VCU College of Engineering

2023-2024

ANNUAL **MAGAZINE**

ENGINEERING FOR HUMANITY

DISCOVERING SOLUTIONS.

BUILDING TOGETHER.

SERVING HUMANITY.

VIRGINIA COMMONWEALTH UNIVERSITY

DISCOVERING SOLUTIONS.

BUILDING TOGETHER.

SERVING HUMANITY.

A problem to be solved isn't an obstacle, it's inspiration. At the Virginia Commonwealth University (VCU) College of Engineering, students go beyond traditional engineering disciplines to discover, build and find solutions to humanity's most challenging questions. Engineering without boundaries, Rams develop skills to become and collaborate with experts who change the world. This is **Engineering for Humanity** and the story of our Ram engineers!

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INTRODUCTION

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DEAN'S LETTER

We are inspired by problems, seeing each as an opportunity for growth and discovery. That is why serving you as Alice T. and William H. Goodwin Jr. Dean of the College of Engineering is my great honor. As our faculty explore artificial intelligence and robotics, pharmaceutical manufacturing, cybersecurity, environmental sustainability, power generation, musculoskeletal research, and more, our students are right next to them, applying classroom theory through hands-on, experiential learning opportunities and both undergraduate and graduate research.

It is for this reason that the U.S. News & World Report consistently places programs within VCU and its College of Engineering in the Best Colleges rankings. We are committed to advancing knowledge and bestowing that passion for discovery and service to the next generation, our VCU engineers.

This important work is recognized nationally and internationally, funded by organizations like the National Science Foundation, the United States Department of Defense, the National Institutes of Health, the National Cancer Institute, the United States Department of Energy, and many more foundations and agencies. Our sponsored awards exceeded last year's by nearly 18%, as the pivotal research our faculty conducts continues to be recognized.

Our faculty have also assumed leadership roles in distinguished professional organizations, such as the Institute of Electrical and Electronics Engineers, the National Institute for Pharmaceutical Technology & Education, and the Royal Society of Biology.

The VCU College of Engineering's state-of-the-art facilities, world-renowned faculty, talented students, and pioneering research enable a transformative impact on engineering, producing some of the most successful leaders in the field. The successes of our alumni are testimony to this. Together with them and VCU's industry partners, we are educating engineers who will be unrivaled, standing out from their peers and leading in their respective fields to face tomorrow's challenges. Our students are well-prepared for the most competitive engineering positions nationally and internationally.

The pages that follow detail our journey through the year. I want to extend my admiration to the faculty, staff, and students who make our achievements possible. We have much to be proud of as we continue drawing inspiration from each other to discover, build, and learn.

Go Rams!

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

Engineers are the driving force behind our modern society. Many of us work collaboratively in multi-disciplinary teams, weaving solutions to complex problems no one person could solve. It is together that we innovate and build a bright future for our communities. *Engineering for Humanity* is the ideal that encompasses our mission and the positive impact engineers make in the world. We aim to produce engineers who contribute to society, serving humanity, in all aspects of their professional and personal lives.

WE ARE INSPIRED BY PROBLEMS, SEEING EACH AS AN OPPORTUNITY FOR GROWTH AND DISCOVERY.

ENGINEERING OUR FUTURE

STATISTICS FROM THE VCU COLLEGE OF ENGINEERING

DEGREES AWARDED

30% FEMALE-IDENTIFYING UNDERGRADUATE STUDENTS

29% FEMALE-IDENTIFYING GRADUATE STUDENTS

AFTER GRADUATION

93% UNDERGRADUATE STUDENTS WORKING IN DEGREE-RELATED FIELD OR ENROLLED IN GRADUATE PROGRAMS

$78,922 AVERAGE UNDERGRADUATE STUDENT STARTING SALARY

SPONSORED AWARDS & STUDENT AID

18% INCREASE IN SPONSORED AWARDS FOR FACULTY

569 PELL GRANT RECIPIENTS

$18,640 AVERAGE PER-STUDENT UNDERGRADUATE AID

EXPERIENTIAL LEARNING

77% PARTICIPATION IN EXPERIENTIAL LEARNING

33% UNDERREPRESENTED MINORITIES

28% FEMALE-IDENTIFYING

Data sourced in part from VCU Institutional Research and Decision Support.

RESEARCH PILLARS

Expertise from multiple engineering disciplines is necessary to solve today's complex problems. Creating an environment where faculty and students can cooperate across departments and subject areas is a core value of the VCU College of Engineering.

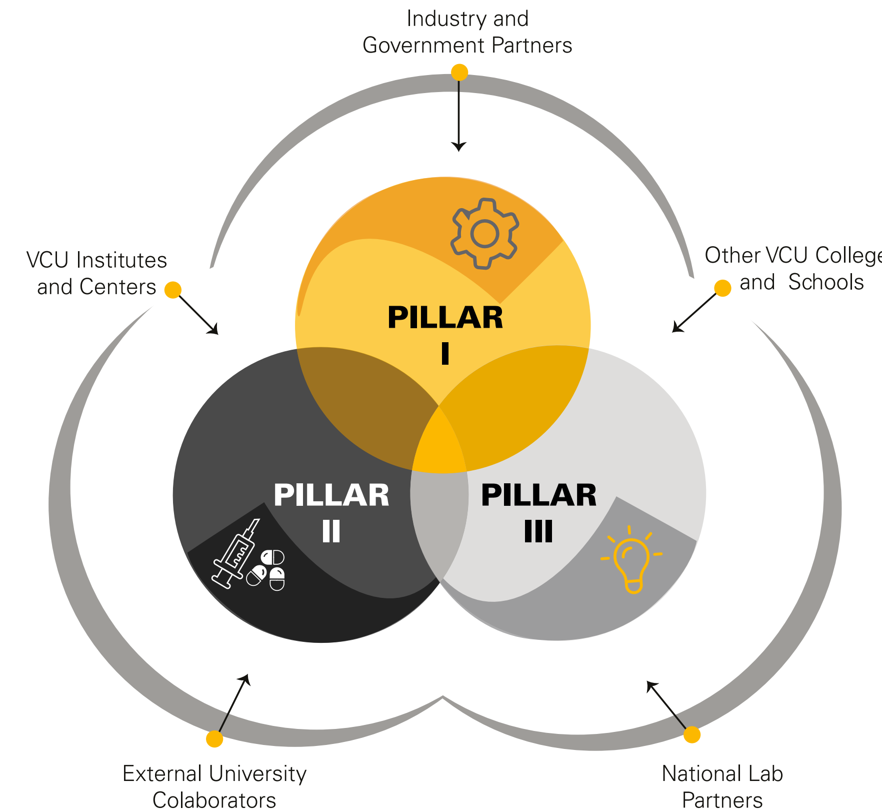
VCU engineers are knowledgeable and well rounded, capable of working with engineers outside their disciplines and outside the field of engineering itself. Our engineering without boundaries strategy encompasses collaboration through programs like Vertically Integrated Projects for students and VCU's many interdisciplinary centers like the Institute for Sustainable Energy and Environment (ISEE), Convergence Lab Initiative (CLI) Cybersecurity Center and Medicines for All, among many more.

Focused on the research pillars of health, medicine, artificial intelligence, autonomous systems, computing, sustainability, energy and materials, the College of Engineering's mission of Engineering for Humanity seeks to make progress in these areas for the benefit of our communities and our world.

"Consider an automobile, it's not just a vehicle with a structure, engine and driving mechanisms," said **Azim Eskandarian, D.Sc.**, the Alice T. and William H. Goodwin Jr. Dean of the VCU College of Engineering. "It's a combination of material science, electromechanical systems, signal processing, sensors, computing and more. Today's engineers need the knowledge and flexibility to function in an ever-changing environment to put forth creative and resolutionary ideas."

This full-cabin driving simulator reproduces driver-controlled and autonomous navigation in a smart traffic environment. It was created using the expertise of several engineering disciplines.

RESEARCH CENTERS, INSTITUTES AND CLUSTERS



PILLAR I
AI, AUTONOMOUS SYSTEMS AND COMPUTING

Center for Analytics and Smart Technologies

Commonwealth Center for Cloud Computing

Commonwealth Cyber Initiative – Central Virginia Node (CCI)

Convergence Lab (CLI)

Cybersecurity Center

RAM (Robotics, Autonomy and Mechatronics) Group

Virginia Microelectronics Center (VMC)

PILLAR II
HUMAN HEALTH AND MEDICINE

Center for Excellence in Particle and Fiber Engineering (CEPFE)

Center for Pharmaceutical Engineering and Science

Institute for Engineering and Medicine (IEM)

Medicines for All

PILLAR III
SUSTAINABILITY: MATERIALS, ENERGY AND ENVIRONMENT

Center for Rational Catalysis Synthesis (IUCRC)

Institute for Sustainable Energy and Environment (ISEE)

Materials and Manufacturing Research Center

Nanomaterial Core Characterization Center (NCC)

01

DISCOVERING SOLUTIONS

Research is the foundation of science, and the application of science is one of engineering's primary tools. New discoveries or refinements of existing knowledge afford the innovations that fuel our modern society.

Hendrick's participation in a VCU Health career exploration led to her interest in biomedical engineering. It resonated with her love of science fiction, specifically the James Cameron Avatar series, where the idea of tissue regrowth made a significant impression.

CREATING TOOLS FOR RESEARCHERS STUDYING FIBROSIS

A love for science fiction and natural aptitude for math and science inspired Taylor Hendrick from a young age, eventually leading her to the VCU College of Engineering. Hendrick is an accelerated master's program student with a concentration in cellular tissue engineering. Her thesis involves developing biomaterials researchers can use to better understand conditions within the human body.

Stimulating fibrosis within hybrid gels composed of decellularized human lung tissue is Hendrick's thesis research. Creating a biomaterial like this provides researchers with an advanced tool to study fibrosis, a condition where connective tissue scars and thickens. Hendrick uses a technique that involves taking whole human lung samples and stripping them of native DNA and other cellular components. Only the basic components of the lung remain, like proteins and similar material that keep the organ together, turning its color from a rosy red to gray. This decellularized product is then run through lyophilization, similar to freeze drying, and made into a fine powder suitable for making gels.

Two main anti-inflammatory drugs are used to treat fibrosis. Hendrick's research would enable easy testing of additional medications prior to early small animal trials. She works in the lab of **Rebecca L. Heise, Ph.D.**, Inez A. Caudill, Jr. Distinguished Professor and Chair in the Department of Biomedical Engineering.

> **VCU IS A CORE FOR AEROSOL RESEARCH. WE PLAY A BIG ROLE IN THE ANNUAL RESPIRATORY DRUG DELIVERY CONFERENCE.**

Small structural differences between individual respiratory systems can alter how much medication needs to be applied for a patient. Golshahi's goal of personalized medicine tailors aerosol delivery mechanisms to the subject, ensuring an effective dose is administered with each use.

PERSONALIZING PHARMACEUTICAL TREATMENTS

THROUGH ENGINEERED AEROSOL TECHNOLOGY

Engineering Foundation professor of mechanical and nuclear engineering, **Laleh Golshahi, Ph.D.**, is a pioneer in the development of personalized airway models for testing delivery systems like nebulizers, inhalers and nasal sprays.

Golshahi's Respiratory Aerosol Research and Education (RARE) lab uses CT or MRI scans to digitally render a patient's nostril, nasal cavity, oral cavity, pharynx and larynx. The resultant model is a map for how to design an individualized aerosol delivery system to the lungs, nose or brain. Using additive manufacturing, a physical mockup is then connected to a machine that simulates breathing. This model of a patient's nasal cavity disassembles into several pieces. Investigating each piece tells researchers the path nasally-administered medication takes and how much material arrived at its intended destination.

Knowledge gained from these experiments has applications beyond aerosolized delivery of medication. Hospitals, for example, can use a respiratory model to calculate the gas required to sufficiently open a patient's airways when oxygen is administered, so they breathe easily and without struggle.

Having worked on the mechanical aspects of aerosols, Golshahi expanded her research into the drug formulations used with nebulizers, inhalers and nasal sprays. Her team is also investigating a nose-to-brain delivery system to reach Central Nervous System (CNS) disease through the nose.

Inhalers and nasal sprays belong to a special category of therapeutic products known as combination products. Since they cross traditional industry boundaries, like drugs, medical devices or biological compounds, separately, they give rise to unique challenges in development and regulatory considerations. This complexity comes from the drug or biological formulation interacting with the dispenser spray followed by the patient's airway and tissues. Researchers must characterize the particulates throughout the process to ensure medication reaches its desired location, called the site of action.

Golshahi looks at viruses for inspiration. Their ability to bypass the respiratory system's mucous layer and underlying tissue is exactly what her formulations need. By incorporating virus surface geometry and other characteristics into the design of medicinal particulates, they can pass through the junction between cells, circumventing mucus and tissue to arrive at the site of action.

Work done by Golshahi's RARE lab is part of a larger group of aerosol specialists at VCU.

"VCU is a core for aerosol research," Golshahi said. "We play a big role in the annual Respiratory Drug Delivery conference. The Greater Richmond Area is also home to a few companies that are very interested in aerosol and filtration technology. This all comes together at the Center for Pharmaceutical Engineering and Sciences, where researchers from many engineering disciplines gather to solve challenging questions related to drug delivery."

The Center for Pharmaceutical Engineering and Sciences at VCU also hosts the United States' only Ph.D. in pharmaceutical engineering. Golshahi is a mentor at the center along with many of her VCU aerosol research colleagues. In addition to the nose-to-brain delivery system for CNS-compromised patients, researchers in the RARE lab are also exploring nasal vaccine delivery, especially for pediatric use.

Scan to read full-length story

GROWING REPLACEMENTS FOR TENDONS AND LIGAMENTS IN THE LAB

Musculoskeletal tissue engineering focuses on the composition and function of things like menisci, tendons, ligaments, muscle and bone, which aid movement while providing joint support and stability. Biomedical engineering Ph.D. student Kelly Ott started her academic career as an undergraduate at the VCU College of Engineering and chose to continue her graduate studies at VCU, researching how mechanical cues can increase the organization of collagen structures.

Ott studies the effects of slow stretch mechanical cues. This represents the slow elongation of the anterior cruciate ligament, more commonly known as the ACL, during development or adolescence. Ott investigates these cues by applying slow stretch loading to high-density collagen hydrogels, literally stretching the material. This work is done through the lab of **Jennifer Puetzer, Ph.D.**, biomedical engineering associate professor. Creating engineered, lab-grown replacements for damaged tendons and ligaments is the lab's primary goal. Injuries like ACL tears are common, and the hierarchical collagen fibers comprising these tissues do not repair themselves after injury. An individual with a torn tendon or ligament is unlikely to regain the same strength and function from it prior to injury.

Puetzer's lab seeks to create clinically-relevant replacements for ligaments, like ACLs, which requires more mature and organized collagen. Ott's research explores whether additional mechanical cues, like slowly stretching hydrogels at rates similar to ACL growth rates, will induce more organization in the system.

EFFICIENT HEAT TRANSFER FOR MOLTEN SALT CONCENTRATED SOLAR POWER

James Vulcanoff, a mechanical and nuclear engineering graduate student, wants to improve power production efficiency in the realm of renewable energy. "The focus of much of my research has been two major projects," Vulcanoff said, "rifled pipes for use in molten salt systems and thermal energy storage tanks for solar salt systems."

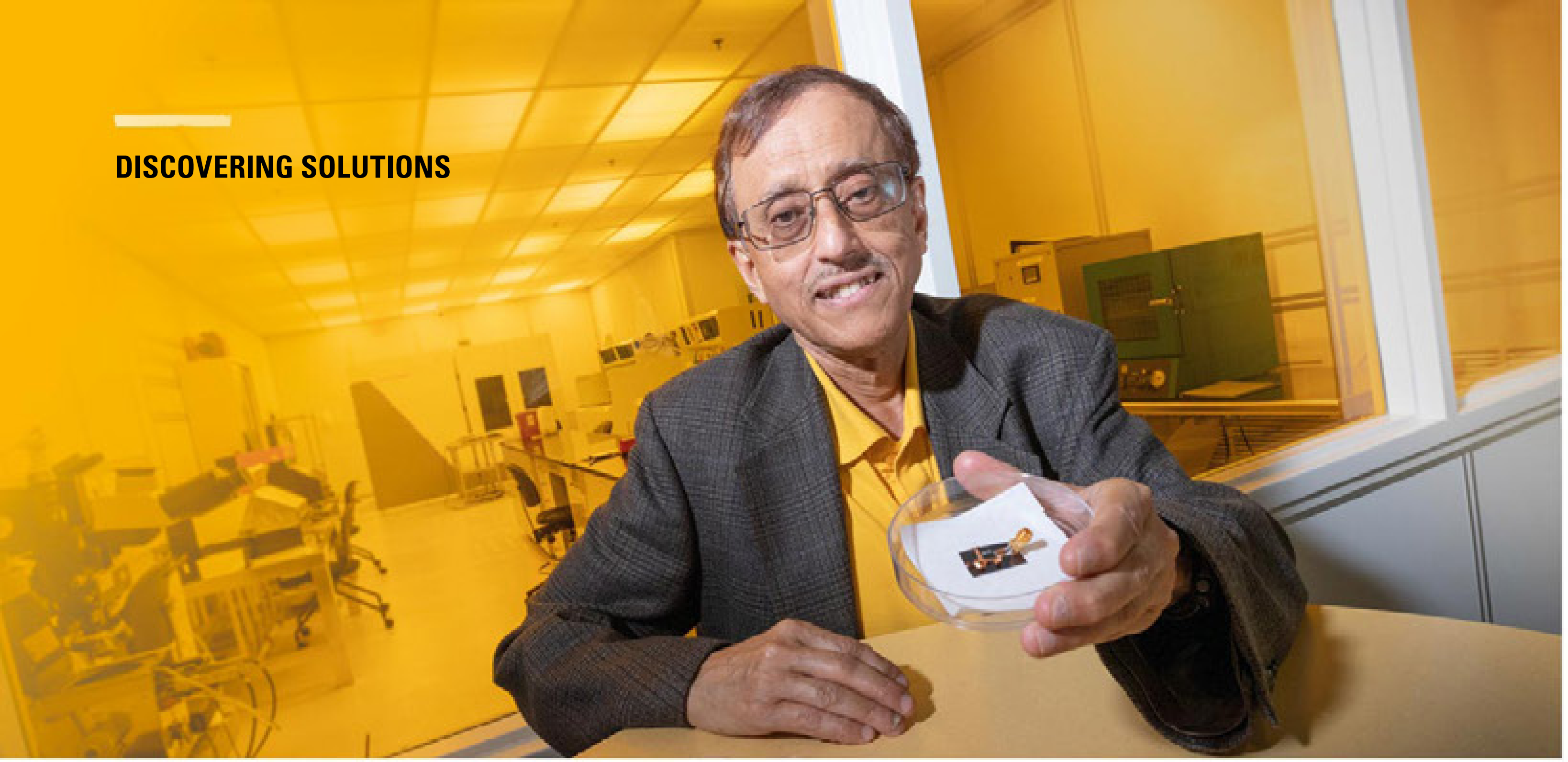
Concentrated solar farms focus the sun's energy to a single point, using heat to create molten salt. In liquid form, salt acts like water and can be used at higher temperatures, which means better efficiency. Running molten salt through a pipe with water on the outside turns the water into pressurized steam. The resultant steam can be used to spin turbine blades and create electricity more efficiently than existing technology.

Rifled pipes use geometric surfaces within the pipe to create centrifugal forces in the mass flow. This separates the fluid from the steam component and forces the fluid towards the tube wall, creating vortices and improving fluid mixtures. Vulcanoff simulates the molten salts within the pipe by applying a heat flux to the walls. The goal is to distribute heat evenly through the pipe using the unique rifled pipe geometries.

Vulcanoff's second project involves nozzle inlets that inject molten salt into a tank for the storage of thermal energy. They quantify the thermocline of fluid within a storage tank, which is the temperature gradient between the liquid's hot and cold layers.

After a project involving thermal piping for a molten salt nuclear reactor, Vulcanoff chose this research into solar energy because it employed his existing knowledge of rifled pipes. "I'd already worked with helically rifled pipes that induced swirling molten salt to more effectively transfer heat further into the pipe without adding mechanical complexity such as pumps or motors," Vulcanoff said. "This project was similar, I wanted to improve heat transfer using geometric modification, but in the realm of renewable solar energy."

Hailing from Henrico County, part of the Greater Richmond area, Vulcanoff is a local who became interested in VCU's growing nuclear program. "VCU Engineering has done a lot to help me with making connections and collaborating with industry professionals," Vulcanoff said. "Whether through internships with groups like Argonne National Laboratory or collaborations with Idaho National Laboratory in regards to high performance computing work, I received many opportunities to advance my education and career."



Bandyopadhyay's research focuses on cutting-edge concepts that completely change the way electronic components are created and used, using "matrix multipliers" to drive AI algorithms and nanomagnets to form minuscule antennas. (Photo credit: Karl E. Steinbrenner)

MINIATURIZED ELECTRONIC HARDWARE FOR BETTER AI AND IMPLANTABLE DEVICES

With tiny hardware and antennas, **Supriyo Bandyopadhyay, Ph.D.**, electrical and computer engineering professor, hopes to usher in a new era of electronics design that could power the future of artificial intelligence, medical implants and more.

Bandyopadhyay's portfolio of technologies include hardware "matrix multipliers" that drive AI algorithms and minuscule antennas that use nanomagnets.

FASTER, MORE EFFICIENT AND SAFER AI

Matrix multiplication is a mathematical function that enables AI applications like Siri, Alexa, self-driving cars or text creator ChatGPT. The complex process is typically software driven. "But software is sluggish, takes a ton of energy, it's expensive, and it's vulnerable to cyberattacks," Bandyopadhyay said.

Instead, he has built matrix multipliers from tiny hardware — hundreds of times smaller than the width of a human hair — that allow for greater energy efficiency, compactness and resilience against cyberattacks.

RIDING THE WAVE WITH BETTER ANTENNAS

In applications requiring electromagnetic waves to pass through soil, ice, water, walls and other objects, antennas that radiate at low frequencies are preferable. Unfortunately, a conventional antenna must be comparable in size to the wavelength. So, for example, an antenna radiating efficiently and sending out a strong signal at 1 megahertz must be about 300 meters long.

This is "an inherent shortcoming" to pushing out low-frequency signals, Bandyopadhyay said. "Imagine taking an antenna that large down a mine shaft or putting it in a submarine."

Many applications can't use a large antenna but still need a strong signal at a low frequency — for example, a medically implanted device.

"A medically implanted antenna cannot radiate at gigahertz frequencies since it would harm human tissue," he said. "We want to overcome this limit and make a tiny antenna radiate just as efficiently as a large antenna. That requires a completely new method of making these devices."

Bandyopadhyay has created unconventional antennas that use nanomagnets built on a piezoelectric substrate. When alternating voltage is applied, an acoustic wave is generated in the piezoelectric material which causes the magnets to emit electromagnetic waves because of a quantum mechanical coupling effect. His research introduces coupling electric charge oscillations (called plasmons) into the antennas, modifying the coupling and improving the antenna performance.

SLUG FLOW REACTORS CREATE MORE UNIFORM CRYSTALS FOR MANUFACTURING

Crystalline materials are the base for many everyday products like pharmaceuticals and batteries. **Mo Jiang, Ph.D.**, chemical and life science engineering assistant professor, is researching ways to consistently produce these high-quality crystals using a continuous manufacturing slug flow reactor technique.

Making the base materials is typically the first step for product manufacturing and uniformity is important when working with crystals. In pharmaceuticals, for example, lack of uniformity is often associated with inconsistency, and crystal/particle uniformity can also impact the effectiveness of drug delivery. This makes material manufacturing a challenging process because traditional batch-mode crystallization reactors, designed around a beaker or agitated tank, have difficulty creating consistent, uniform crystals.

Slug flow reactors solve this problem by converting bulk liquid into individual millimeter-size "slugs," pockets of fluid between gas pushed along tubing by combining the liquid solution and gas through a simple connector. Each slug becomes a miniature reactor that is self-stirred by intrinsic recirculation, which is the natural flow pattern as the slug moves. Molecules or ions are assembled directly into uniform microcrystals or microparticles within the flowing slugs. They have very high uniformity and can be reproduced at flexible manufacturing scales.

"I have noticed this particle non-uniformity phenomena in many different systems. Crystals or particles of amino acids, proteins and lipids are some examples of biopharmaceutical materials that may benefit from improving particle uniformity and reproducibility. The same can be true for inorganic materials like metal oxides used in lithium-ion batteries. I collaborate with researchers from different application fields to better understand and address this non-uniformity phenomenon."

These collaborations are a unique characteristic of Jiang's lab. He also works with undergraduate students outside the VCU College of Engineering, mainly from chemistry and biology, because continuous crystallization technology has widespread use. Many of these students have gone on to win awards and co-author journal articles.

Nibir Dhar, Ph.D. (middle) and his team seek to miniaturize mid-wave infrared sensors, putting them in the hands of soldiers, healthcare workers and even automated vehicles.

SHARPER INFRARED VISION IS MADE PORTABLE

Infrared imaging is a crucial tool for the United States military. It aids in surveillance and detection, helping keep troops safe in combat scenarios. Mid-wave infrared (MWIR) sensing technology specializes in the detection of large vehicles like tanks and airplanes. However, due to the technology's need for supercooling chambers, the devices are costly and bulky, often mounted to trucks or other large vehicles. **Nibir Dhar, Ph.D.**, professor of electrical and computer engineering, is developing a method for miniaturizing MWIR technology to make it more affordable and easily carried by soldiers.

Mid-wave infrared devices are prone to electronic noise from thermally generated charges in the detectors caused by heat generated within the sensor during operation, electronic noise such as dark current or other signals not originating from the object being imaged. Cryogenic cooling chambers help counteract this phenomenon, enabling high-fidelity infrared images, but they greatly increase the size and cost of the detectors.

Dhar and his team are developing a cryogenic cooling alternative. Innovations in photon management allow photon absorption in thinner infrared-absorbing materials such as Mercury Cadmium Telluride (HgCdTe). Then, using a graphene lattice and thin photon absorber, it is possible to quickly transport photogenerated carriers to where their information can be converted into an electrical signal. Dhar hopes to create smaller, portable MWIR devices with enhanced image quality.

02 BUILDING TOGETHER

Our increasingly complex world requires expertise from many disciplines to move us forward. Collaboration is an essential part of engineering, with support for interdisciplinary research and education.

The FBI established the DCLA to publicly acknowledge achievements of community members promoting education and the prevention of crime and violence. Manic is a close FBI partner, supporting cybersecurity training for students and inventing new ways to combat cyber threats.

PROMOTING CYBERSECURITY EDUCATION

For dedication in advancing the field of artificial intelligence to protect the United States' critical infrastructure from cyber attacks, **Milos Manic, Ph.D.**, computer science professor at the VCU College of Engineering, was presented with the FBI Director's Community Leadership Award (DCLA) by FBI Director Christopher Wray.

Manic has been a long-standing partner of FBI Richmond, supporting and advocating the importance of cybersecurity as a growing field, which has impacted FBI investigative activities and outreach and recruitment programs. Most recently, he was instrumental in planning and hosting FBI Richmond's 2023 Regional Cyber Collegiate Academy. Due in large part to Manic's championing the program, over 200 students from four Richmond-area universities were able to attend the experiential cyber learning program, the first of its kind for the FBI, the next iteration of which is planned for fall 2024.

VCU's Cybersecurity Center (CSeC) hosted the Cyber Collegiate Academy. Over the course of four sessions, students received first-hand insight into FBI cyber careers and examples of tackling international hacking groups. FBI agents leading the event covered topics ranging from cryptocurrency and internet scams to cellular analysis.

Agents also shared and analyzed real FBI cases to educate students on how experts solve real-world cyber crimes, including how agents dismantled an international hacking group and the use of technology to identify a serial bank robber.

"The CSeC, composed of four VCU schools (College of Engineering, School of Business, Wilder School of Government and Public Affairs and College of Humanities and Sciences), addresses the contemporary topics of cybersecurity and establishes VCU as leading cybersecurity educator in (central) Virginia," said Manic. "The CSeC is designated by the National Security Agency and the Department of Homeland Security as a National Center of Academic Excellence in both cybersecurity defense and cyber research."

In addition to the distinction from the FBI, Manic was elected by the National Academy of Inventors to the rank of senior member. The honor recognizes faculty, scientists and administrators who have produced technologies that have brought, or aspire to bring, real impact on the welfare of society. He was one of only three inventors from Virginia included in the academy's 2023 class of senior members.

Manic's creative thinking has led to inventions using artificial intelligence for cybersecurity, energy efficiency and hard drive disk arrays, among other projects.

One of the more recent AI-based inventions is the Autonomic Intelligent Cyber Sensor, co-developed with collaborators from Idaho National Laboratory. Through machine learning, AICS protects the nation's critical infrastructure from cyberattacks. The sensor rapidly updates decoy virtual hosts — known as honeypots — to distract hackers from targets, which provides time to identify the threat.

> "AS AN ENGINEER, I WANT TO USE MY TRAINING TO HAVE A POSITIVE IMPACT ON PEOPLE'S LIVES.

Using 3D-printed upper respiratory pathway models, Worth Longest, Ph.D. and his colleagues are able to test the effectiveness of their dispersal mechanism to ensure the dry powder formulation is disbursed in the necessary quantities.

IMPROVED TREATMENT FOR RESPIRATORY DISTRESS SYNDROME IN NEWBORNS

A Virginia Commonwealth University team is developing an affordable, noninvasive treatment for respiratory distress syndrome (RDS) that can be delivered without the need for complex medical equipment, supported by a $3 million grant from the Bill & Melinda Gates Foundation.

RDS occurs in newborns who lack natural surfactants – materials that reduce liquid surface tension, enabling carbon dioxide and oxygen to easily exchange as lungs expand and contract, oxygenating blood and facilitating the body's natural functions. This grant is helping **Worth Longest, Ph.D.**, the Louis S. and Ruth S. Harris Exceptional Scholar Professor in the Department of Mechanical and Nuclear Engineering in the College of Engineering, and his colleagues create a surfactant that can be aerosolized and a device to deliver it.

Among the challenges is how to deliver an effective dosage of the aerosol formulation. Current dry powder inhalers require more air to operate effectively than can be administered to an infant based on their smaller lung capacity. These inhalers also are limited to about 1 milligram of medication, significantly less than is required for surfactant treatment.

Work is currently underway with refinement of the delivery mechanism, followed by validation using computational fluid dynamics and concurrent lab testing to explore different design alternatives. The goal is a high-efficiency rapid aerosol delivery product that can fully restore an infant's blood gas levels and be administered as a stand-alone therapy in less than one minute, or simultaneously during nasal continuous positive airway pressure, or CPAP, therapy.

The team will also employ unique 3D-printed airway models that replicate the anatomy of preterm infants with the goal of expanding the age range of treatment and preparation for commercial production. Concurrent with this research will be development of a larger spray-drying system for producing the dry powder surfactant formula.

The proposed devices, strategy and formulation funded by the National Institutes of Health are also based on earlier and ongoing work by Longest and Michael Hindle, Ph.D., Peter R. Byron Distinguished Professor in the VCU School of Pharmacy.

"As an engineer, I want to use my training to have a positive impact on people's lives," Longest said. "Many elements of my skill set line up well with the treatment of respiratory diseases, and I came to VCU almost 20 years ago based on the opportunity to work with the School of Pharmacy Aerosol Group, including Drs. Hindle and Peter Bryon, who is now retired, as well as the chance to be a part of a young and growing engineering program."

Longest is now part of a strong and established collaboration between VCU's College of Engineering and School of Pharmacy. Foundational research performed by his Aerosols in Medicine Lab enables existing treatments to be reengineered for new challenges, such as developing products for treating premature infants with RDS in low-resource populations.

Scan to read full-length story

UNLEASHED POTENTIAL: GRADUATES ENTER THE WORKFORCE

Perez came to VCU to pursue her passion for engineering, she is now enrolled in the College of Engineering's Ph.D. program.

REALIZING A LONG-HELD DREAM

Lineth Perez wanted to study engineering since 10th grade. Her father and mother worked in the petroleum industry, as an industrial engineer and an inspector, respectively. Perez met one of her father's partners — a female mechanical engineer — and couldn't stop asking questions.

"I wanted to be her," Perez said. "I was so excited, because in Colombia they give you the side eye if you say you are a mechanical engineer and you're a girl."

It all feels like destiny to Perez. She received a scholarship to study at Virginia Commonwealth University, and recently graduated with a master's degree in mechanical engineering. And she isn't done. She is already enrolled and taking courses in the VCU College of Engineering's Ph.D. program.

Perez moved to Richmond in 2021 to advance her studies after receiving her bachelor's degree in mechanical engineering in Colombia. Not knowing any English, she was lonely and homesick. She questioned continuing her education here, but her host family supported her and made her feel comfortable.

At VCU, the first person to extend a hand to Perez was professor **Karla Mossi, Ph.D.**, graduate program director in the Department of Mechanical and Nuclear Engineering. She and Perez's advisor, associate professor **Hong Zhao, Ph.D.**, were supportive and understanding of what Perez was going through as a stranger in a strange land.

"They are two people that know a lot, they have a lot of knowledge, and they taught me a lot," Perez said. "And they're women. And I know that is not a big thing here, but because we are … from different countries — Karla Mossi is from Honduras — she knows how difficult it is for women in this field. Dr. Zhou is from China, and she came here for better opportunities. So I'm comfortable with them because they went through similar situations as me."

Perez also made friends with fellow students from around the world.

"I have friends from Honduras, Venezuela, India and Iran," she said. "I didn't want to feel weird because I still have some problems with my English. I didn't want to feel judged. [VCU is] always open to new cultures. That helped me a lot."

President of the student organization Black Women in STEM and member of the Alpha Kappa Alpha Sorority, Moore found community at VCU, complimenting the academic and athletic passions she was pursuing.

Lyons completed his undergraduate degree in three years thanks to a dual enrollment program with VCU. He is on track to earn his master's degree in two years while working as a software engineer at Newport News Shipbuilding.

SETTING THE PACE FOR ACADEMIC EXCELLENCE

Karah Moore came to VCU on a track and field scholarship. She wanted to join outstanding programs in athletics and academics, particularly in her chosen major of biomedical engineering. The latter ended up including significant undergraduate research – a VCU priority – and it has shaped her college experience in unexpected ways.

"I've been getting paid to do undergrad research, which is really rare, but I haven't had the need to go out and get an internship or a job because I get paid to work here," Moore said. "I was surprised by how many programs there were for women and Black people in STEM, separately and together."

Moore envisions ultimately pursuing a doctorate in the U.S., with a focus on biomaterials, and then working in industry. She said she has always been interested in the human body but didn't necessarily want to be a doctor.

"The more I read about biomedical engineering, the more I realized that we are unlimited in our field and there are so many different avenues we can take with the information we learn in pursuing this degree," Moore said. "My job searches have ranged from positions at NASA to pharmaceutical companies to artificial organ generation – and that doesn't even begin to show the expansive set of career fields I could enter."

The summer after her freshman year, Moore joined what is now called the MARC program – Maximizing Access to Research Careers. It placed her with **Rebecca L. Heise, Ph.D.,** Inez A. Caudill, Jr. Distinguished Professor and Chair in the Department of Biomedical Engineering and she began working in the pulmonary mechanobiology lab in the Center on Health Disparities.

"VCU allowed me to find a community in Richmond," Moore said. "I've loved my time here at VCU."

INVESTING IN THE POTENTIAL OF VCU

Sam Lyons wanted a range of options when choosing among colleges, so he applied to a fair number – in his case, 48. His acceptance by 40 set a record at Franklin High School, as did the more than $1.6 million in scholarship offers he received, leading to a press release from the local school system.

Before his story made headlines, Lyons had put Virginia Commonwealth University on his short list. He saw rich possibilities at the school. Lyons also embraced the diversity of opportunity – and people – at VCU.

"I saw that it had a lot of internship potential. And I also liked that a lot of different people from different backgrounds come to VCU," he said. "I wanted to meet a wide range of people" – one of whom, Jannah, a double-major in psychology and forensic science, is now his wife.

Lyons recently graduated from the College of Engineering with a degree in computer science. In high school he taught himself JavaScript, by watching YouTube videos– "I just had a passion for computers and technology," he said – and at VCU, he knew he was on the right path when taking an introduction to computer science course taught by **Caroline Budwell, Ph.D**, computer science associate professor.

"That course really started the ball rolling and really introduced me to what computer science entails, the basics of computer science," Lyons said. "I knew one language, but I didn't know that it can translate to all the different languages. I didn't really know the logic behind coding, and that [class] taught me a lot. … She really had a profound impact in laying the foundation of my knowledge in computer science."

Thanks to VCU's dual enrollment partnership, in which students receive credit for college-level courses taken in high school, Lyons is graduating after only three years. He is on the College of Engineering's accelerated pathway to earn his master's degree in two years while working part-time as a software engineer at Newport News Shipbuilding.

EXPLORING THE DIVERSE APPLICATIONS OF DATA SCIENCE THROUGH CROSS-DEPARTMENTAL COLLABORATION

Accelerated master's student Charles Cutler has spent his time at the VCU College of Engineering investing in collaboration. From his senior capstone project working with VCU Health and the VCU School of Medicine, to working alongside chemical engineers and their complex patents, Cutler is bringing innovative data science solutions to difficult problems across many disciplines.

As an undergraduate, he began working in the Natural Language Processing (NLP) lab alongside **Bridget McInnes, Ph.D.**, computer science associate professor, spurring his passion for data science and training machines to solve complicated problems. Additionally, research in the NLP lab inspired Cutler's current thesis project focused on continual learning within Named Entity Recognition (NER).

Named Entity Recognition is the process by which a NLP model identifies and classifies named entities (such as people, locations, organizations, etc.) within unstructured text. Continual learning is the ability of these models to then adapt and learn as new data becomes available or a new task is assigned. The main challenge with continual learning is something called catastrophic forgetting, or when a model loses previously learned information as it takes in new knowledge or tasks.

Cutler's thesis explores ways to mitigate catastrophic forgetting in new, less expensive and more effective ways. One solution implements a student-teacher framework in which an older NLP model trains a new model, guiding the newer model to adapt to new entities while retaining the old information.

In addition to this system, Cutler utilizes generative AI to create synthetic data, minimizing the typical privacy concerns that occur when working with large datasets. This leads to a more robust, safe and extensive training process that improves the models' adaptability to evolving language.

Cutler is using this same method to help chemical engineers sort through complex patent material, presenting his findings at the recent graduate poster symposium.

"We want to apply it to chemical patents so we can extract these really difficult chemical entities from the often vague patents, getting them out and into the chemical engineers hands," Cutler said. "Papers are being published faster than we can read them. We want to be able to take any text, maybe it's scientific literature or chemical patents, and extract useful information from it."

Last year, Cutler and his senior capstone team collaborated with the Department of Occupational Therapy in the VCU College of Health Professions. Their sponsor within the department, Virginia Chu, Ph.D., aided their research, creating a system to automatically detect early motor skill deficiencies in children. This project ultimately won both the Sternheimer award and overall first place at the 2023 Capstone Design Expo.

With the majority of his work surrounding NLP, Cutler emphasizes the importance of speaking out about the ethical use of AI, fostering conversations among researchers and field professionals about responsible data usage and ways to develop more transparent algorithms.

"I'm an optimist about the future," Cutler said. "But it's important to talk about these things now so we don't regret it down the road. It's something I'm passionate about and would love to continue researching beyond graduation."

After graduation, Cutler wants to continue researching to make an impact on the world. His current aspiration is working with the National Institute of Health or the National Library of Medicine, solving meaningful problems in the field of health and medicine.

I'M AN OPTIMIST ABOUT THE FUTURE, BUT IT'S IMPORTANT TO TALK ABOUT THESE THINGS NOW SO WE DON'T REGRET IT DOWN THE ROAD.

Cutler uses his computer science skill set to collaborate outside his field, working with VCU Health and the VCU School of Medicine as well as chemical engineers. He applies innovative data science principles to solve difficult problems.

Scan to read full-length story

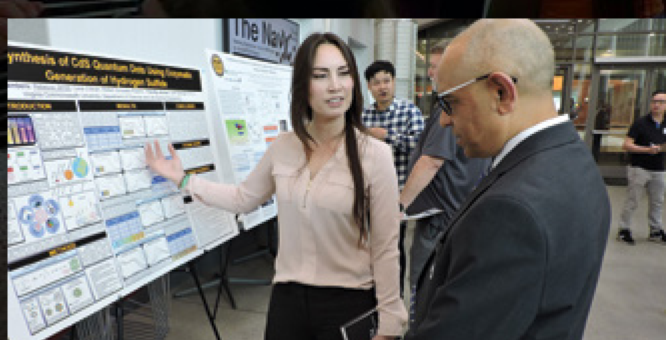
BUILDING TOGETHER

SHARING KNOWLEDGE TO BENEFIT HUMANITY

Research symposiums are an important opportunity for students to showcase their work and gain valuable experience communicating their findings to peers and those outside the scientific community. Embracing diverse research methods is one of the many ways VCU is affirming its commitment to promoting excellence across all disciplines. In the last five years, VCU's efforts towards research excellence have intensified, acquiring $464.6 million in combined awards for sponsored research programs and ranking 47th in the Research and Development expenditures among public institutions. Additionally, VCU was ranked one of the top 20 most innovative public universities by the U.S. News & World Reports in 2024.

BETTER WAYS TO BUILD QUANTUM DOTS

Rebecca Jarrell, a doctoral student in the Department of Chemical and Life Science Engineering, took first place at VCU's 27th Annual Graduate Research Symposium. Her research project focuses on developing a green and sustainable method for producing quantum dots.



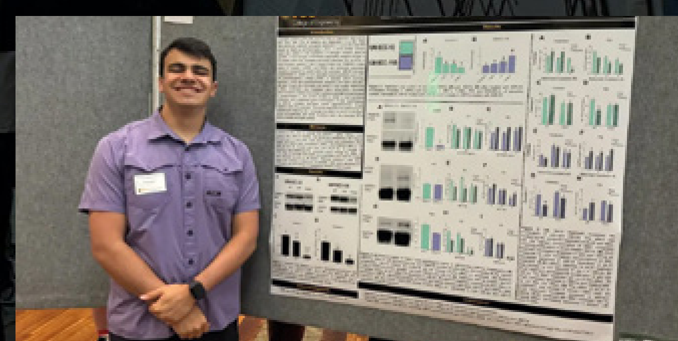
Quantum dots are tiny semiconductor particles or nanocrystals, typically ranging from two to ten nanometers in diameter, which have numerous applications in optoelectronics and biomedicine. Jarrell's innovative approach leverages enzymatic proteins to synthesize quantum dots, offering a more environmentally friendly and cost-effective solution. Her research has the potential to revolutionize the rapidly growing quantum dot market.

UNDERGRADUATES LEARN THE IMPORTANCE OF RESEARCH

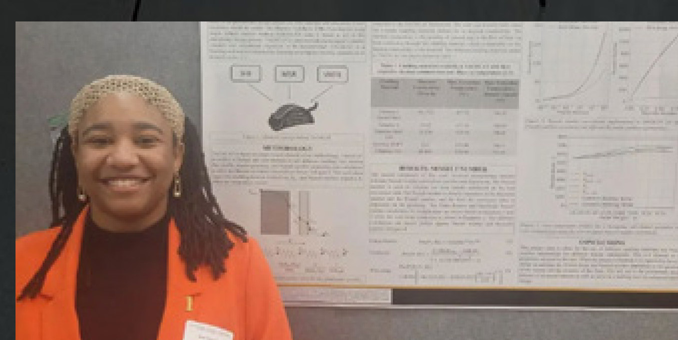
The 16th annual Poster Symposium for Undergraduate Research and Creativity spotlighted how VCU's younger students are advancing knowledge in many fields – and how the university is prioritizing research as part of the undergraduate experience.

Brock Lodato, a biomedical engineering major, looked at two cell types in laryngeal cancer tumors and how they behaved differently to treatment with vitamin D. He emphasized the personal connection of research.

"I do research because I strive to know things. I was diagnosed in high school with type 1 diabetes, and they couldn't tell me why. That irked me. I do research to find my 'why,'" Lodato said. "I do that to learn more and expand the human knowledge of our own bodies."



Skye Thurston, a mechanical engineering and physics major, researched how heat will function and travel through nuclear reactors – a project whose coding component could propel her on a path to graduate school.



FUSING EXPERTISE TO AID ADVANCED NUCLEAR REACTOR DESIGN

The Department of Energy (DoE) awarded Supathorn **Phongikaroon, Ph.D.**, professor and director of nuclear engineering programs, with $1.5 million over the next three years for his Integrated Research Project (IRP), which will establish a research, education and training Center of Excellence. The goal is to assemble comprehensive expertise on the nuclear fuel cycle and waste management to further assist advanced reactor designs.

The proposal team will bring students from Virginia Commonwealth University (VCU), Virginia Union University (VUU) and Virginia State University (VSU) to construct a unique research and education training program designed to support "collaboration and cross-pollination of ideas" between nuclear engineering communities. It will give students the opportunity to work with national laboratories like Idaho National Laboratory, Oak Ridge National Laboratory and Pacific Northwest National Laboratory as well as companies within the nuclear industry like Dominion Energy, Seaborg Technologies and NuVision Engineering.

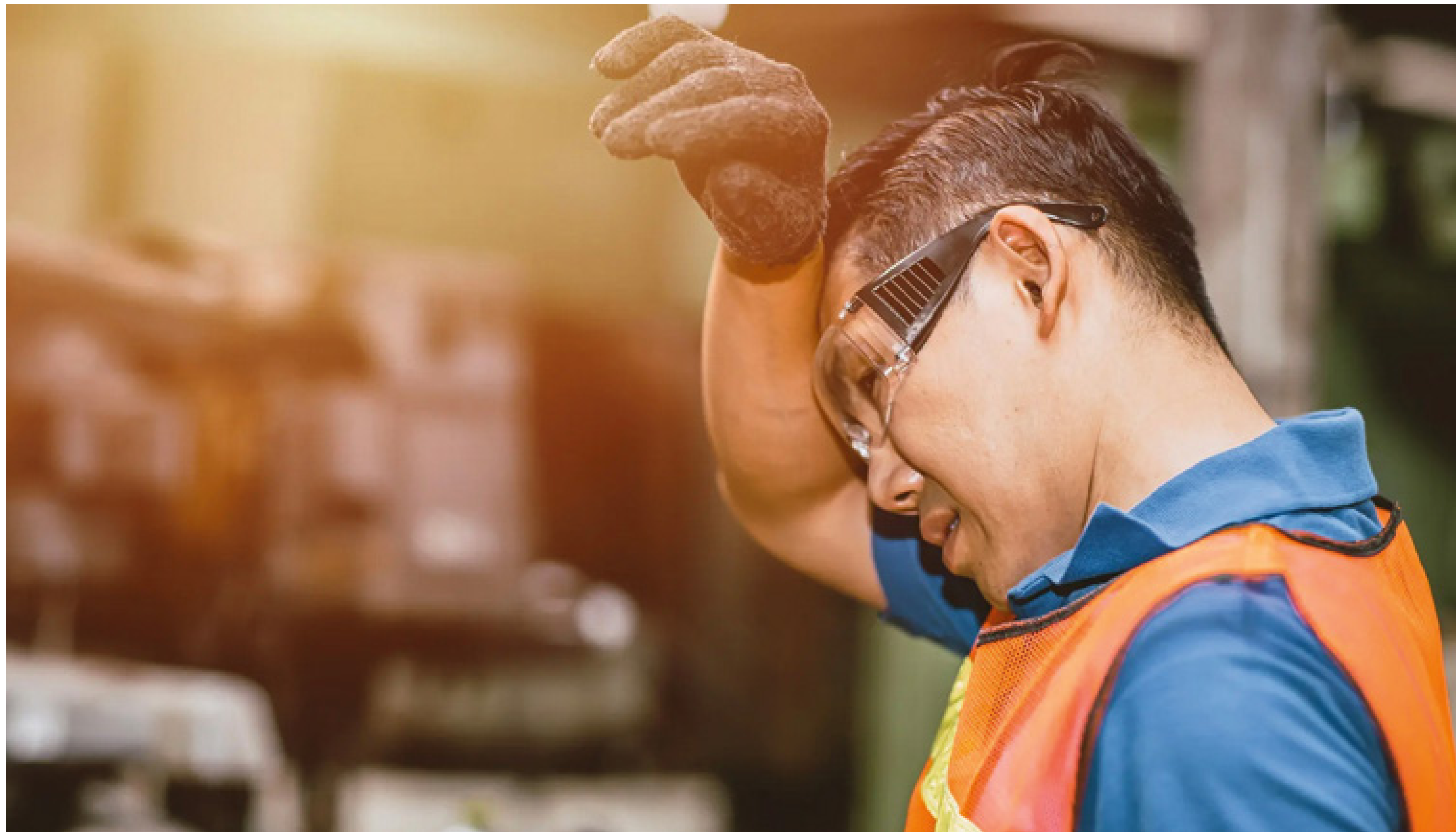
By uniting the efforts of universities, national laboratories and the nuclear industry IRP aims to equip the upcoming generation of scientists and leaders with the necessary skill set, flexibility of thinking, diversity and collaborative mindset to solve future DoE nuclear engineering needs.

IMPROVING MEDICINE DESIGN THROUGH RESEARCH PARTNERSHIPS

James Ferri, Ph.D., chemical and life science engineering professor, has been named Chair-Elect of the National Institute for Pharmaceutical Technology & Education (NIPTE) faculty, highlighting VCU's position as a front-runner in the advanced pharmaceutical manufacturing space.

NIPTE brings together academic professionals and researchers, industry leaders and informative stakeholders to support the organization's mission – to improve the way medicines are designed, developed and manufactured to meet the needs of patients in the 21st century.

As professor and Associate Chair of the Department of Chemical and Life Science Engineering at VCU, Ferri has been integral in facilitating research between VCU and NIPTE. Recently, he has been working with other NIPTE members on an initiative to build a Center of Excellence in Advanced and Continuous Pharmaceutical Manufacturing in the region. With his new position as Chair-Elect, Ferri is focused on supporting a wide-range of emerging initiatives and activities.



Prolonged periods of extreme heat are becoming more common due to climate change, costing the U.S. approximately $1 billion in health care costs every summer, according to a new report.

HEALTH CARE COSTS OF EXTREME HEAT REVEALED BY INTERDISCIPLINARY STUDY

A new report produced by an interdisciplinary group of faculty, staff and students at Virginia Commonwealth University and published by the Center for American Progress is shedding light on the connections between rising heat and harm to health. The report, titled "The Health Care Costs of Extreme Heat," sets the stage to discuss heat's impact by recalling recent heat events that have collectively harmed and hospitalized thousands of people.

The researchers used available data in Virginia to estimate the increase in health care utilization associated with extreme heat, such as emergency department visits, hospital admissions and the health care costs those services generated. Daily climate data collected from 15 weather stations serving Virginia showed that an average of 80 heat event days occurred per summer from 2016 to 2020.

Extrapolated nationally, the researchers found that heat event days would be responsible for almost 235,000 emergency department visits and more than 56,000 hospital admissions for heat-related or heat-adjacent illness, adding approximately $1 billion in costs every summer.

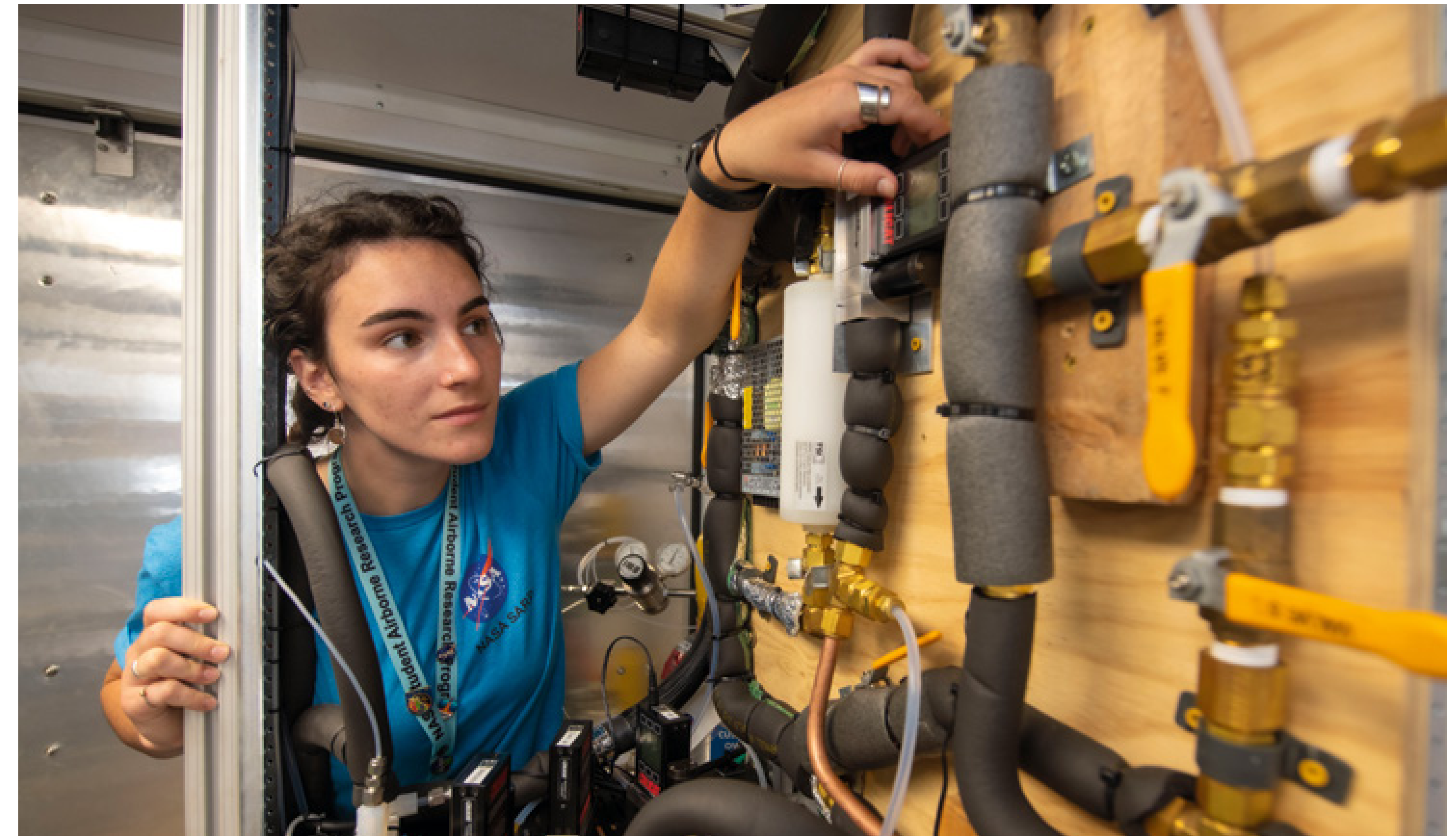
"The U.S. Environmental Protection Agency has been monitoring long-term weather patterns in the United States, and every decade since the 1960s has seen an increase in both the frequency and duration of heat waves," said **Stephen Fong, Ph.D.**, director of the VCU Integrative Life Sciences doctoral program and a professor in the Department of Chemical and Life Science Engineering at the VCU College of Engineering, who co-authored the report. "While the situation now is not great, effects of heat are projected to continue to worsen."

The harmful health effects of extreme heat include heat-related illness due to dehydration as well as heat exhaustion and heat stroke. Extreme heat also affects people with heart disease, pulmonary disease and other chronic problems, whose health can further deteriorate when exposed to hot conditions. Those people often get seen in an outpatient setting or the emergency department, and if they are sick enough, they will be admitted to the hospital.

03

SERVING HUMANITY

An engineer's ultimate goal is to improve life for individuals and society, this is engineering for humanity. Whether it is a student embarking on a new career path or established faculty with wide-ranging research impact, our destination is the same, leaving the world better than we found it.



Chemical and life science engineering student, Gwendolyn Verity, spent a summer researching with NASA and advancing crucial conversations regarding women in STEM with the goal of breaking down gender barriers.

CHAMPIONING GENDER EQUALITY IN ENGINEERING THROUGH NASA

Gender equality within Science, Technology, Engineering and Mathematics (STEM) has undoubtedly come a long way; however, there is still a glaring lack of women pursuing careers in this field. Data from the Equal Employment Opportunity Commission's 2022 report shows only 29% of federal STEM workers are women. To many this is disheartening, but for students like Gwendolyn Verity, a chemical and life science engineering student, these statistics are no deterrent. Verity's passion for the environment and love of engineering propels her desire to make a difference through researching climate change solutions.

Verity's hard work led her to participate in NASA's Student Airborne Research Program (SARP). Operating on the West Coast for the past 15 years, this prestigious research opportunity established a joint program on the East Coast this year with the help of VCU. SARP East utilizes VCU's Rice Rivers Center, a collaborative academic research station located on the James River.

During the eight-week long program, Verity got to experience intensive field research, visit renowned institutions, such as NASA's Langley Research Center, and take flights on research aircraft to collect data. She used the data collected from their flights to inform her independent research project, which focused on comparing anthropogenic (man-made) and natural methane emitters.

Another aspect of the program that stood out to Verity was its commitment to open conversations about gender bias in STEM. The great diversity in gender among students lead to many in-depth discussions about what it's like to be a woman pursuing a career in STEM and the challenges they face. Students and faculty of all genders participated, with Verity stating the importance of including everyone in these conversations. For Verity, building a community of supportive peers is essential in navigating a career in STEM.

While the fight for gender equality in the field of STEM is ongoing, students like Verity continue to challenge the status quo and show the importance of gender diversity within engineering. Verity has a bright future ahead of her, and her accomplishments show that with passion, determination and grit, any person, regardless of gender, can break through the barriers and succeed in STEM.

> CREATING A FRESCO MAY SEEM LIKE AN UNASSUMING PROCESS, BUT THERE IS AN IMPORTANT CHEMICAL PROCESS HAPPENING BENEATH THE SURFACE.

High school students from Virginia Beach to Miami Beach are being introduced to STEM through history and heritage, thanks to a program originating from the VCU College of Engineering Chemical and Life Science Engineering Department.

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CHEMISTRY, CULTURE AND CONSERVATION:

UNDERSTANDING STEM THROUGH THE LIFE CYCLE OF AN ITALIAN FRESCO

In 2021, professor and associate chair of the Department of Chemical and Life Science Engineering (CLSE), **James Ferri, Ph.D.**, began working on an initiative to bring relevant, hands-on chemistry education to high school students.

The goal was to create a transdisciplinary approach to chemistry education that implemented real-world applications for students. Ferri and fellow educator Rachel White, Ph.D., the former Governor's STEM Academy Coordinator at Landstown STEM Academy in the Virginia Beach Public School system (VBCPS), co-authored a curriculum that would intersect chemistry, world history and engineering through the life cycle of Italian frescos.

Creating a fresco may seem like an unassuming process, but there is an important chemical process happening beneath the surface. At its simplest, painting a fresco involves applying pigments to wet plaster. As the plaster dries, a chemical reaction occurs between the plaster, the pigments and the atmospheric carbon dioxide to form calcium carbonate crystals. These crystals create a durable bond, solidifying the pigment and protecting the fresco from fading and peeling over time.

Ferri named this program CReST (Culturally Relevant STEM Education). It utilizes both chemistry and world history test questions from the Virginia Standards of Learning to measure student's learning outcomes.

The CReST support curriculum, which occurs over six instructional days and approximately three calendar weeks, has three threads: the historical, cultural context, STEM concepts from chemistry and engineering, and experiential learning. Students learn the fresco lifecycle by creating, painting and conserving a fresco using nanotechnology to create a meaningful link between STEM concepts and real world, societal challenges – like cultural heritage conservation.

For students, this meant the opportunity to create and chemically preserve their own fresco.

The curriculum was first implemented in the VBCPS and Miami-Dade County Public Schools. Since its inception, over 2,000 high school students have been able to learn the integration of chemistry, engineering and world history with this program. Through this collaboration, Ferri and the VCU College of Engineering chemical and life science engineering department was named a model partner of the Virginia Beach Public School system in 2022.

After the pilot implementation of the program, Ferri saw an opportunity for a more in-depth experience and planned a professional development experience for the five high school educators in Florence, Italy. This allowed the teachers a once-in-a-lifetime experience in immersive education, the opportunity to see first-hand the power chemistry holds in preserving our world's history.

Following this professional development experience, the teachers saw how their instructional approach shifted when implementing the CReST curriculum in terms of a positive impact on student engagement and understanding of the convergence of disciplines.

Ferri and White report the CReST pilot program in the journal, Education Sciences. They report significant gains in student academic performance in chemistry and world history. Both students and teachers voiced overwhelmingly positive responses on the efficacy of the program, emphasizing the need for convergent educational strategies to enhance engagement and deepen learning experiences in high school STEM education.

SERVING HUMANITY

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STUDENTS SHOWCASE SOLUTIONS TO REAL WORLD CHALLENGES AT CAPSTONE DESIGN EXPO

Whether assembling a wheelchair-lifting system, constructing a hybrid bike for veterans with limited mobility or exploring safe human-industrial robot collaboration, the College of Engineering's annual Capstone Design Expo showcased many innovative student prototypes. Below are some of this year's best projects.

BIOMEDICAL ENGINEERING

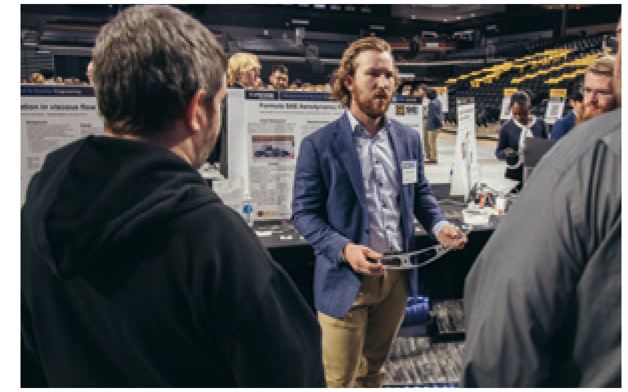
Mini Sensors to Track Movement of Preterm Babies

Premature babies are more susceptible to health challenges and require constant monitoring. This project tracks newborns' movements using sensors to identify any potential issues, such as neurological complications or infections. It aids in early detection, ensuring these babies receive care for optimal health and development.

CHEMICAL AND LIFE SCIENCE ENGINEERING

Subcritical Hydrothermal Catalytic Degradation of PFAS

Poly- and perfluoroalkyl substances — commonly referred to as PFAS, or "forever chemicals" — take nearly forever to breakdown and, since they contaminate drinking water, can build up in the body over time. This project developed a continuous method of degrading PFAS found in water. Implementing two separate methods, the students removed up to 76.5% and 98.8% total PFAS, respectively, setting the stage for future experiments to see how adsorption affects the final concentration of PFAS in the treated solution.



Jonathan Morton explains his team's two-foil front splitter that produces maximum downforce while maintaining laminar flow over the front tires of a formula SAE car, resulting in more speed when taking corners.

Madison Hofmann attributes her team's win to creating a demonstration that both a technical and non-technical audience could easily understand.

Ellen Patchin's team designed a pulse oximeter that reduced inaccuracies due to skin pigmentation.

COMPUTER SCIENCE

Sentiment Voice: Integrating Emotion AI and VR Performance in Arts

Can artificial intelligence "read" people's emotions when they're inside virtual reality? These students developed a system using the Unity Platform that tracks a user's emotional changes. Based on what users say and how their facial expressions change, the environment — in this case, a computer-generated Tokyo — changes around them, showing how someone's emotions can project into the environment around them. Based on research by VCU's **Semi Ryu, Ph.D.**, the project offers potential in multiple settings, including treating patients with PTSD or helping users process trauma and stressful situations.

ELECTRICAL AND COMPUTER ENGINEERING

Microgrid Model and Design

Dominion Energy sponsored this project where students designed an energy management system to forecast electric demand. It helps decide how to use electricity most efficiently and at the best price by determining where the electricity should come from — the sun, the wind or a diesel generator.

Josiah Wilson, Chase Taylor and Ariana Thomas programmed artificial intelligence to "read" a virtual reality user's emotions based on their facial expressions and what they say, altering the "environment" around them. The program has many applications including helping patients process trauma.

MECHANICAL AND NUCLEAR ENGINEERING

Fabrication of Magnetic Filaments for Fused Deposition Modeling Technology

Additive manufacturing reduces reliance on traditional supply chains by enabling on-demand production of spare parts and components. This team set out to produce a magnetized filament by combining recyclable polymer with magnetic powders and conductive fillers. Ultimately, the proposed filament could be used for 3D-printing electromagnetic shielding, which is used for applications such as surface ship radar, weather radar, air traffic control, inflight Wi-Fi and spacecraft telemetry.

SHAPING THE FUTURE WITH THE DEPARTMENT OF DEFENSE

Offered by the Department of Defense (DoD), the Science, Mathematics and Research for Transformation (SMART) Scholarship program provides accepted students with full tuition, annual stipends, internships, and guaranteed employment with the DoD after graduation.

JOSEPH LEE

Joseph Lee's impressive academics were not the only reason he received the prestigious SMART Scholarship. He has spent time working on numerous projects, including creating components that went into a patent for a transcranial magnetic stimulation machine, developing code for an autonomous robot and serving for a year as the mechanical team lead for Hyperloop at VCU. In addition, Lee is also involved with the Society of Hispanic Professional Engineers and the VCU Biomagnetics Laboratory.

Ravi Hadimani, Ph.D., associate professor and director of Biomagnetics Laboratory, was integral in the development of Lee's education at VCU. He credits Hadimani as taking him under his wing and teaching him the important skills not learned in a classroom setting.

SEAN GODWARD

Sean Godward's passion for engineering has been propelled by getting to work on complex and meaningful projects, with his interest lying in materials science manufacturing and development and research into renewable energy resources. Most recently, he performed research alongside chemical and life science engineering professor and associate chair **James Ferri, Ph.D.**, to increase manufacturing efficiency and availability of the essential drug albuterol.

Godward is also a member of the American Institute of Chemical Engineers (AIChE), shaping his time at VCU with the opportunities and experience that has come along with it.

SOPHIE KOTHE

A biomedical engineering student, Sophie Kothe's SMART Scholarship award emphasizes both Kothe's focus and determination to her work and her impressive academic history, as she began working in a lab her second semester. Currently, she is a member of the Biomedical Engineering Society (BMES) and the Society for Women Engineers (SWE). She has worked on many independent projects, with her work being published twice.

"I've had many great mentors and opportunities through VCU Engineering. I think I've been very fortunate with what I've experienced," said Kothe. "Mingyao Mou was the first Ph.D. candidate I ever shadowed under and she was a huge mentor to me. She is incredibly kind and thoughtful. She helped teach me confidence in the lab setting and showed me how fun research can be."

Abdelwahed's OpenCyberCity helps students and researchers ask important questions about monitoring and automation while exploring innovative solutions to these challenges.

SMART CITY RESEARCH: SMALL BUILDINGS, BIG IMPACT

Municipalities around the world have invested significant resources to develop connected smart cities that use the Internet of Things (IoT). With this increased demand for IoT experience, the VCU College of Engineering formed the OpenCyberCity testbed in 2022. The 1:12 scale model city provides a realistic, small-scale cityscape where students and researchers can experiment with new and existing smart city technology.

Sherif Abdelwahed, Ph.D., electrical and computer engineering professor, is director of OpenCyberCity and answered some questions about new developments within the testbed.

How does the OpenCyberCity address privacy? With so much technology related to monitoring, how are individual citizens protected from these technologies?

Privacy is a major concern for smart cities and it is one of the main research directions for VCU Engineering's OpenCyberCity. We are developing several techniques to prevent unwanted surveillance of personal information. Sensitive data is protected by solid protocols and access restrictions that only allow authorized users to view the data. Our aim is to find a reasonable middle ground between technological progress and privacy rights, staying within legal and ethical bounds.

How is the College of Engineering's OpenCyberCity test bed different from similar programs at other institutions?

While other universities have similar smart-city-style programs, each has their own specialty. The VCU College of Engineering's OpenCyberCity test bed focuses on real-world contexts, creating a physical space where new technologies, infrastructure, energy-efficient transportation and other smart city services can be tested in a controlled environment. Our lab monitors real-time data and develops smart buildings, smart hospitals and smart manufacturing buildings to enhance the city's technologies.

How has the OpenCyberCity changed in the last year? Is the main focus still data security?

What started with research examining, analyzing and evaluating the security of next-generation (NextG) applications, smart city operations and medical devices has expanded. Data security is now only one aspect of OpenCyberCity. Its scope has grown to encompass more expansive facets of cybersecurity like automation and data analytics in the domain of smart manufacturing systems.

The implementation of a smart manufacturing system in 2023 is something students really enjoy. Thanks to the vendor we used, undergraduate students had the option to develop functionality for various features of the manufacturing plant. Graduate students were also able to research communications protocols and cybersecurity within the smart manufacturing system.

EMPOWERING STUDENT SUCCESS IN STEM

STARS — Supporting Tech Achievement for Richmond Students — aids students from populations typically underrepresented in engineering and computer science. Introduced to the program by her high school guidance counselor, Inayah O'Neil participated in the summer 2022 challenge, analyzing and then presenting Richmond-specific data concerning urban heat islands. Her work won best presentation at the end of the two-week camp.

O'Neil was encouraged by the representation she saw during the program, saying, "I saw the representation a lot. We were able to interact with researchers, professors and students, and I was really excited. I was like, 'they look like me and I can do this too!' It was heartwarming to feel. Definitely empowering."

The confidence O'Neil gained throughout the program motivated her to continue pursuing STEM and she worked as a peer mentor for the Summer Challenge while preparing to attend the VCU College of Engineering as a computer science major.

LEARNING ON THE JOB WITH DOMINION ENERGY

Alyssa Cadua's nuclear engineering internship with Dominion Energy gave her insight into a career path she has never considered. Based at Dominion's Glen Allen office, she worked on a project for the North Anna Power Station in Louisa County digitizing piping blueprints. The pipes carry steam and water throughout the nuclear plant.

"I started off by taking these really old drawings and having to update them," Cadua said. "I have to figure out the dimensions of the pipe…from the original blueprint. [Then,] go down to the North Anna Power Station and [measure] the pipes…I have to make sure the dimensions are accurate and make sure nothing has changed."

In addition to her research ensuring the accuracy of new digitized blueprints, Cadua documented any corrosion within the pipes. "The end goal is to test them and make sure they are still safe and make sure they have not corroded from the steam or water," she said.

The internship broadened her view of the type of work that can match her mechanical engineering background. She might even consider a career in nuclear power, and though she has not discussed specific opportunities with Dominion, she is grateful for the experience.

CREATIVE CORAL CONSERVATION WITH NANOTECHNOLOGY AT TEDX

Nastassja Lewinski, Ph.D., associate professor in the Department of Chemical and Life Science Engineering, recently gave a TEDx talk about the use of nanotechnology in the preservation of coral reefs.

"Nanotechnology is the understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications," Lewinski says, citing the National Nanotechnology Initiative (NNI).

Lewinski's research group investigates whether nanomedicines can mitigate coral heat stress by reducing reactive oxygen species. Initial findings suggest promise in using cerium oxide nanoparticles (CeNPs), or nanoceria, which are nanoparticles being studied for their antioxidant properties. However, Lewinski stresses the necessity of rigorous testing and responsible development to ensure the safety and effectiveness of nanotechnology in marine environments.

DISTINGUISHED COMPUTER SCIENCE PROFESSOR BECOMES EDITOR-IN-CHIEF

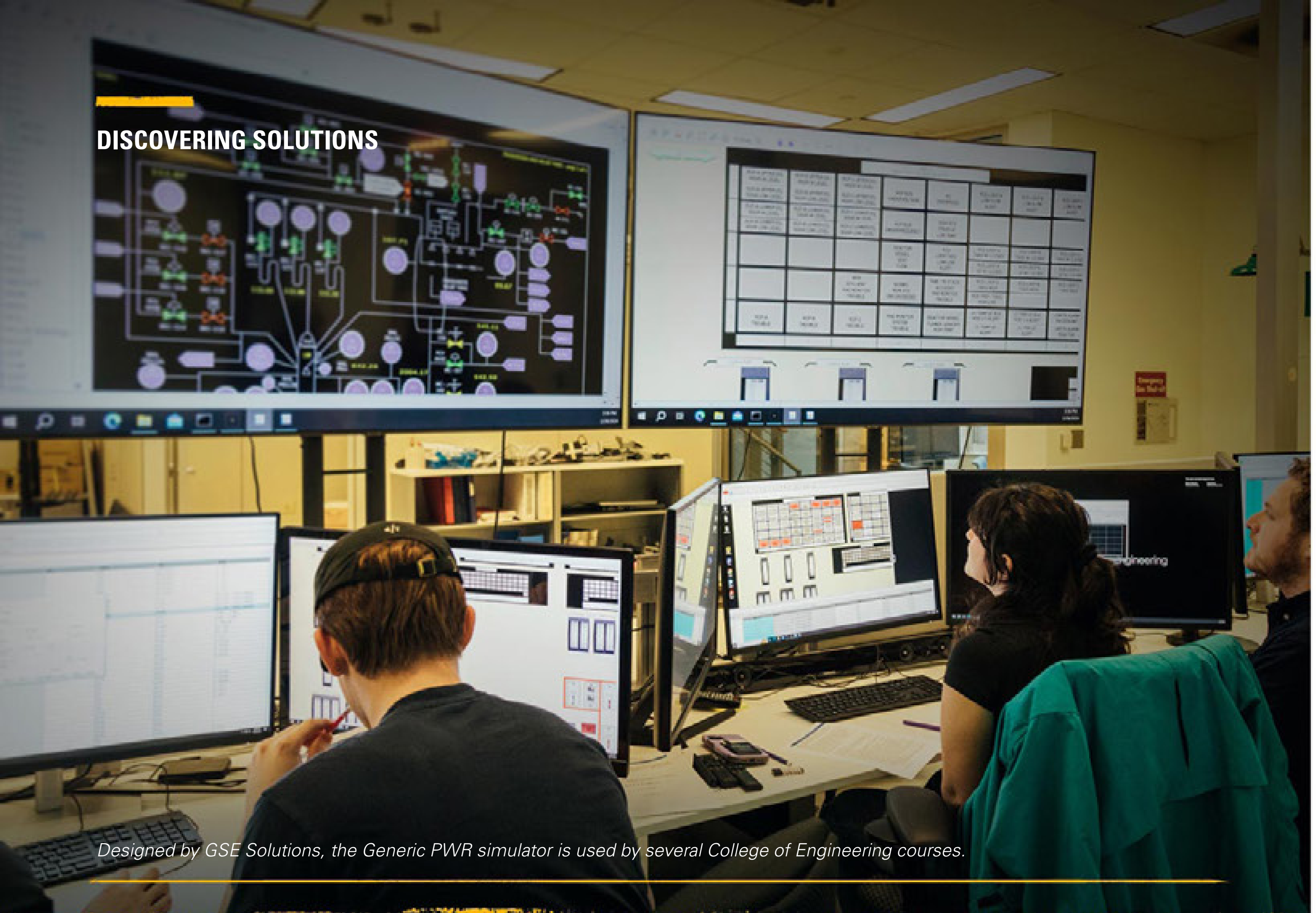
Lukasz Kurgan, Ph.D., vice chair of the Department of Computer Science at Virginia Commonwealth University, was recently named an editor-in-chief of the international journal Biomolecules, a peer-reviewed open access journal whose scope lays in the intersection between biochemistry, molecular biology, bioinformatics, molecular medicine and material sciences. He was also inducted as a Fellow of the Royal Society of Biology.

PREPARING FUTURE ENGINEERS TO SOLVE CHALLENGING DEFENSE PROBLEMS

The Department of Defense awarded a $9 million grant to the Virginia Commonwealth University College of Engineering for research and development of electro-optics, infrared, radio frequency and edge security technologies. These areas are pivotal in managing the electromagnetic spectrum and ensuring network security.

Electrical and computer engineering professors **Nibir K. Dhar, Ph.D.**; **Erdem Topsakal, Ph.D.**; and **Ümit Özgür, Ph.D.**, head The Convergence Lab Initiative which will bring together scientists, engineers and technicians with electro-optics, infrared, radio frequency and edge security specializations to solve pressing defense challenges for the United States.

Funding will support education and specialized training with the goal of preparing the next generation of researchers and leaders in these critical technology areas. The VCU College of Engineering's expertise with public-private partnerships will help bridge the gap between academia and industry to promote knowledge exchange between universities and CLI partner companies. Beyond defense, CLI's commercial benefits include advances in health care, transportation and smart city technologies.



Designed by GSE Solutions, the Generic PWR simulator is used by several College of Engineering courses.

REAL-WORLD TRAINING ENABLED BY NUCLEAR REACTOR SIMULATOR

Reactor simulators are an important component of nuclear power plants. They are used as training tools for operators at all commercial nuclear power stations in the United States. Modeled after the Harris pressurized water reactor (PWR) in North Carolina, the Virginia Commonwealth University (VCU) College of Engineering's nuclear reactor simulator is an industry-standard tool used to educate engineering students interested in nuclear technology.

"In the nuclear industry, simulators are a critical part of everyday work. Giving our students exposure to systems like the PWR simulator will give them an edge upon entering the workforce," said James Miller, mechanical and nuclear engineering professor in charge of the Nuclear Reactor Simulator Laboratory.

Nuclear power plant simulators are analog, with physical dials, switches and knobs. The VCU College of Engineering's simulator is digital. Several windows contain a grouping of interactive controls that mirror those of actual PWRs. Students interact using a mouse and keyboard, but the controls themselves are exact digital representations of their analog counterparts. The Generic PWR simulator can be fully programmed with a variety of scenarios for students to respond to, like fluctuations in power demand or even a disastrous nuclear accident. It all happens in real time and responds exactly like a real PWR.

"We've had the simulator for just under two years now," said Miller. "We're using it as a teaching tool, but it can be used for so much more. Working with Dominion Energy, it's possible to turn it into a resource for nuclear industry professionals in the greater Richmond area. It can even be applied to research."

Led by Irfan Ahmed, Ph.D., computer science students were recognized for the development of their NAZAR intrusion detection system.

TOP AWARDS FOR COMPUTER SCIENCE AT DEPARTMENT OF DEFENSE SYMPOSIUM

A team of five representatives from the VCU College of Engineering Department of Computer Science were recently presented with the top two awards and a special military honor at the 2024 CyberRECon Symposium, an event hosted by the U.S. Department of Defense command USCYBERCOM.

The conference challenges teams to tackle top USCYBERCOM missions, developing their own original solutions to the real-world problems facing our nation today. Teams worked on projects in four categories: the Hunter Award for research with offensive Cyberspace Operations applications; the Analyst Award for research focused on threat actors or intelligence analysis methodologies; the Strategist Award for research focused on Cyber Policy and strategy; and the category VCU competed in, the Guardian Award for research with defensive Cyberspace Operations applications.

Within the Guardian category, Ahmed and his team of students developed NAZAR, a stateful intrusion detection system. It consists of two parts, one at the network level and one at the device level. Together, they enable the user to monitor malicious activity on the control logic.

The VCU team not only won the Guardian Category Award for NAZAR, but they also received the "Best in Show" award: the coveted Commander's Cup.

"During the entire event, it felt like VCU was everywhere," says Ahmed. "Our students were just all over the conference participating in different components. Everyone came up to talk with us and we just kept receiving awards. It was incredible; we did not expect so much."

Ahmed oversees the Security and Forensics Engineering (SAFE) Lab at VCU, where students are active in both offensive and defensive Cybersecurity research. It is fully-equipped with Desktop computers, laboratory-scale ICS testbeds from a variety of vendors (including GE, Mitsubishi, Allen-Bradley, Siemens, Schneider Electric, Omron, WAGO and AutomationDirect), 3D printers, and access to a data center of high-performance computing infrastructure.

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