2022 - 2023

ANNUAL REVIEW

VCU College of Engineering

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EDITOR
Jennifer Pulver

PHOTOGRAPHER
Daniel Wagner

COPY EDITOR
David Pulgar

WEB DEVELOPER
Dustin Kratochwill

WRITERS
David Pulgar
Rebecca Antler

ART DIRECTOR
Chereen Baramki

CONTRIBUTORS

ChemTreat
Kendra Gerlach
Sean Gorman
A.J. Hostetler
Leah Landry
Joseph McClain
Michele McDonald
Brian McNeill
Sarah Murphy
Joan Tupponce
Leila Ugincius
Sarah Verneret
Dina Weinstein

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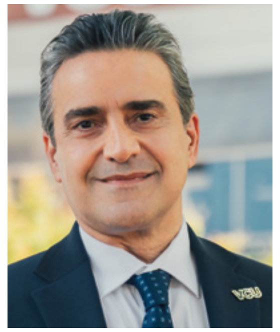


DEAN'S MESSAGE

It is my great honor to be serving you as the Alice T. and William H. Goodwin Jr. Dean for the College of Engineering. Engineering is the foundation of modern society. From smartphones and the internet to artificial intelligence, from health care and energy to transportation, security and defense, engineering is in every aspect of our lives.

The VCU College of Engineering is making significant contributions to these areas. Faculty researchers are improving the health of our oceans, protecting critical infrastructure from cyber threats, investigating the possibilities of quantum computing technology, understanding the movement of cancer cells within the body, creating more efficient infrared detectors and much, much more. Alongside them are our bright and inspiring students, taking advantage of the College of Engineering's many undergraduate and graduate research opportunities that provide hands-on experiential learning. This kind of research is what earned VCU a ranking among the 30 most innovative public universities in the country in the latest U.S. News & World Report Best Colleges rankings.

This important work is recognized nationally and internationally, with funded support from organizations like the National Science Foundation, United States Department of Defense, National Institutes of Health, National Cancer Institute, United States Department of Energy and many more foundations and agencies.

Our faculty have also been invited to join and serve as part of distinguished organizations like the National Institute for Pharmaceutical Technology & Education, National Academy of Inventors and European Academy of Sciences and Arts, to name a few.

In my short time with the College of Engineering, I have seen great results that are the fruits of labor from people passionate about education and engineering. We all share a common goal, the success of our students.

Combining our undergraduate and graduate students, 58% of them identify as female while 44% of our student population is from underrepresented minorities within the engineering industry. From 2018 to 2022, our graduate programs have experienced a 109% increase in students from underrepresented minority groups while undergraduate programs have seen a 37% increase. This reflects the VCU College of Engineering's goal to provide STEM education and opportunity to the "missing millions" and encourage them to become engineers.

We are consistently among the top graduate programs in the nation ranked by U.S. News and World Report. This year, VCU Engineering's overall rating climbed more than 10 ranks, with all department graduate programs also recognized within their respective industries.

We have much to be proud of as we continue building on the solid foundation laid by those before us. Let's continue moving forward together.

Go Rams!

Azim Eskandarian, D.Sc., Fellow of ASME
Alice T. and William H. Goodwin Jr. Dean
College of Engineering
Virginia Commonwealth University

LOOKING BACK AT THE VCU COLLEGE OF ENGINEERING
BY THE NUMBERS

30% FEMALE GRADUATE STUDENTS

28% FEMALE UNDERGRADUATE STUDENTS

14% UNDERREPRESENTED MINORITIES IN GRADUATE PROGRAMS

30% UNDERREPRESENTED MINORITIES IN UNDERGRADUATE PROGRAMS

FROM 2018-2022

109% **INCREASE** OF UNDERREPRESENTED MINORITIES IN GRADUATE PROGRAMS

37% **INCREASE** OF UNDERREPRESENTED MINORITIES IN UNDERGRADUATE PROGRAMS

GRADUATE DEGREES AWARDED **INCREASED BY** **35%**

UNDERGRADUATE DEGREES AWARDED **INCREASED BY** **17%**

BIOMEDICAL ENGINEERING FACULTY ADVANCE RESEARCH WITH HELP FROM NEW AWARDS





Left to right (top to bottom): Priscilla Hwang, Ph.D., Jennifer Jordan, Ph.D., Michael McClure, Ph.D., Carrie Peterson, Ph.D., and Jennifer Puetzer, Ph.D.

Research faculty from VCU Engineering's Department of Biomedical Engineering (BME) are diligently working to advance their investigations with support from research grants and collaborations with the private sector.

Priscilla Hwang, Ph.D., Assistant Professor
Through funding from the National Science Foundation (NSF) CAREER Award, Hwang investigates how leader cells contribute to collective migration, a process important to human development and an enabler of progression in diseases like cancer.

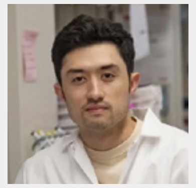
Jennifer Jordan, Ph.D., Assistant Professor
Working with VCU's Pauley Heart Center, Jordan is also an associate director of the Undergraduate Cardiovascular Summer Research Program funded by the American Heart Association and NIH National Heart, Lung and Blood Institute. The program aims to provide funded research opportunities to students interested in cardiovascular research who come from disadvantaged or underrepresented communities.

Michael McClure, Ph.D., Assistant Professor
McClure researches muscle-specific collagen scaffolds called decellularized muscle matrices (DMM). Made possible by the VCU Commercialization Award, the grant allows his company, Sarcogenics, LLC, to refine DMMs for use in rotator cuff injuries needing surgical repair.

Carrie Peterson, Ph.D., Assistant Professor
Developing and testing a home-based, upper-limb rehabilitation program for individuals with tetraplegia after spinal cord injury is the focus of Peterson's work. Backed by the Department of Defense Spinal Cord Injury Research Program Investigator-Initiated Research Award, the funding provides for the participation of service members, veterans and civilians with spinal cord injury-related tetraplegia; hardware and software development for the rehabilitation program; and training for graduate students assisting with the project.

Jennifer Puetzer, Ph.D., Assistant Professor
Collagen fibers are the primary source of strength in tissues throughout the body, particularly tendons, ligaments and menisci. Unfortunately, these collagen fibers do not regenerate after injury or in engineered tissues, providing limited treatment options. Puetzer and her team use funding provided by the National Science Foundation (NSF) CAREER Award and a National Institutes of Health (NIH) R01 to investigate how mechanical cues drive cells to regenerate these fibers. The goal is to understand how cells know to create hierarchical collagen fibers and what drives them to make bigger, stronger fibers. This enables the body to produce functional replacements and better regenerate connective tissues throughout.

SANTIAGO LOPEZ IMMIGRATED TO THE U.S. AT A YOUNG AGE WITH A PASSION FOR STEM THAT CULMINATED IN A PRESTIGIOUS NSF FELLOWSHIP



Santiago Lopez is a recipient of the 2023 National Science Foundation Graduate Research Fellowship. The grant will help support his research as a doctoral student at Vanderbilt University. His research — looking at the tumor environment and how its environment triggers cancer metastasis — builds upon his work at VCU as an undergrad.

Lopez's current research focuses on looking at cell-to-cell junctions and how altering these junctions affects the cells' behavior — an interest that a VCU biomaterials class helped solidify.

"I was really interested in cellular interactions with different materials and implants and how our immune system responds to these different phenomenons," he said. "Everything just clicked for me in that class and I had an amazing teacher — [**Jennifer Puetzer, Ph.D.**, assistant professor of biomedical engineering] — that not only explained the concepts really well but also challenged us to think of solutions for problems currently in the world."

The summer after his sophomore year, Lopez investigated cancer heterogeneity in breast cancer cells at Vanderbilt as part of the NSF Research Experiences for Undergraduates.

"My experience at VCU engineering has had its ups and downs, but overall it helped give me the toolbox necessary to solve today's biggest problems," Lopez said. "VCU engineering sculpted me to become the best engineer and scientist that I could be."

Priscilla Hwang, Ph.D., holds her team's "cancer-on-a-chip model," a microfluidic model of breast cancer.

FUELED BY NATIONAL CANCER INSTITUTE GRANT, PRISCILLA HWANG, PH.D., FURTHERS STUDY OF CANCER CELL MIGRATION

Priscilla Hwang, Ph.D., assistant professor in the Department of Biomedical Engineering, is studying metastasis and the microenvironments cancer cells live in. She is partnering with Gregory Longmore, M.D., and Amit Pathak, Ph.D., on a new phase of research fueled by a grant from the National Cancer Institute (NCI).

When cancer metastasis occurs, it often means that a group of cancer cells is moving. Hwang and her partners' research combines biomedical and mechanical engineering with molecular biology in hopes of developing a comprehensive understanding of how and why groups of cancer cells move together.

Early on in their research, Hwang and the team borrowed electrical engineering concepts to design a "cancer-on-a-chip model," a microfluidic model of breast cancer. Researchers draw out their blueprint and etch it on a silicon wafer to make a mold. They can then make copies of the print and insert breast cancer cells into this constructed environment and get different cells to move by adding different signals.

"From the first phase, we identified certain cells that can drive or initiate migration," says Hwang. "Now, this new grant from the National Cancer Institute is focused on investigating what those actual pathways are that might be regulating the phenomenon that we've observed."

When there are clusters of tumor cells moving together, there are many different types of cells wrapped up in the cluster, such as stromal helper cells or immune cells. Hwang and her fellow researchers want to understand how different signaling pathways in the various cells within the moving cluster work separately or together to contribute to metastasis.

Scan to learn more about Biomedical Engineering at VCU.

CHEMICAL AND LIFE SCIENCE ENGINEERING UNDERGRADUATES FOLLOW RESEARCH PASSIONS, CO-AUTHORING PAPER ON ELECTROSPINNING TECHNIQUES

Undergraduate research is a critical resource for established labs. Students with fresh ideas infuse new creativity into the questions researchers are attempting to answer. **Christina Tang, Ph.D.**, associate professor of chemical and life science engineering, encourages students to get involved early in their academic careers.

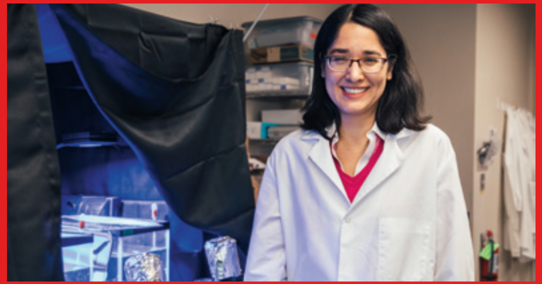
Tang's lab recently explored different collector plate implementations in order to create functional 2D and 3D shapes from a single-step electrospinning process. Undergraduate students Jocelyn Trapp, Ioana Caloian and Ryan A. Kim worked alongside Tang and her graduate students.

Tang's research is part of a multidisciplinary team of arts, business and engineering faculty and students. The goal was to construct fibers using different methods and materials in a collaborative project between the VCU College of Engineering and VCU School of the Arts. Funding for the initiative was made possible, in part, through Tang's National Science Foundation CAREER award for Directed Self-Assembly of Multifunctional Polymer Nanoreactors for Sustainable Chemical Manufacturing.

In their experiments, Tang's lab uses a charged mesh collector plate to control how fibers deposit themselves when the solution jet evaporates and nanofiber material is formed. Material gathers more densely around the mesh structure and not the gaps between, creating a template the fibers build around. Variations in the mesh size and electric charge influence the patterning and thickness of the nanofibers.

Creating disposable items like surgical masks or shoe covers for clean rooms on demand using electrospinning with an electrically-charged mesh is one application of this technology. Rapid fabrication like this can also be applied to filtration, tissue engineering, drug delivery and electronics.

Jocelyn Trapp (left) and Christina Tang, Ph.D., were part of a multidisciplinary team of faculty and students constructing fibers using different materials and methods, like electrospinning.



RESEARCHERS SEEK TO APPLY NANOPARTICLE DRUG DELIVERY TO CORAL WOUND HEALING

Researchers like **Nastassja Lewinski, Ph.D.**, associate professor of chemical and life science engineering, are working to understand how corals heal in order to aid the restoration of these fragile ecosystems. They also seek partnerships with stakeholders that can support coral preservation by applying this research to industry practices and providing funding for continued research.

Discovering the limits of coral healing is part of Lewinski's work. Ideal water temperature for coral is 25 degrees Celsius, so research is conducted at the ideal temperature and elevated temperatures of 28 to 31 degrees Celsius, the projected water temperatures influenced by global warming.

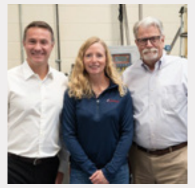
"We're looking to understand the mechanics of healing," Lewinski said, "Some of what we've found suggests a process similar to human healing. We want to understand the actors in this process at a cellular level and what their role is in repairing tissue."

These observations inform the mathematical, cell-based wound healing model developed by Lewinski's collaborators. Similar to humans, corals have been documented as following the same four stages of the healing process: 1) coagulation to close the site of injury, 2) infiltration with immune cells to ward off infection, 3) cell migration and proliferation and 4) scar remodeling.

Nutritional variables are also being considered within the experiment. Corals derive energy from consuming small organisms and their symbiotic relationship with algae colonies. Modifying nutritional balance in the lab emulates the coral's participation in the food web, where accessibility to vital nutrients could impact healing.

Developing a nanoparticle drug-delivery system designed to deliver molecules to speed wound healing is the culmination of this research. Lewinski hypothesizes the delivery system would promote an energy-burning state within the corals that could result in increased healing.

PRIVATE-PUBLIC SECTOR COLLABORATION AIMS TO SUPPORT THE NEXT GENERATION OF CHEMICAL ENGINEERS



ChemTreat expanded its longstanding partnership with the VCU College of Engineering to co-lecture a course on Water Essentials, teaching the fundamentals of industrial water treatment and its vital importance for environmental sustainability.

This specialized course provided aspiring chemical and life science engineers a unique opportunity to learn from real-life water treatment applications. A variety of technical experts from ChemTreat with decades of combined experience served as guest lecturers.

The course, led by Professor and Associate Chair of the Department of Chemical and Life Science Engineering **James K. Ferri, Ph.D.**, covers topics ranging from natural water sources and pretreatment to microbiological monitoring and sustainability practices. It examined the most important water applications, covering water chemistry and its impact on critical industrial processes including steam generation, heat exchanger and steam condenser cooling, high-purity water production and wastewater treatment.

Ferri said of the partnership, "Working with the industry-leading technical experts at ChemTreat has been a very rewarding experience. The breadth of perspective and experience of the ChemTreat technical experts is invaluable to students – both in their professional development and technical mastery of the subject matter. The Department of Chemical and Life Science Engineering is very grateful for the partnership opportunity."

The ongoing partnership allows students to become familiar with the industry and gives ChemTreat an opportunity to interact with, impact and prepare the next generation of chemical engineers with industry-specific, practical content.

Scan to learn more about Chemical & Life Science Engineering at VCU.

'GENCYBER' BOOTCAMP AIMED AT BUILDING NEXT GENERATION OF CYBERSECURITY PROS

The VCU GenCyber Cybersecurity Summer Bootcamp is part of a nationwide initiative funded by the National Security Agency (NSA) with more than 70 locations across the U.S. It aims to provide summer cybersecurity camp experiences at the K-12 level, raising cybersecurity awareness, introducing cybersecurity career opportunities and increasing student diversity in cybersecurity colleges.

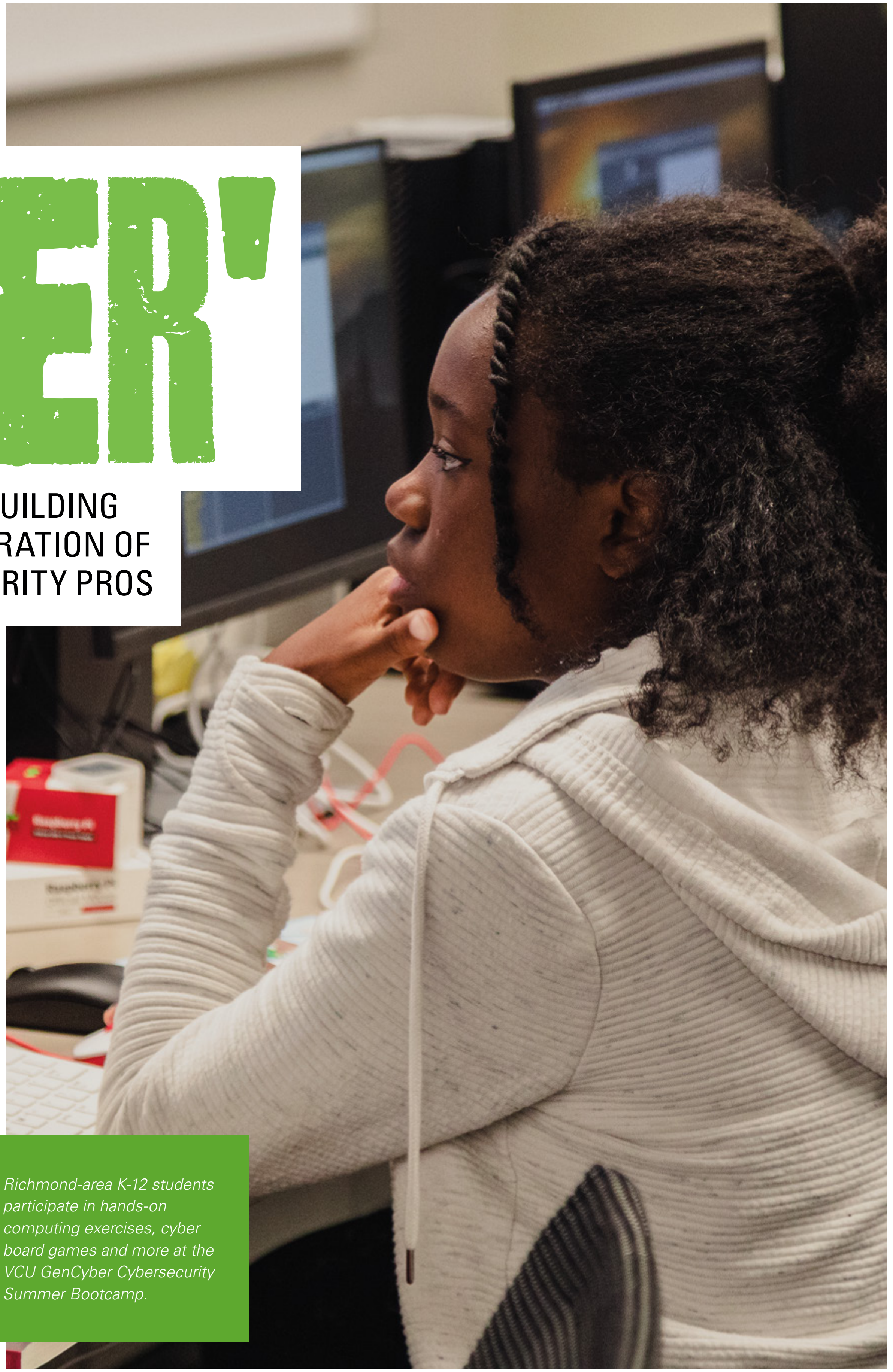
"The idea is to engage young students and introduce cybersecurity early in their life so that later, when it comes to choosing a profession, they know [cybersecurity] is an option to them," says **Irfan Ahmed, Ph.D.**, associate professor in the College of Engineering Department of Computer Science.

Students participated in hands-on exercises, cyber board games and a tour of VCU cybersecurity facilities. Instruction was led by **Ahmet Sonmez, Ph.D.**, associate professor in the College of Engineering Department of Computer Science. Colonel Carlton Day, Senior Army Instructor at Franklin Military Academy, served as the camp's middle and high school pedagogical expert.

A popular activity involved a Raspberry Pi: a low-cost, credit-card-sized computer that plugs into a monitor or TV and uses a standard keyboard and mouse. Each camp participant received their own Raspberry Pi to complete camp activities and to keep afterward.

Throughout the week, participants also heard from speakers in industry, government and academia, including an Algorithm Software Engineer at Oak Ridge National Laboratory, Director of Cybersecurity at Capital One, Tech Leader at Ferguson Enterprises and Cyber Warrior from the U.S. Army.

Participants walked away from VCU GenCyber with a deeper understanding of the cybersecurity profession. Ahmed and his team also organized a post-camp activity in the fall to keep students engaged. "Over 94% of our participants said they want to learn more about cybersecurity," says Ahmed. "We want to give them more opportunities to explore."



Richmond-area K-12 students participate in hands-on computing exercises, cyber board games and more at the VCU GenCyber Cybersecurity Summer Bootcamp.

VIRTUAL REALITY SURGICAL SIMULATOR WITH HAPTIC FEEDBACK HELPS SURGEONS HONE THEIR SKILLS

Drawing on the expertise of urogynecologist Lauren Siff, M.D., VCU Health adjunct assistant professor, VCU Engineering computer science professor **Milos Manic, Ph.D.**, and his students created a 3D virtual model of a patient's anatomic structures to train surgeons on how to implant a midurethral sling device. This device alleviates bladder control loss many women experience during physical stress like coughing or laughing. Implanting the sling is a widely-used procedure where doctors rely heavily on their sense of touch rather than seeing a patient's internal anatomy.

For the prototype training system the team combined virtual reality and "haptic" feedback, which mimics the resistance a surgeon feels when pushing into human tissue. Manic and his students got to work writing code and creating the virtual simulation using data from MRI and CT scans, artificial intelligence and feedback from Siff.

The "SlingVR" simulator creates a 3D representation of a patient's pelvis by piecing together two-dimensional images drawn from CT and MRI scans of unidentified patients. A trainee surgeon views that virtual environment on a screen or a VR headset.

Beyond looking real, the VCU sling training model is unique because it's also designed to feel real by providing the doctor touch feedback as they maneuver a device called a trocar through the virtual patient's anatomy.

If the trocar collides with the virtual pelvic bone, the instrument creates a rigid push-back response. It provides a more "pliable" feel when touching the bladder and an even slighter response while pressing on simulated blood vessels. The system also provides feedback on distance from critical anatomical structures and will provide "scoring" for levels of proficiency.

RESEARCH TEAM AIMS TO ENHANCE SECURITY OF MEDICAL DEVICES

Tamer Nadeem, Ph.D., the principal investigator (PI) of the VCU-based MedKnights project, and co-PI **Irfan Ahmed, Ph.D.**, both associate professors in the VCU College of Engineering Department of Computer Science, recently received an award from the NSF's Office of Advanced Cyberinfrastructure to put together a framework to improve security for the Internet of Medical Things (IoMT).

IoMT devices are used in a range of diagnostic, monitoring and therapeutic applications. IoMT includes patient monitors, ventilators and MRI machines. Ahmed cited the internet-connected insulin pump as a good example of an IoMT device. Internet connectivity allows for both monitoring and adjusting the dosage remotely — functions that require a high degree of security for patient privacy and safety.

Security is a considerable concern for the new generation of devices because the current IoMT devices have been hit hard by hackers, Nadeem said. Security is an issue that extends from the individual patient to the institution. The MedKnights team's preparation for taking on malicious IoMT attacks includes building a "test bed," an isolated hardware/software assembly that Nadeem says will mimic the internet-enabled hospital setting.

The test bed will incorporate IoMT datasets based on typical device behavior, traffic and known malicious attacks. Nadeem explained that MedKnights will explore vulnerabilities of various IoMT hardware and software by subjecting the elements of the IoMT test bed to a range of attacks.

Scan to learn more about Computer Science at VCU.

OPENCYBERCITY TESTBED

PROVIDES PLATFORM FOR RESEARCH INTO DIGITALLY-CONNECTED SMART CITIES

The OpenCyberCity is a 1:12 scale model of a smart city where students can learn about and experiment with the various systems found in real-life smart cities.

The Commonwealth Cyber Initiative (CCI) has funded three new VCU testbeds aimed at analyzing the security of smart city operations, medical devices and NextG applications.

Developed under the leadership of **Erdem Topsakal, Ph.D.**, director of the CCI Central Virginia regional node, senior associate dean of the VCU College of Engineering and professor of electrical and computer engineering, the new initiative includes the OpenCyberCity Testbed, which provides a realistic, small-scale cityscape in which to run experiments related to smart cities and autonomous vehicles.

A 1:12 scale model, the OpenCyberCity is a smart city testbed where students can learn about several aspects of modern smart cities. The testbed consists of data collection and processing units, database management, distributed performance management algorithms, and real-time data visualization, said **Sherif Abdelwahed, Ph.D.**, project director and VCU electrical and computer engineering professor.

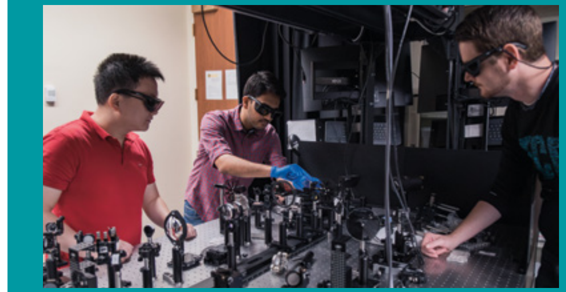
"The testbed provides a near real-life platform to allow students to learn about the unique features of smart cities and explore the supporting technologies," Abdelwahed said. Six graduate students are working on OpenCyberCity-related projects.

The smart city testbed's Intelligent Transportation System includes autonomous cars and intelligent infrastructure.

OpenCyberCity is one of three new testbeds that complement VCU's Dreams to Reality Incubator, which recently launched two new companies that also received early-stage funding from CCI.

Symple Solutions, Inc. is innovating the next generation of safe and secure instrumentation and control systems for critical infrastructures, including nuclear power, autonomous systems and more.

Another startup, VirtualPLC, is designed to mimic programmable logic controllers used in industry settings to collect threat intelligence on physical processes in the U.S. critical infrastructures.



OPTICAL RESEARCH ILLUMINATES A POSSIBLE FUTURE FOR COMPUTING TECHNOLOGY

Nathaniel Kinsey, Ph.D., Engineering Foundation Professor in the Department of Electrical and Computer Engineering (ECE), is leading a group to bring new relevance to a decades-old computing concept called a perceptron. Emulating biological neuron functions of the messenger cells within the body's central nervous system, perceptrons are an algorithmic model for classifying binary input.

When combined within a neural network, perceptrons become a powerful component for machine learning. However, instead of using traditional digital processing, Kinsey seeks to create this system using light with funding from the Air Force Office of Scientific Research. This "nonlinear optical perceptron" is an ambitious undertaking that blends advanced optics, machine learning and nanotechnology.

The United States Department of Defense sees optical computing as the next step in military imaging. Kinsey's work, while challenging, has the potential to yield an enormous payoff. Nonlinear optical computing could also be applied to a number of non-military applications. For example, optical computing could make better light detection and ranging equipment (better known as LIDAR) in driverless cars.

The concept of optical computing is not new, but interest (and funding) in theory and development waned in the 1980s and 1990s when silicon chip processing proved to be more cost effective. Recent years have seen many advancements in computing, but the more recent slowdown in scaling of silicon-based technologies has opened the door to new data processing technologies.

Kinsey and other researchers working in the field are in the early stages of scientific exploration into these optical computing devices. Consumer applications are still decades away, but with silicon-based systems reaching the limit of their potential, the future for this light-based technology is bright.

ENGINEERING STUDENT GAINS REAL-WORLD EXPERIENCE THROUGH SMART SCHOLARSHIP

Sekai Clayton is a recent graduate who completed a Science, Mathematics and Research for Transformation (SMART) Scholar summer internship with the U.S. Department of Defense in Northern Virginia.

"Electrical engineering at VCU prepared me to go into the government sector with the ability to positively impact the work being done on base," said Clayton.

Clayton's research involved developing communication solutions for a fleet of classified emergency radio response team vehicles. He aided in the device configuration of truck-mounted radios, antennas and arrays. Clayton also assembled test beds for networked solutions, like a virtual radio environment that mimicked a disaster zone where getting a good signal would be difficult.

VCU was not top of mind when Clayton considered colleges until he visited the campus to look at the senior design projects during the College of Engineering's Capstone Design Expo.

"I must have gotten lost for an hour, and then it started to rain. Long story short, my socks squished on the car ride home. Even still I had fun. I felt like I was home," Clayton said. "When I walked down West Main Street that day, I felt it was a place I could grow and become a better version of myself. That's why I decided to come to VCU."

During his own Capstone Design Expo experience, Clayton recalls many unexpected challenges. "There were a lot of issues at the front end, but in the best way. I gained a lot of real world engineering experience in my last year that gave me the confidence to step into any lab and get the job done."

Scan to learn more about Electrical & Computer Engineering at VCU.

CRUISING TO FIRST PLACE

ON A CUSHION OF AIR AT ASME'S INNOVATIVE ADDITIVE MANUFACTURING 3D CHALLENGE

Students from the VCU chapter of the American Society of Mechanical Engineers (ASME) recently won first place in ASME's Innovative Additive Manufacturing 3D (IAM3D) challenge.

Fifteen teams participated in the competition, which challenged students to use additive manufacturing to build a hovercraft capable of navigating a course, securing a package and delivering it.

"Our first hovercraft was a rudimentary one made of a fan, cardboard and trash bags," said **Ishaan Thakur**, vice president of the VCU ASME chapter and project manager for the IAM3D challenge. "We wanted to give our team the ability to test concepts and experiment with different parameters that can impact a hovercraft's ability to fly. Should we put a skirt on the bottom? Will having small perforations increase stability? What's the best way to let air flow out from underneath? Since the materials were cheap, we were able to make several of these prototypes and learn valuable lessons that informed our final design."

VCU Engineering's hovercraft was built from this iterative design process. Students collaboratively developed the vehicle's chassis, power systems, hover devices and payload delivery mechanism. Mechanical, electrical and computer engineering students comprised the majority of the team who worked together on this project.

VCU ASME students pilot their hovercraft through the IAM3D challenge obstacle course.

RESEARCHERS USE COMPUTER MODELS AND SIMULATIONS TO PREDICT SATELLITE RESILIENCE

Gennady Miloshevsky, Ph.D., is an associate professor of mechanical and nuclear engineering who specializes in computational physics with an emphasis on plasma, lasers and particle beams. He works to predict the behavior and state of materials when under extreme pressure, temperature and radiation.

With funding from the Defense Threat Reduction Agency (DTRA), an agency of the U.S. Department of Defense (DoD), Miloshevsky is studying the effect weapons of mass destruction have on satellites within Earth's orbit. Part of Miloshevsky's research involves developing methods to computationally simulate temperature, pressure and radiation in order to study the state known as "warm dense plasma," which occurs between the solid and classical plasma states and exhibits the characteristics of both.

Miloshevsky's research includes quantifying and reducing the uncertainty of computer model material properties, such as diamond, under the conditions of a nuclear blast using the REODP (Radiative Emissivity and Opacity of Dense Plasmas) computer code he developed. He works to understand and predict the interaction between X-rays and satellite surface materials (like silicon, germanium and other materials used to make solar panels) during a nuclear detonation in space.

Practical experiments in a lab use lasers to replicate the heat and pressure generated by X-ray radiation, shock and other physical effects of a nuclear detonation. Miloshevsky's colleagues at the John Hopkins Extreme Materials Institute heat carbide diamond and silica materials typically found in solar panels to temperatures between 11,600 and 1,160,000 Kelvin using lasers at the University of Rochester and Pacific Northwest National Laboratory to observe this momentary transformation into warm dense plasma. Researchers then use shadowgraphy, spectroscopy and other visual analytical methods to quantify the result. They can also investigate the depth, size and shape of the crater created by the laser within the material surface.

PHYSICAL MODELS OF A PATIENT'S BRAIN HELP RESEARCHERS TREAT NEUROLOGICAL DISORDERS AND DISEASES

Brain phantoms are a creative solution for a challenging question: How do you tune an electromagnetic field to a patient without testing on the actual patient? Transcranial magnetic stimulation (TMS) is an application of electromagnetic research with the potential to change the way we treat migraines, depression, obsessive compulsive-disorder and even conditions like schizophrenia and Parkinson's disease.

Ravi Hadimani, Ph.D., associate professor of mechanical and nuclear engineering, leads a team of researchers who seek to use TMS to excite or inhibit brain neurons to alter specific brain functions and treat these conditions.

Designed to specifications obtained from MRI scans, brain phantoms are a physical model of a patient's brain. Materials used in brain phantom construction are designed to replicate the electrical conductivity and electromagnetic permeability of different brain sectors. The result is a representation that, when connected to electrodes, provides instantaneous feedback to researchers calibrating TMS coils.

Scan to learn more about Mechanical & Nuclear Engineering at VCU.

STUDENTS PRESENT

INNOVATIVE RESEARCH AND PROTOTYPES AT VCU COLLEGE OF ENGINEERING CAPSTONE DESIGN EXPO

A vertical, soil-less garden. A clothes dryer that uses vacuum technology instead of heat. A system that precisely tracks wheel-based equipment. These were some of the innovative prototypes unveiled by more than 90 student teams at this year's annual Engineering Capstone Design Expo.

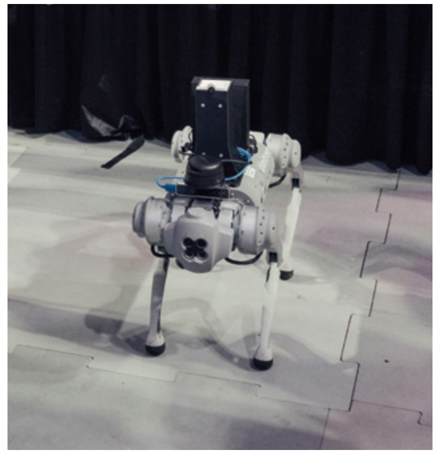
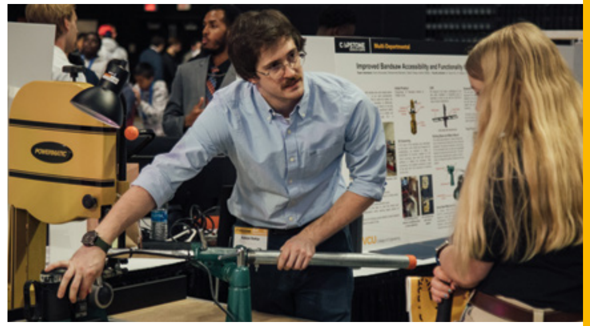
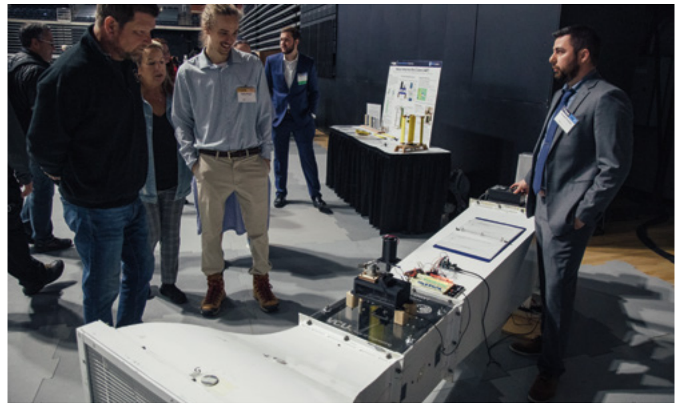
A signature event of the Virginia Commonwealth University College of Engineering, the annual Capstone Design Expo represents the culmination of the graduating class's education and offers design teams the opportunity to display and demonstrate their working prototypes to the Greater Richmond community.

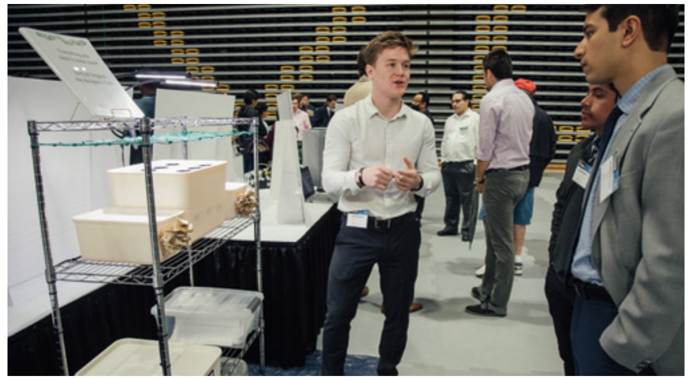
The projects are the product of a yearlong Capstone Design course, led by staff and a team of faculty representatives from each department, which immerses senior engineering students in the hands-on processes of solving practical problems.

Through their projects, student teams practice customer discovery, the engineering design process and rapid prototyping. Working with sponsors, students tackle this practical learning experience by solving real-world problems under real-world constraints, learning the fundamentals of teamwork and applying learned theory.

Read more about this year's Capstone Design Expo projects.



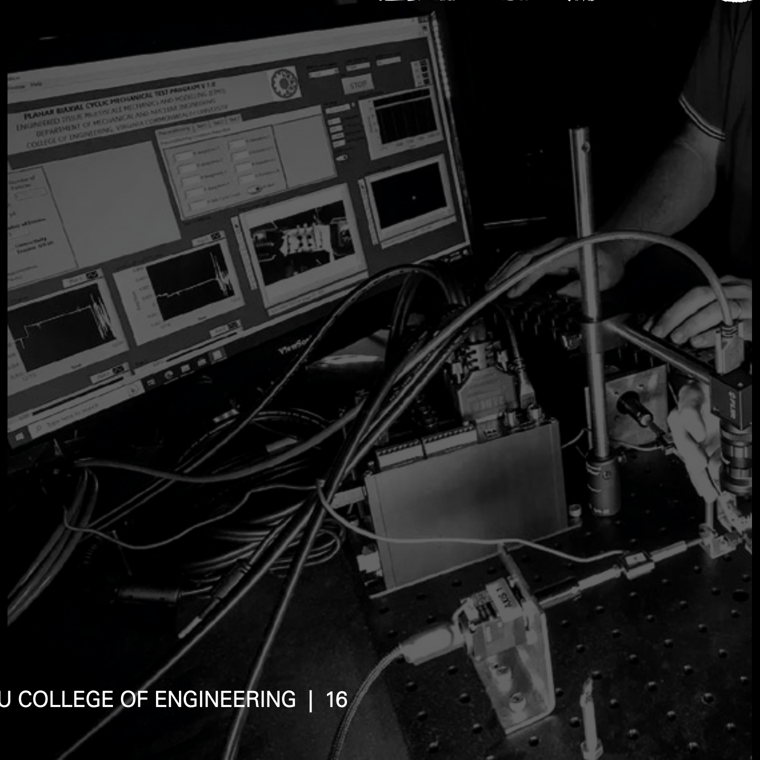
Caleb Wells,a Virginia Commonwealth University College of Engineering senior, devotes hours to a microscopic project that has a very big application: tissue engineering.

"We put cells in the scaffold, and the cells build around the scaffold. Just like at the end of a construction project, you tear down the scaffold," said Wells, a student in the Department of Mechanical and Nuclear Engineering. "This scaffold biodegrades inside the human body. So at some point, the only thing left is the host's own cells. So there's no chance of rejection or anything. It's a perfect replacement."

Fibers made of a polymer called polycaprolactone form the scaffold, and Wells is focused on the properties of those fibers. To test and establish a baseline measure for the fibers, he uses a scanning electron microscope that magnifies 3,000 times. The minuscule fibers are roughly 1 micrometer in diameter.

Joao Silva Soares, Ph.D., (left) and Caleb Wells use electrospinning to build biodegradable scaffolds for use within the human body.

VCU ENGINEERING SENIOR LOOKS TO BUILD A BETTER TINY SCAFFOLD



To produce the scaffold, a process known as electrospinning distributes the polymer in solution. "You get fibers oriented in every direction on the scaffold, kind of like spinning cotton candy around that cardboard tube," Wells said.

Wells works under the guidance of Joao Silva Soares, Ph.D., mechanical and nuclear engineering assistant professor, in his Engineered Tissue Multiscale Mechanics & Modeling (ETM3) Laboratory. It aims to develop highly integrative experimental-computational approaches for cardiovascular tissue engineering. Wells met Soares while taking the professor's Mechanics of Deformables class, which gave him a window into how materials and shapes bend and deform with their forces.

Wells also is working with device design to do material testing using uniaxial and biaxial mechanical tensile testers. "This helps us determine how those fibers that we looked at on the microscope are affected over time using Young's Modulus of Elasticity," he said. "If I'm pulling in every direction, I can look at how each direction's fibers are being affected. I get to play with programming and electrical design along with operating machines that already exist. I'm now getting to build machines and work on the back end at the same time."

James Ferri, Ph.D., (left) and Justin Turnage are part of a team working to apply continuous manufacturing processes to albuterol, improving production efficiency to reduce cost and increase availability.

ALBUTEROL SHORTAGE SPARKS VCU STUDY ON CONTINUOUS MANUFACTURING PROCESS

It's likely that at some point in your life, you or someone you know has used an inhaler to help treat bronchial spasms. Inhalers deliver medicine to the airways, opening the lungs and relaxing the muscles. The most common generic drug prescribed with inhalers is liquid albuterol. Yet despite its essential status, this drug is in short supply.

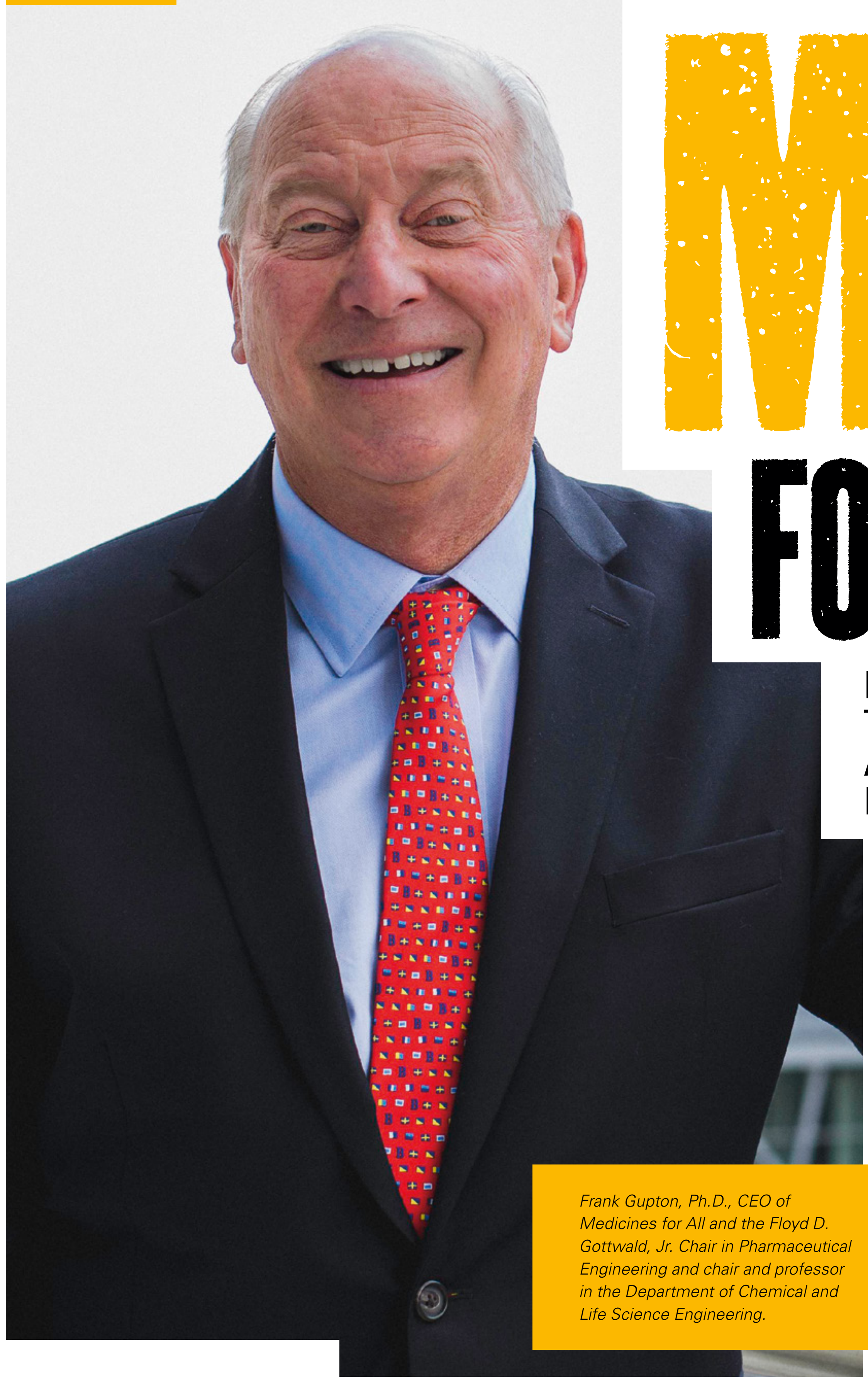
This shortage inspired a new research project spearheaded by **James Ferri, Ph.D.**, professor and associate chair in the Department of Chemical and Life Science Engineering at the Virginia Commonwealth University College of Engineering. The project looks at how albuterol is manufactured, identifying how chemistry can help build a process that improves efficiency, reduces drug costs and ultimately increases availability for those who depend on the drug.

"When there are only one or two big factories making a drug, that is where you run into problems," said undergraduate Justin Turnage, who has played a large role in the research thus far. "We're looking to build a process that increases efficiency and makes it easy to set it up anywhere without specialized infrastructure. That way, if supply chain issues happen, you're not losing access to the source."

Researchers are looking to develop a continuous manufacturing process for albuterol production, a flow that would eliminate transition times and create the final product much more quickly. Continuous manufacturing has been applied to pharmaceuticals before, but never liquid formations like albuterol.

Turnage, a senior at VCU, began working in Ferri's lab during the Fall 2022 semester. "Since joining the lab, I have learned a lot about practical experimental design and how to get the most information out of working with limited resources," said Turnage. "I have also noticed that my technical communication skills have greatly improved while working on a project with a team."

Projects like Ferri's allow students to apply theoretical knowledge to practical situations and develop skills essential to a career in engineering. These hands-on research opportunities help students learn to think critically, work in teams and communicate effectively, preparing them for success in graduate school and beyond.



Frank Gupton, Ph.D., CEO of Medicines for All and the Floyd D. Gottwald, Jr. Chair in Pharmaceutical Engineering and chair and professor in the Department of Chemical and Life Science Engineering.

MEDICINES FOR ALL

RECEIVES **$18.7 MILLION** TO INCREASE GLOBAL ACCESS TO LIFESAVING MEDICATIONS

The Medicines for All Institute at Virginia Commonwealth University will work on 14 new global health projects and expand its capabilities to improve access to medicines around the world thanks to an $18.7 million grant from the Bill & Melinda Gates Foundation. The grant will support projects to reduce the costs of medicines for tuberculosis, malaria, HIV and neglected tropical diseases.

Medicines for All dramatically improves global access to these medicines by developing significantly more cost-effective methods to produce these materials. Medicines for All, with support from the foundation, then provides direct access to these new technologies through market engagement with pharmaceutical manufacturers worldwide.

With this grant, Medicines for All has received more than $60 million from the foundation over the past decade — including $25 million in 2017 to establish the institute that allows VCU to work on multiple projects. The institute will use this latest grant to strengthen its partnerships with a global network of researchers, manufacturers and distribution partners who work together to maximize the impact of novel development processes for lifesaving medicines.

Medicines for All's methodology for developing cost-effective processes relies on its unique utilization of chemistry. Led by **Frank Gupton, Ph.D.**, CEO of Medicines for All and the Floyd D. Gottwald, Jr. Chair in Pharmaceutical Engineering and chair and professor in the Department of Chemical and Life Science Engineering, the organization works closely with the VCU College of Engineering. Medicines for All has reimagined every step of the pharmaceutical manufacturing process from simplifying raw materials to optimizing development processes.

Vapourtec flow reactors are used as part of the continuous manufacturing processes.

For instance, Medicines for All improved the manufacturing process for Bedaquiline — a crucial medicine in the global fight against TB — resulting in yields twice as high as current methods and, therefore, more economical.

As the cornerstone of the regional Alliance for Building Better Medicine, Medicines for All is helping to bring essential medicine production back to the United States. Last year, the U.S. Department of Commerce's Economic Development Administration awarded the public-private coalition $53 million through the Build Back Better Regional Challenge. The alliance will use a portion of the funding to build a first-of-its-kind scale-up facility that bridges research and manufacturing to accelerate commercialization of lab discoveries. The facility will make Central Virginia a hub for advanced pharmaceuticals.

NEW INSTITUTES CO-LED BY COLLEGE OF ENGINEERING FACULTY ENRICH VCU INNOVATION, SCHOLARSHIP AND CREATIVITY

As Virginia Commonwealth University rises to meet societal challenges, new research centers are expanding a campus environment rich in research, scholarship and creativity with funding from the Office of the Vice President for Research and Innovation and additional external support.

The Institute for Sustainable Energy and Environment will address the existential threat of climate change by creating sustainable energy systems and sustainable ecologies, while educating students and working with community partners to meet these challenges. Among its associate directors is **Jayasimha Atulasimha, Ph.D.**, Engineering Foundation Professor with the VCU Department of Mechanical and Nuclear Engineering.

The Center for Microbiome Engineering and Data Analysis will lead a highly interdisciplinary and collaborative effort to study the human and environmental microbiomes while developing novel computational and analytical tools to interpret, present and visualize multi-omic microbiome data. It is co-directed by **Tomasz Arodz, Ph.D.**, associate professor of computer science.

RESEARCH AWARDS

$35 MILLION Fiscal Year 2023

61% INCREASE From 2019-2023

15M	5M	14M	.925M
FEDERAL	INDUSTRY	FOUNDATIONS	STATE

NOTABLE AWARDS

$21,543,920
FRANK GUPTON, PH.D.
Bill & Melinda Gates Foundation
Medicines for All Institute: Low Cost Manufacturing for Global Health Drugs

$6,000,000
NASTASSJA LEWINSKI, PH.D.
Department of Commerce
VCU/VSU – Joint Degree and Research Program

$4,125,000
KAI DONSBACH, PH.D.
Phlow Corporation
API Development Projects for Onshoring Essential Medicines in the U.S.

$3,203,576
WORTH LONGEST, PH.D.
Bill & Melinda Gates Foundation
Development of Synthetic Lung Surfactant Formulations and Delivery Devices for Treating Infants with RDS in Low Resource Environments

$2,500,000
ERDEM TOPSAKAL, PH.D.
Commonwealth Cyber Initiative
CCI Central Virginia Node

$1,659,812 (5 YEARS)
JENNIFER PUETZER, PH.D.
National Institutes of Health
Unraveling the Mechanism of Mechanotransduction in Hierarchical Collagen Fiber Formation

$1,428,844 (5 YEARS)
JENNIFER JORDAN, PH.D.
National Institutes of Health
Cardiovascular Impact of Near-complete Estrogen Deprivation for Breast Cancer

$1,350,759
JAMES FERRI, PH.D.
Food & Drug Administration
A Model-based Systems Engineering Approach to End-to-End Pharmaceutical Manufacturing of Liquid Dosage Forms

NSF DIRECTOR

TOURS COLLEGE OF ENGINEERING FACILITIES AND DISCUSSES VCU'S ROLE IN BRINGING THE "MISSING MILLIONS" TO STEM CAREERS AND EDUCATION

Sethuraman Panchanathan, Ph.D., director of the National Science Foundation, and several elected officials recently visited Virginia Commonwealth University. They met with VCU leaders, touring labs and hearing from researchers about how VCU is advancing NSF-supported projects and serving as a national model for bringing the "missing millions" to STEM careers and education.

Panchanathan's visit comes just a month after VCU ranked among the top 50 public research universities in the U.S. based on research expenditures, according to the NSF's Higher Education Research and Development fiscal year 2021 survey.

On VCU's campus, Panchanathan's group took a tour of the Nanomaterials Core Characterization Facility, a partnership between the VCU College of Engineering and the VCU College of Humanities and Sciences. It offers technologies that benefit multidisciplinary industrial and scholarly research in a broad range of sciences to modify, manipulate or tailor the surface, size or shape of a particular material.

The delegation also toured the Virginia Microelectronics Center in the College of Engineering. This shared research center provides principal investigators, students and industrial researchers training, access and technical support for their project tasks.

Panchanathan led a roundtable discussion with VCU Provost Fotis Sotiropoulos, Ph.D., VCU President Michael Rao, Ph.D., NSF-supported research faculty, community partners and VCU students about the importance of engaging the missing millions and highlighting NSF-funded efforts at VCU.

WORKING TOGETHER FOR THE FUTURE OF ENGINEERING

GETTING TO KNOW VCU ENGINEERING DEAN AZIM ESKANDARIAN, D.Sc., AND HIS VISION FOR ENGINEERING EDUCATION

For **Azim Eskandarian, D.Sc.**, Alice T. and William H. Goodwin Jr. Dean of the VCU College of Engineering, the future of engineering education and practice is cross disciplinary.

"Today's engineering problems are complex and they need solutions from different engineering disciplines," said Eskandarian. "You may need elements from the physical or computing sciences, for example. And if human interaction is a factor, psychology and social sciences are also important."

Creating an environment where faculty and students work across their departments is one of Eskandarian's main goals. The College of Engineering's Vertically Integrated Projects (VIP) already provide students with an immersive experience. Collaboration occurs between a variety of disciplines, including some outside of engineering, and Eskandarian wants to grow that practice.

"Engineering should not have traditional boundaries," said Eskandarian. "The fundamentals taught within each discipline remain important, but we have to create opportunities for students to learn outside their disciplines and engage with systems that are not part of their specialty's curriculum. More companies are expecting students to have knowledge in areas previously not required, so this kind of education is necessary to ensure our VCU Engineers are well prepared."

Eskandarian learned the importance of cross-disciplinary focus through his own experience in the field of control systems, specifically for automotive passenger safety and collision avoidance.

"If you look at a car, it's not just a vehicle with a structure, engine and driving mechanisms," said Eskandarian. "It's a combination of material science, electromechanical systems, signal processing, sensors, computing and more that create the final product. A modern automobile is a package of technologies from different engineering fields."

Learning how things work is something Eskandarian enjoys. He grew up surrounded by family members who were interested in factories, building parts and other topics from both the engineering and medical fields. Gadgets fascinated Eskandarian from an early age and his aptitude for math and science helped.

"With my childhood toys I did a lot of dismantling and figuring out how parts were connected," said Eskandarian. "Of course I would destroy them in the process, but it was a good learning experience."

After receiving his master's degree, Eskandarian worked as a practicing engineer, but wanted to do more than apply existing engineering knowledge to form solutions.

"I was interested in the new knowledge we could discover through research," said Eskandarian. "Researchers want to know the unknowns and face the challenges no one has discovered yet. That's the true nature of research and it's an element of great interest to me and every other engineering researcher."

As the new dean for the VCU College of Engineering, Eskandarian brings a wealth of industry, research and educational experience. He believes in being an example for others and stresses the importance of one idea over all others – service.

"You have to be of service to your community," said Eskandarian. "Many books have been written about what being a good leader means and, to me, a good leader serves their community. For a dean specifically, having a vision and making sure the mission of the university is well understood and pursued by everyone within the organization is also important."

STARS

Supporting Tech Achievement for Richmond Students

"STARS" CAMP STUDENTS EXPLORE REAL-WORLD STEM PROJECTS TO DEVELOP DEEPER UNDERSTANDING OF RICHMOND NEIGHBORHOODS

The "STARS" program hosted its first set of summer camps last summer, engaging with 40 Richmond City students to encourage STEM learning and to highlight the role computer science and data analysis plays right in their hometown.

The camp used real data from the Science Museum of Virginia to explore the topic of urban heat islands: urbanized areas that experience higher temperatures than nearby areas. Participants had two weeks to work with the Richmond-specific data given to them before presenting their findings in teams at the end of camp.

Founded in 2021, STARS—Supporting Tech Achievement for Richmond Students—brings together Bank of America, Richmond Public Schools (RPS) and the VCU College of Engineering to enhance awareness of STEM education opportunities in the Richmond region. It aims to support students from populations typically underrepresented in engineering and computer science.

WRIGHT ENGINEERING ACCESS SCHOLARSHIP PROFILE: ENES KALINSAZLIOGLU

Enes Kalinsazlioglu is a computer science undergraduate who dreams of becoming a full stack developer. A Wright Engineering Access Scholarship recipient, the award helps Kalinsazlioglu overcome financial hardship, allowing him to focus on building a strong foundation in the core concepts of computer science.

Born in Ankara, Turkey, Kalinsazlioglu immigrated to the United States in 2019. He settled in Richmond, temporarily living in an Airbnb before securing a more permanent home. It was at Kalinsazlioglu's father's small electronics repair shop in Turkey where he learned how to troubleshoot and solve technical problems.

"The Wright Engineering Access Scholarship was a big reason why I decided to transfer to VCU," Kalinsazlioglu said.

"But the inclusivity at VCU and the College of Engineering made me feel right at home. Having worked to make myself a financially independent student, the values and practices of my chosen institution are important to me."

Now deep in his major-related, high-level courses, Kalinsazlioglu is enjoying his experience learning about computer science at the VCU College of Engineering. Introduction to the Theory of Computation taught by **Daniel Cranston, Ph.D.**, associate professor of computer science, is a favorite course because it gave Kalinsazlioglu a new perspective on approaching problems and learning how to think with algorithms in mind.

The Wright Engineering Access Scholarship was established with a generous gift from longtime benefactor C. Kenneth Wright (H.D.L. '11). It is VCU Engineering's flagship scholarship program that gives need- and merit-based awards to a wide range of students, including nontraditional students and community college transfers.

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