechanical Engineering, '18
Engineer, *Volvo Trucks North America*
Events Committee
"I joined YAAB because I see the value in reigniting and maintaining the individual connections between young alumni and the University."

THALIA ALLEN

ALBERTO QUIROGA

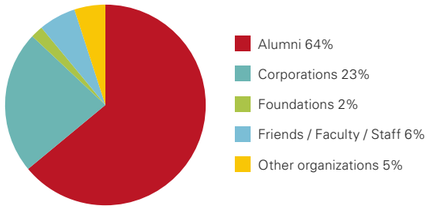
Aerospace Engineering, '19
F135 Process and Methods Engineer, *Pratt & Whitney*
College Relations Committee
"My passion of wanting to join YAAB stems from my background of being an Engineering Ambassador, which taught me how to give back to the University, and a desire to keep assisting students in the pursuit of their education and future endeavors within the workforce."

ALBERTO QUIROGA

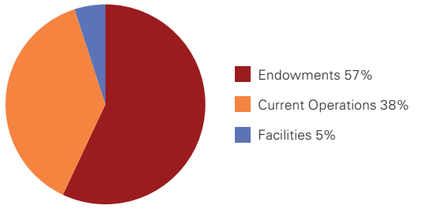
Foundation **Year in Review**

The NC State Engineering Foundation, Inc., established in 1944, is the fundraising arm of the College of Engineering. For more information on the Foundation, including financial statements, audits and tax identification number, please visit ***foundationsaccounting.ofa.ncsu.edu/foundations/nc-state-engineering-foundation-inc.***

GIFTS AND NEW COMMITMENTS BY GIFT SOURCE, FISCAL YEAR 2020-21



GIFTS AND NEW COMMITMENTS BY GIFT USE, FISCAL YEAR 2020-21



In line with other fundraising efforts across campus, the **NC State Engineering Foundation, Inc.** led the College in surpassing its $230 million Think and Do the Extraordinary Campaign goal this year, with $250,010,197 raised to date. We are poised to raise $260-$270 million by campaign close on December 31, 2021.

Fundraising totals to the College were $26,651,510 during the 2020-21 budget year. The College has invested heavily in projects like Day of Giving, raising a record $6.1 million from 1,706 donors this March in support of department enhancement funds, the Women and Minority Engineering Programs (WMEP), scholarships and professorships. Closing the fundraising gap for the now-open Fitts-Woolard Hall remains a priority, and we hope that the ability to introduce prospective donors to the building will facilitate more gift conversations.

Endowments to the College generally fall into one of three categories: scholarships, named professorships and fellowships. There are now 67 permanently endowed named professorships and more than $70 million in total endowed scholarships. Total endowment support for the College is $199.7 million as of June 30, 2021, including directly owned assets as well as endowments held outside of the Engineering Foundation.

The annual giving program raised a total of $536,767 for the College of Engineering Leadership Fund. The Dean's Circle, the College's leadership annual giving society, grew to a total of 566 members, which includes 262 new members.

These results illustrate an all-hands-on-deck advancement mentality. The Foundation is working to expand its front-line capacity to assign more fundraising resources to the largest departments and create space to better support WMEP. ■

TO INVENT, DESIGN AND BUILD: ENGINEERING STUDENTS SHOWCASE THEIR TALENTS WITH 2021 ARTS NC STATE STUDENT ART SALE

Engineers are known for their abilities to invent, design and build complex concepts. While usually reserving their skills for machines, data systems and structures, seven engineering students showcased their artistic abilities through the virtual Arts NC State Student Art Sale. The College of Engineering was the second largest participant of the colleges and units at NC State.

"This sale is a great opportunity for student artists to share their work, generate some income, and to develop valuable entrepreneurial skills by learning how to sell their artwork," said Amy Sawyers-Williams, Arts NC State's manager of outreach and engagement. "This annual sale lets student artists get their work out and share it with the wider public."

While the sale has drawn numerous participants across multiple colleges, in recent years, Sawyers-Williams has noticed an increase in STEM students.

"At first it was pleasantly surprising; you would expect drastically more design or humanities students, but now after a few years it just makes sense," said Sawyers-Williams. "Even though NC State is well known as a STEM institution, many STEM majors are not only creative, but very talented artists."

Engineering students who participated in the sale are: Olivia Allen, a sophomore engineering major; Lauren Bartek, a senior civil engineering major; Luke Hinshaw, a senior civil engineering major; Shilpa Kancharla, a graduate student in computer science; Jimmy Lewis, a senior environmental engineering major; Mehrzad Mehrabipour, a graduate student in civil engineering; and Nicole Worth, a senior computer science major.

Kancharla, who was awarded two honorable mentions for her work, found oil painting to be an outlet that enabled her to be more successful within the world of engineering.

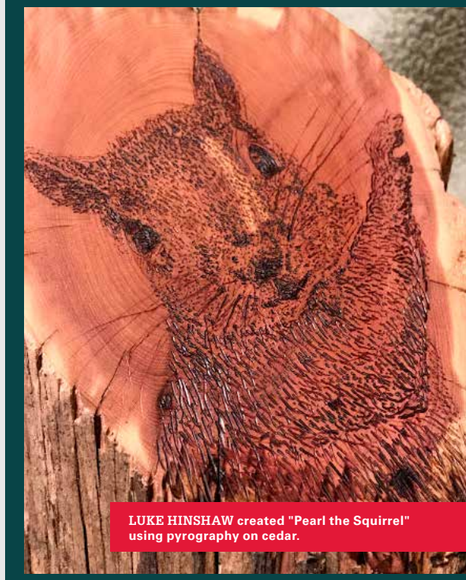
"I found that as I took breaks from my engineering work to work on paintings, I would somehow come back to my technical work with new perspectives and be able to solve problems," said Kancharla. "I was able to break down my engineering problems piece by piece, and appreciate each aspect of it."

Hinshaw appreciates wood burning, or pyrography, as an outlet that allows him to be simultaneously creative and productive.

"Pyrography takes a lot of focus when doing the fine details, which helps clear my mind while I'm producing the artwork. Bringing out the beauty of a piece of wood and incorporating knots or grain patterns into the work has been one of my favorite parts of wood burning."

Student work can be found and purchased through the student art gallery: **go.ncsu.edu/studentart**. ■

SHILPA KANCHARLA received an honorable mention for her piece, "Back Study."



LUKE HINSHAW created "Pearl the Squirrel" using pyrography on cedar.

"Flora," made with ink pen and colored pencil, by OLIVIA ALLEN.

NC STATE Engineering

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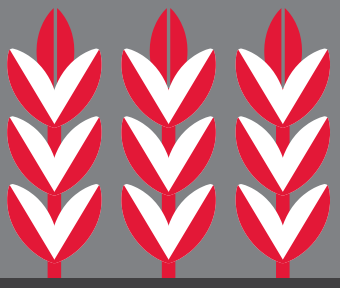

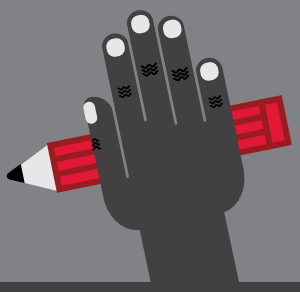

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