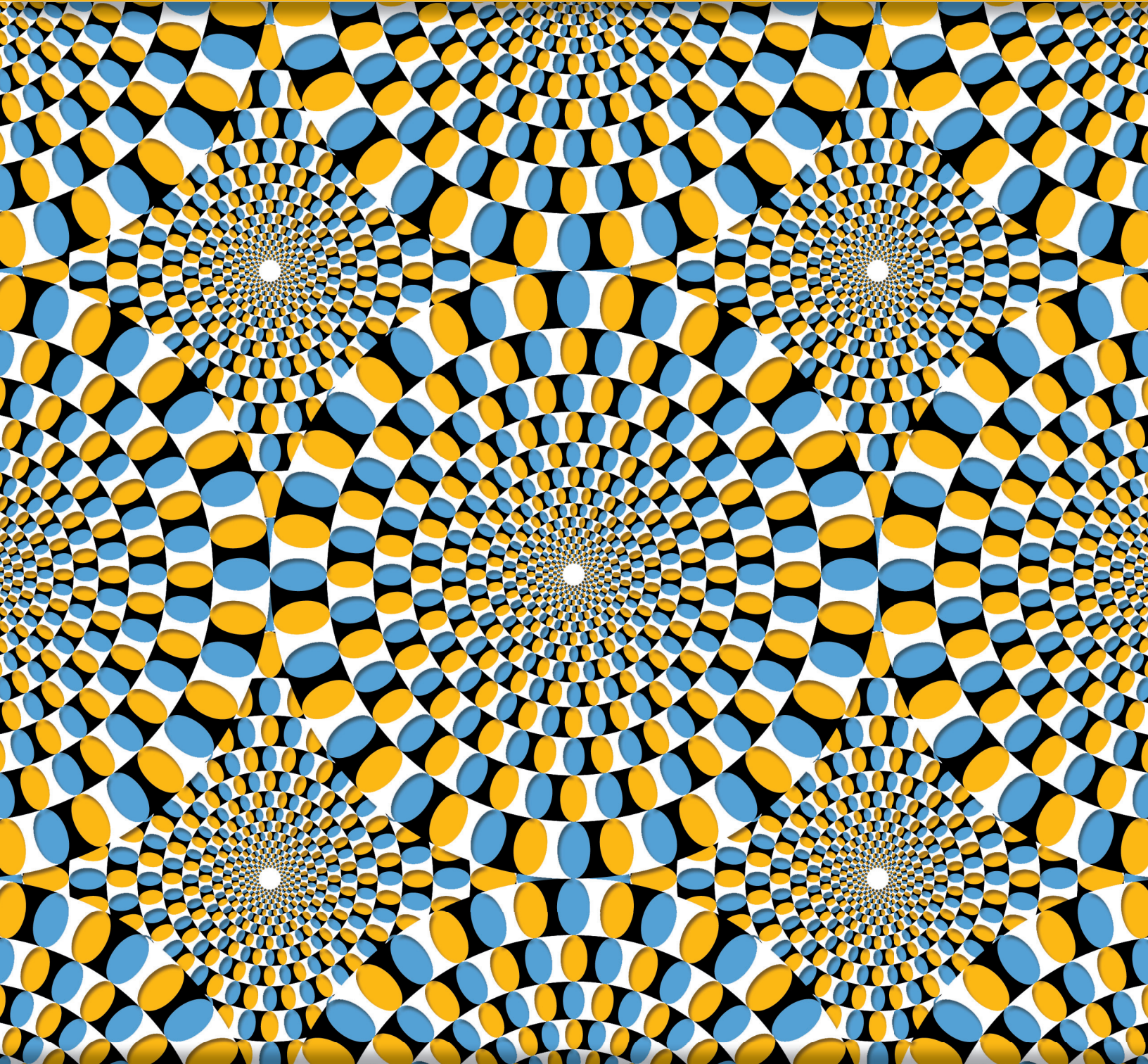


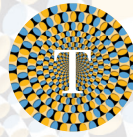


VCU School of Engineering

Research Report | Volume 6



TRANSFORMATIVE CHANGE



This edition of the Research Report, *Transformative Change*, presents a slice of the vibrant energy and innovative research within the Virginia Commonwealth University School of Engineering. Here at VCU's youngest school, we create tools that open new worlds and our faculty forge multidisciplinary collaborations leading to national recognition.

In this report, you'll learn how our talented faculty and students are transforming lives. Our research laboratories are humming with work that advances healthcare, improves time predictability architecture, analyzes biological networks, handles ultralarge datasets and rebrands the nuclear fuel cycle.

The VCU School of Engineering has seen tremendous growth in its 17-year history and I am happy to be a part of our promising future. We have a lot to be proud of...

- A diverse and dynamic student population that addresses and adapts to the needs of industry
- A first-of-its-kind Ph.D. in Mechanical and Nuclear Engineering
- Nearly 90 percent of our graduates either enter the workforce or continue their education in advanced studies within six months of graduation

Our future holds a strategy for continued growth: the school size will double over the next five years through new faculty recruitment and our collaborative approach will include the School of the Arts, the School of Business and the College of Humanities and Sciences as well as others where students and faculty have ample opportunities to "make it real" in today's rapidly changing environment.

Personally, the chance to be a part of VCU's strategy to overcome the challenges that engineering education will face over the next decade is irresistible to my entrepreneurial spirit. There is a great momentum here at VCU and I am very excited about the enthusiasm in our students and the collaborative atmosphere that permeates the campus.

It is indeed a time of transformative change.

Barbara D. Boyan, Ph.D.

Alice T. and William H. Goodwin, Jr. Chair in Biomedical Engineering
Dean, VCU School of Engineering

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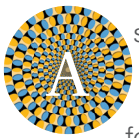
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Building *on Our* *Momentum*



As Barbara D. Boyan, Ph.D., transitions from associate dean for research and innovation in Georgia Tech's College of Engineering to her new role as dean for the Virginia Commonwealth University School of Engineering, she comes more than well-prepared for what lies ahead: recruiting 49 new faculty members and doubling the size of the school in the next five years. This, in addition to strategically building on the school's success and extraordinary growth since it welcomed its first class in 1996.

Dean Boyan, a member of the National Academy of Engineering and a fellow of the World Congress of Biomaterials, is a renowned researcher known for her uncanny ability for envisioning the future of engineering. She is also a successful entrepreneur as founder of Osteobiologics Inc., an orthopedic device company, and SpherIngenics Inc., a stem cell delivery company. She sits on the boards of a number of biomedical companies, including ArthroCare Corporation and Carticapt Medical, Inc.

"The opportunity to help VCU meet the challenges that engineering education will face over the next decade was irresistible to my entrepreneurial spirit," she said of her decision to come to Richmond in her new position. "There is a great momentum at VCU and I am very excited about the enthusiasm I see in our students and the collaborative atmosphere that permeates the campus."

Dean Boyan is a fellow in the American Association for the Advancement of Science and in the American Institute of Mechanical and Biomedical Engineering. At Georgia Tech, she held an endowed chair in tissue engineering and was a professor in the departments of biomedical engineering at both Georgia Tech and Emory University. She was also a Georgia Research Alliance Eminent Scholar in tissue engineering. She has received numerous awards, is the author of approximately 400 peer-reviewed papers, reviews and book chapters, and holds 14 U.S. patents.

"Bringing someone of Dr. Boyan's national stature, particularly given her standing in the National Academy of Engineers, signals VCU's commitment to engineering and its move toward becoming one of the nation's great research universities," said VCU President Michael Rao, Ph.D. "It also signals VCU's continued presence in a competitive economic landscape."

Dean Boyan served as professor and vice chair for research in the Department of Orthopaedics at the University of Texas Health Science Center at San Antonio, where she also served as director of Industry University Cooperative Research Center and director of the Center for the Enhancement of the Biology/Biomaterials Interface. She received her bachelor's, master's and doctoral degrees in biology from Rice University.

Dean Boyan couldn't be more pleased to be at VCU. "Few people know this about me, but I have a minor in the history of art," she says. "Science can't be divorced from art. As engineers, we are really artists in our own field. I don't know of any other school that has the science, the business, the design, and the art foundations such as ours that allow us to think outside the box. As a collaborative interdisciplinary team, we'll go forward with this as our core into the 21st century."

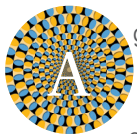
"There is a great momentum at VCU and I am very excited about the enthusiasm I see in our students and the collaborative atmosphere that permeates the campus."

– Barbara D. Boyan, Ph.D.

Collaboration

Helps Understand

Aging Lungs



Aging brings about many changes in the human body, much of which isn't clearly understood. But that's about to change thanks to a research collaboration at Virginia Commonwealth University.

Rebecca L. Heise, Ph.D., in the VCU Department of Biomedical Engineering and Angela Marie Reynolds, Ph.D., in the VCU Department of Mathematics and Applied Mathematics, along with Ramana Pidaparti, Ph.D., in the VCU Department of Mechanical and Nuclear Engineering, are working to develop a multiscale hybrid mathematical model to help prevent ventilator-induced injury and inflammation in an aged lung.

"We want to try to understand how the cells in the lungs respond to the mechanical forces of breathing. We're putting different parameters of the math model together to help clinicians use the correct ventilator settings on patients to help prevent lung injuries that occur due to the ventilator," said Heise.

The researchers are combining models at the cellular, tissue and

organ level to determine the levels of inflammation in an aged lung that has ventilator-induced inflammation.

Heise is conducting lab experiments using stretched aged and non aged lung cells. Her cell and tissue research mimics a lung injury similar to a critically ill patient.

"The model itself will be among the first of its kind by trying to incorporate the whole body," said Heise. "I think that's what is unique about this project – it's the multiscale nature. From the cellular level to the whole body. It's a pretty complex project where our mathematical modeling and the actual experiments go hand in hand. Collaboration is definitely a big component."

Until the team began their research, there was no existing data on the aging of lung cells. "A lot isn't known about the precise mechanisms of lung injuries in older people. Part of what we're trying to understand is how the multiscale model would work for a healthy lung and then see how that changes with age. We'll uncover some interesting questions about how the lung is aging and how cells

respond differently," explained Heise.

The work, she says, is grounded in the end result: a scenario in which a critical care doctor can safely ventilate an elderly patient without causing injury. "It's an exciting time to be at VCU."

Incidences of respiratory failure impact approximately 1 in 3,000 U.S. residents with mortality rates of approximately 40 percent. The majority of patients receiving mechanical ventilation are the elderly whose respiratory systems fail to function due to various lung and airway disease, such as acute respiratory distress syndrome and asthma.

"We'll uncover some interesting questions about how the lung is aging and how cells respond differently."

– Rebecca L. Heise, Ph.D.

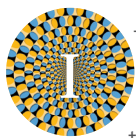




“Understanding mechanical cues might lead to a new paradigm in treating disease by targeting the mechanical properties of the tissue around it.”

– Christopher Lemmon, Ph.D.

A New Way of Looking at Disease



If a man is known by the company he keeps, the same may be said of the cells in the human body. With a tendency to respond to mechanical cues, cells attach themselves to their neighbors and their surrounding extracellular matrix (ECM) by contracting and pulling on each other. They can also generate forces to build new tissue. In the company of a stiff surface, a stem cell may become a bone cell; on a soft surface, it may become a brain cell.

"This cell evolution is based on no other changes other than the surrounding stiffness," said Christopher Lemmon, Ph.D., who is studying the signaling process among cells in his lab at the Virginia Commonwealth University School of Engineering. His work may change the way diseases are treated and tissues are generated.

"Understanding the mechanical cues might lead to a new paradigm in treating disease by targeting the mechanical properties of the tissue around it," Lemmon explains. "Cells are reacting to what's surrounding them. They're pulling on what's around them and responding to what they're feeling. It's really a different way of looking at disease."

The work of Lemmon's Cell and Matrix Mechanics Lab at VCU has health implications in two main areas: tissue engineering and cancer research.

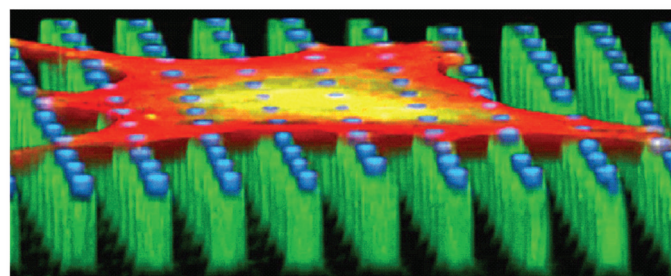
"If we can learn how cells are assembling new tissues, we can mimic those strategies in regenerative medicine," he said. "And in cancer research, where we know tissue assembly is happening excessively in the tumor environment, we are trying to address other ways we can block or stop it from happening in the first place."

Mechanical signals and ECM proteins work together to facilitate changes in cells from one type to another. Epithelial cells lining tissues and organs can change into mesenchymal cells, the cells that build tissue, under certain conditions. Lemmon and his students are investigating how changes in both mechanical signals and the type of ECM protein affect this process through microcontact printing where different ECM proteins are stamped to surfaces such that only two cells can interact with each other. This allows researchers to precisely control and study the relationship between the two cells and determine what signals drive

this change from epithelial to mesenchymal cell type.

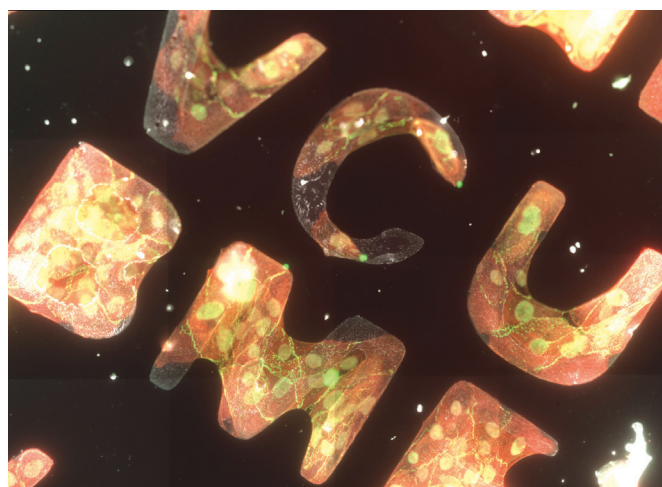
"We want to understand how cells interpret mechanical signals from their surroundings and use those signals to grow new tissues. We're interested in this in situations where it should happen such as embryonic development and tissue engineering and regenerative medicine, and in situations where it shouldn't happen as in tumor growth in cancer, fibrosis and scarring in wound healing, liver disease and kidney disease."

The work is funded through VCU Massey Cancer Center in conjunction with the American Cancer Society and a VCU Presidential Research Incentive Program award.



The above image shows a cell (red) sitting on top of mPAD pillars (green).

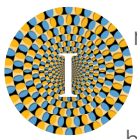
The image below is an example where epithelial cells have been grown onto a microcontact printed "VCU BME" pattern. Cells can be identified by their nucleus (round green objects) and their cell-to-cell junctions (thin green lines).





“Our results show that we’re able to handle millions of records with higher accuracy in a much shorter amount of time with fewer resources.” — Vojislav Kecman, Ph.D.

Getting the Most from Ultralarge Datasets



In the words of Virginia Commonwealth University associate computer science professor Vojislav Kecman, Ph.D., “There is no part of contemporary human activity left untouched by the need and desire to collect data.”

Indeed. Human beings, he explains, are immersed in a sea of data generated by myriad sources – sensors, cameras, microphones, software and other devices. From measurements, images and patterns, to sounds, Web pages and tunes, humans simply cannot process ultralarge scale datasets. But, he says, there are algorithms and methods that can be developed specifically to perform the job of learning from data.

“There is no efficient tool for dealing with millions of records,” Kecman explains. “This is why we are attacking this problem in our lab. We are developing algorithms to handle ultralarge datasets in all areas of human activities by using statistical learning approaches and models. We are inventing new ways to analyze datasets and we’re creating novel mathematical structures.”

In his lab at the VCU School of Engineering, Kecman and his students are developing and applying models in

bioinformatics, medicine, engineering, science, e-commerce and Web mining. They are tackling the challenges associated with what is known in the information technology industry as “Big Data.” The challenges presented by vast amounts of digital data are so many, in fact, that the White House announced the “Big Data” initiative in March 2012.

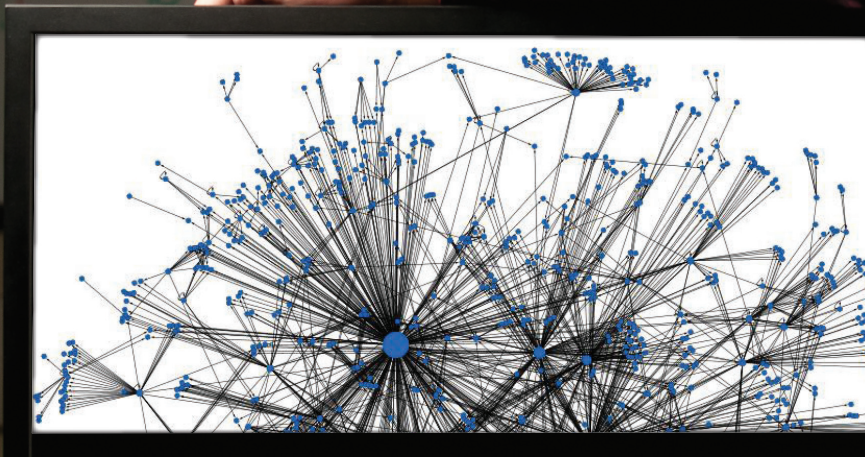
“We’re very proud that we started working on the Big Data project long before it became an initiative of the U.S. government,” Kecman said. “We believe we’re just a step ahead of many other machine learning (ML) and data mining (DM) labs.”

By teaching graduate students how to better analyze and mine today’s ultralarge databases, Kecman is helping prepare them for the workplace by giving them a competitive edge. He is also at work developing a new undergraduate data analysis course that goes beyond the traditional statistics approach of years past, which is not equipped to handle today’s Big Data problems.

“Our results show that we’re able to handle millions of records with higher accuracy in a much shorter amount of time with fewer resources,” he said.

In the sea of data in today’s world, that’s quite a life raft.

Understanding the Properties of Biological Networks



Preetam Ghosh, Ph.D., may not have a crystal ball to predict the future, but that's precisely what he's trying to accomplish in his computer science lab in the Virginia Commonwealth University School of Engineering.

"We're working to understand the properties of biological networks and to make predictions based on those properties. The predictions in gene regulatory networks and protein interaction networks, for example, can play a significant role in healthcare in general," he said. "This work allows us to look at complete networks and how they behave, which can impact all types of disease research and drug discovery."

Ghosh and his students primarily focus on algorithm development, modeling, simulation, analysis and visualization of large-scale networks with an emphasis on complex biological networks.

Some ongoing projects involve protein aggregation simulation involved in Alzheimer's disease, RNA interference pathway simulation, influenza lifecycle simulation, reverse engineering algorithms to infer genome-scale context-specific regulatory networks, and analysis and visualization schemes to study their time-varying properties.

"Our influenza research examines the virus' life cycle," Ghosh explains. "How does it interact with cells of healthy patients? We're creating a computer-based model which tries to mimic what happens so that we can predict the 'if, then' scenarios. This knowledge can then applied in the treatment

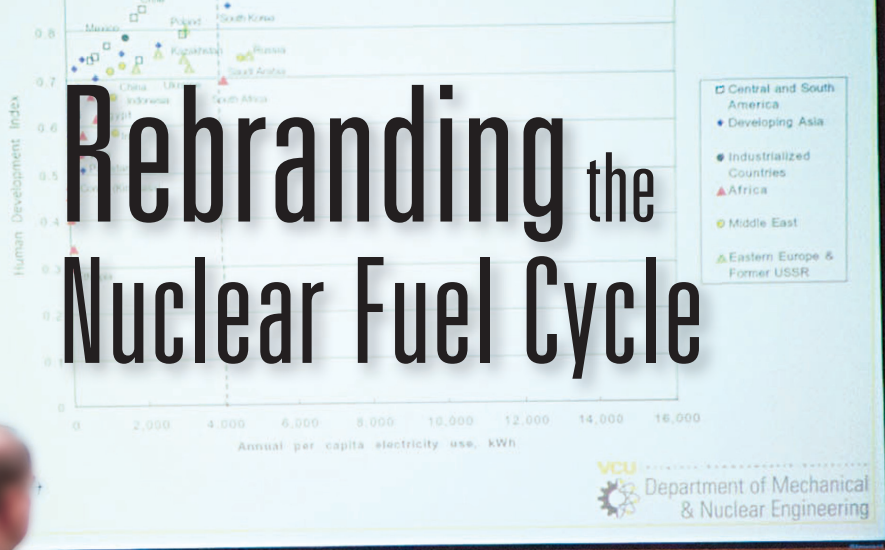
of influenza. We know the drugs, but the problem is control. How often to dose? And at what intervals?"

In his Alzheimer's work, Ghosh is studying protein aggregation, which leads to plaques on the brain. "These plaques are responsible for killing some of the neurons in the brain. So we're trying, based on our computer models, to determine how many of these protein molecules are being formed. Next, we can tell how many plaques are being formed. If we can stop the plaque formation using our predictability studies for use in drug discovery, we can help determine proper dosing in the future."

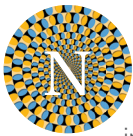
The various processes of disease have been known in isolation, Ghosh explains. But by examining complete biological networks, researchers can begin to understand the properties behind diseases. Once the properties are known and computer science helps predict the outcome of possible scenarios, treatment becomes faster and more cost efficient.

"We're working to understand the properties of biological networks and to make predictions based on those properties. The predictions in gene regulatory networks and protein interaction networks, for example, can play a significant role in healthcare in general." — Preetam Ghosh, Ph.D.

Rebranding the Nuclear Fuel Cycle



VCU Department of Mechanical & Nuclear Engineering



o matter what people think about nuclear energy in America, one thing is certain: just about everyone has an opinion. From those with a “not in my backyard” attitude to those who embrace nuclear power as an integral part of the U.S. energy mix, the public’s perception of the nuclear fuel cycle is often misguided and misunderstood.

Under the direction of principal investigator Sama Bilbao y León, Ph.D., associate professor and director of nuclear engineering programs at the Virginia Commonwealth University School of Engineering, public opinion regarding the nuclear fuel cycle is about to be carefully studied.

Bilbao y León is leading a multidisciplinary research project to serve as the basis for a strategic communications plan. Designed to help rebrand the nuclear fuel cycle, the project is funded by a grant from the Nuclear Energy University Program of the U.S. Department of Energy. It is one of the DOE’s 48 nuclear energy research and development projects.

“We need to look at the nuclear fuel cycle with fresh eyes,” said Bilbao y León. “The project will attempt to better understand what people’s concerns and priorities really are when it comes to nuclear energy and to synthesize that information so that scientists and policymakers can redesign the nuclear fuel cycle in the U.S. in a way that addresses the public’s concerns. Knowing what is really important to most people will also help craft communication strategies and educational programs that will ensure the public has the facts in hand to make an informed decision.”

In addition to the VCU School of Engineering, the project involves the VCU da Vinci Center for Innovation, the VCU Brandcenter, and the Virginia State University Department of Mass Communications.

The three-year project involves a pilot study in two or three carefully selected sample areas of the country. “We’ll be gathering information about people’s perceptions,” Bilbao y León explains. “The ultimate deliverable will be a comprehensive process for the development of decision-making strategies and communications plans on the nuclear fuel cycle.”

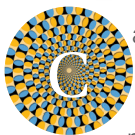
When the research is complete, a fully-inclusive strategic decision making process will have been designed so that scientists and policy makers can implement a country-wide full scale study. Ultimately, the project will result in an effective nuclear fuel cycle program that addresses people’s concerns, and a public well informed about the reality of the nuclear fuel cycle as a low-risk concept that contributes positively to everyday life.

“Knowing what is really important to most people will help craft communication strategies and educational programs that will ensure the public has the facts in hand to make an informed decision about the nuclear fuel cycle.”

– Sama Bilbao y León, Ph.D.



Hybrid Ph.D. is Nation's First



Career development and professional readiness has always been a key focus of the Virginia Commonwealth University School of Engineering. In fact, in 2007, the VCU Department of Mechanical and Nuclear Engineering established a nuclear engineering program in response to the industry's demand for qualified professionals and a growing national interest in nuclear energy.

In 2012, as a result of the continued need for highly trained nuclear professionals, VCU received state approval to offer a doctoral degree in mechanical and nuclear engineering – the first of its kind in the nation. The advanced degree program prepares students to enter critical fields such as power generation, alternative energy, nuclear medicine and national defense and homeland security.

The new doctoral degree is offered in addition to a Bachelor of Science in Mechanical Engineering, which includes a nuclear engineering track, and a Master of Science in Mechanical and Nuclear Engineering.

"This type of hybrid education allows students to be trained in both disciplines," said Karla M. Mossi, Ph.D., director of graduate studies, VCU Department of Mechanical and Nuclear Engineering. "It's not easy to create a true interdisciplinary curriculum such as the new doctoral program in mechanical and nuclear engineering, but there is a strong demand for students educated at the intersection of these two important disciplines."

Mossi and her colleagues introduced two pilot courses and are already rolling out the new degree program. "Our collaborative environment helps foster many academic advancements like this new Ph.D. program. We're very proud of that," Mossi said. "The new degree offers a hybrid of our department's three critical strengths – energy, materials and medicine. It offers an unprecedented approach to prepare engineering students with broad, interdisciplinary training to bridge two complementary fields."

The mechanical and nuclear engineering department is the largest department

in the VCU School of Engineering. Currently enrolling approximately 475 undergraduate students and 70 M.S. and Ph.D. students. The department has 19 full-time faculty members who teach and perform research in cutting-edge areas such as smart materials, drug delivery systems, nanoscale materials, biomedical devices, robotics, energy conversion systems, nuclear engineering, surface science and air filtration.

"It's not easy to create a true interdisciplinary curriculum such as the new doctoral program in mechanical and nuclear engineering, but there is a strong demand for students educated at the intersection of these two important disciplines."

– Karla M. Mossi, Ph.D.

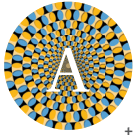


“Our collaborative regenerative medicine activities will enhance partnerships among Virginia’s major research institutions, industries, government organizations and the Virginia BioTechnology Research Park.”

— Xuejun Wen, M.D., Ph.D.

Meet Xuejun Wen, M.D., Ph.D.

Alice T. and William H. Goodwin Jr. Chair in Regenerative Medicine
Department of Chemical and Life Science Engineering



As one of the newest members of the Virginia Commonwealth University's dynamic engineering community, Dr. Xuejun Wen focuses his work in the area of regenerating functional and safe human tissues. His research combines the principles of biomaterial and biomedical science, stem cell biology and engineering, tissue engineering and regenerative medicine with the advanced techniques of molecular and cell biology.

"Before I came to VCU from Clemson, my team had developed many new technologies in the area of regenerative medicine research," Wen said. "I trained as a dentist specializing in cranial facial surgery in China and moved into the area of engineering biomaterials. That became my career path."

From regenerating cartilage *in vivo* without cell transplantation to using nanotechnology and injectable materials for spinal cord and brain repair, he and his research colleagues are adept at formulating novel approaches to healthcare challenges. In his first few months at the VCU School of Engineering, Wen created a robotic drug screening system to accelerate the new drug development.

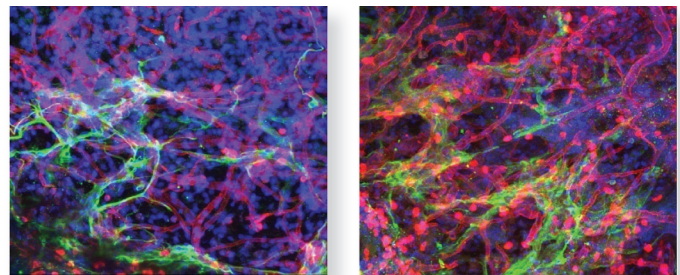
Wen's research goal is to develop clinically applicable tissue and organ repair strategies based on tissue engineering and regenerative medicine principles to enhance human health. His lab's short-term objective is to establish a university-level base for biomaterials, tissue engineering, stem cell biology and engineering, computer-aided tissue biofabrication, and regenerative medicine that offers essential research resources to serve the needs of local researchers for novel biomaterials, novel scaffolds, dynamic bioreactors, stem cells, computer-aided tissue fabrication technologies, animal models and translational research in collaboration with the School of Engineering's Institute for Engineering and Medicine.

"Regenerative medicine is one field with great hope for clinical translation and commercialization," he says. "It integrates engineering with many disciplines, such as stem cell biology, biomaterial science, biomolecule science, biomedical science, clinical science and more. Our collaborative regenerative medicine activities will enhance partnerships among Virginia's major research institutions, industries, government organizations and the Virginia BioTechnology Research Park."

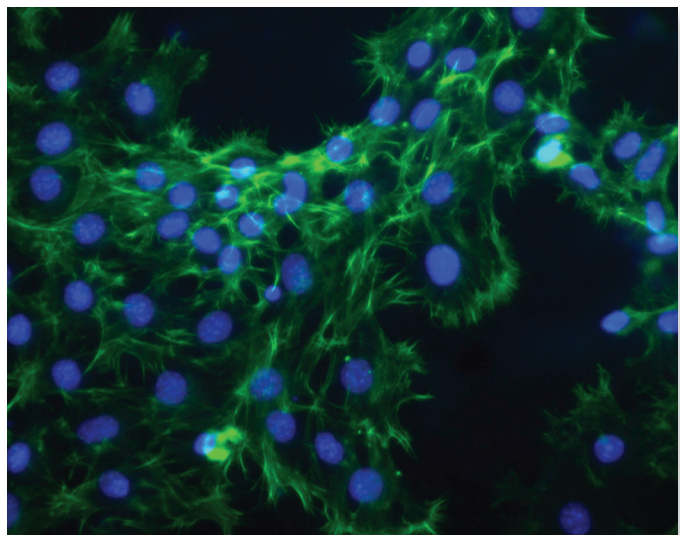
He plans to establish the VCU Center for Biofabrication, an emerging field involving the computer-aided manufacture of biologically relevant material with the purpose of engineering functional 3D tissues and organs.

"We hope to build new avenues of collaboration and to provide supporting infrastructures for small companies in the Virginia BioTechnology Research Park. The Center for Biofabrication can give VCU a competitive edge in the new field of biofabrication."

Wen is a fellow in the American Institute for Medical and Biological Engineering and a recipient of the prestigious National Science Foundation Career Award for his research in stem cell-viability aimed at curing such diseases and injuries as Alzheimer's, Parkinson's, heart and brain strokes, diabetes, spinal cord injuries and skeletal and craniofacial injuries. He received his M.D. from Henan Medical University in China and his Ph.D. from the University of Utah.

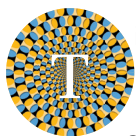


In the labs of Ning Zhang, Ph.D. and Dr. Xuejun Wen, neutral compatible hydrogels were used as the carrier for the transplantation of human stem cell derived neural progenitor cells. After transplantation into the brain lesion site, a complete vascular network can be regenerated to support neural cell repopulation.



A low cost biocompatible and degradable hydrogel system developed by Dr. Wen's lab supports robust 3D cell culture.

Balancing Time Predictability and *High-Performance*



Time predictability is crucial in hard real-time and safety-critical systems such as aircraft, automotive and medical controls. The accurate deployment of airbags or the functionality of heart pacemakers, for example, where timing is critical, can mean life or death in many scenarios.

Fortunately, scenarios such as these are being put to the test at the Virginia Commonwealth University School of Engineering where Wei Zhang, Ph.D., associate professor in the Department of Electrical and Computer Engineering, is working to perform worst-case execution time (WCET) analysis of critical real-time applications in his research lab.

Because of changes in technology and advancements in computer architecture design, modern microprocessors now achieve much higher performance than their predecessors. At the same time, they have become increasingly complex and unpredictable with respect to timing behaviors.

Historically, computer architecture research has focused on innovations to improve the average-case performance and energy efficiency, which are often harmful to the time predictability of computing.

Many emerging real-time applications require both time predictabil-

ity and high performance. Speech recognition software, for example, must be computed with real-time deadlines to be useful; otherwise, users have to speak slowly. With the widespread use of portable computing devices such as smartphones and tablets, the deep integration of speech recognition and other functions such as face and motion recognition into those devices will offer tremendous benefits in terms of convenience, security, entertainment and usability among others. However, for maximum utility, these applications must be performed in real-time.

Conventional architectural design presents severe challenges when real-time guarantees are required. So the need for high-performance and time-predictable processors that can improve not only hard real-time tasks but also non hard real-time tasks becomes even more important. Balancing time predictability and performance is likely to benefit more applications, increasing the quantity of the processors with customized architectures targeted towards real-time applications which will eventually lower the manufacturing cost per chip.

The objective of Zhang's research is to design a time-predictable yet high-performance multicore architecture to provide predictable performance for future high-performance real-time applications ranging from

aircraft and automobile control systems to emerging applications for smartphones, without significantly impacting the performance and energy efficiency of other non-real-time applications.

Even when predictability isn't as critical, as in video gaming and graphic animations, which are important parts of our society, real-time applications must be able to harness the full potential of multicore chips in a deterministic manner, Zhang says.

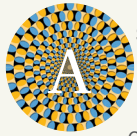
"Time predictability is a delicate balancing act which requires hardware and software cooperation and design trade-offs."

The National Science Foundation, IBM, Intel, Motorola and Altera have supported Zhang's research. He is a senior member of the Institute of Electrical and Electronics Engineers.

For real-time applications to harness the full potential of multicore chips, the execution time of multicore processors must be predictable, which is particularly crucial for hard real-time and safety-critical systems." — Wei Zhang, Ph.D.



Graduate Students Recognized at “Education Drives America” Event



As the U.S. Department of Education’s annual bus tour made its way across the country in September 2012, it stopped at the Virginia Commonwealth University School of Engineering where Debra Saunders-White, Ed.D., deputy assistant secretary of education, addressed the link between education and jobs.

“We are living in a global space,” Saunders-White said. “We need to be first in the world in terms of being able to produce the type of intellectual talent that’s needed to sustain the U.S. and keep our national security intact.”

As a testament to VCU’s commitment to workforce development and educational excellence, six of eight engineering graduate students participated in the meeting where attendees included students and faculty from the schools of engineering and education as well as the VCU College of Humanities and Sciences and the VCU School of Medicine. The students, all past or present fellows in the Department of Education’s Graduate Assistance in Areas of National Need (GAANN), shared their experiences in hopes of stimulating interest in post secondary science, technology, engineering, math or health (STEM-H) degree programs.

The GAANN program supports exceptional doctoral students who plan to pursue the highest degree available in their course of study in fields deemed critical to the U.S.: biology, chemistry, computer and information sciences, engineering, mathematics, nursing, physics and educational assessment, evaluation and research.



Rosalyn S. Hobson Hargraves, Ph.D., in the VCU Electrical and Computer Engineering Department at the VCU School of Engineering and the VCU Teaching and Learning Department at the VCU School of Education (bottom), with VCU GAANN students. Not pictured: Amy Throckmorton, Ph.D., in the VCU Mechanical and Nuclear Engineering Department at the VCU School of Engineering. Hargraves and Throckmorton, co-principal GAANN grant investigators, spearheaded VCU’s efforts to provide financial support for exemplary doctoral students in areas of greatest national need.

VCU GAANN Fellows

Sonya Bhavsar (Not pictured)

Thesis Advisor: Amy Throckmorton, Ph.D.
Bhavsar received her master's in mechanical and nuclear engineering in 2010 where she conducted research in congenital heart defects, specifically single ventricle anomalies. She is pursuing her doctoral studies abroad at RWTH Aachen University in Aachen, Germany.

Steven G. Chopski (Top row: left)

Chopski received his bachelor's in biomedical engineering in 2008. He is studying for his doctorate in mechanical engineering.

Joshua Clarke (Not pictured)

Thesis Advisor: James T. McLeskey Jr., Ph.D.
Clarke received his master's in mechanical and nuclear engineering in 2011 and continued in the doctoral program conducting research in energy conversion. After receiving his doctorate, he will work as a research engineer at the Naval Surface Warfare Center in Dahlgren, Va.

Christopher Gowen, Ph.D. (Not pictured)

Dissertation Advisor: Steven Fong, Ph.D.
Gowen received his master's and doctorate degrees in chemical and life science engineering in December 2008 and August 2011, respectively. He accepted a postdoctoral position at the University of Toronto where he is continuing his research.

Landon Holbrook (Top row: right)

Dissertation Advisor: P. Worth Longest, Ph.D.
Holbrook received his bachelor's in mechanical engineering with minors in physics and mathematical sciences in 2009 and continued in the doctoral program.

Dat Tien Nguyen (Middle row: right)

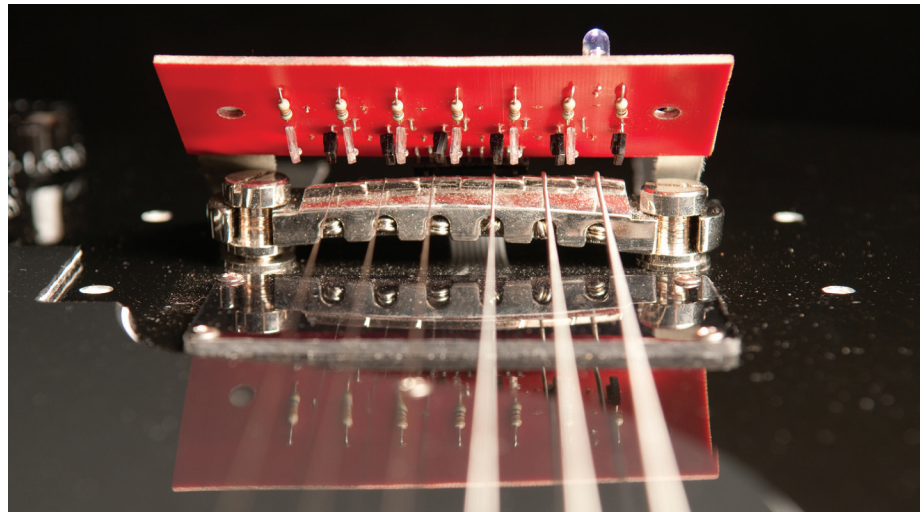
Dissertation Advisors: Krzysztof Cios, Ph.D., Rosalyn Hobson Hargraves, Ph.D.
Nguyen will complete his doctorate in computer science in 2013. With bachelor's degrees in both information systems and computer science from the University of Economics in Ho Chi Minh City, Vietnam, he received a master's in computer science from National University in Ho Chi Minh City. One focus of his research is learning algorithms.

Marshall Louis Sweet (Middle row: left)

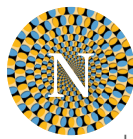
Dissertation advisor: James T. McLeskey Jr., Ph.D.
Sweet received his master's in mechanical and nuclear engineering in 2010 and will complete his doctorate in 2013 with a dissertation titled "Water Soluble Polymer Solar Cells based on Electro Spray Atomization Deposition."

Kendra Woodberry (Top row: center)

Dissertation advisor: Frank Gupton, Ph.D.
Woodberry received her master's in chemical and life science engineering in 2011 and will complete her doctorate in 2013. Her research focus is in the development of heterogeneous catalysts used for cross coupling chemical reactions.



Senior Design Project Captures Rock Star Attention



Nathan Hilbish never imagined he'd be comparing notes with one of the world's most famous guitarists, but Coldplay's Jonny Buckland developed a special interest in the Virginia Commonwealth University School of Engineering alumnus after learning of his research with sound signal transference.

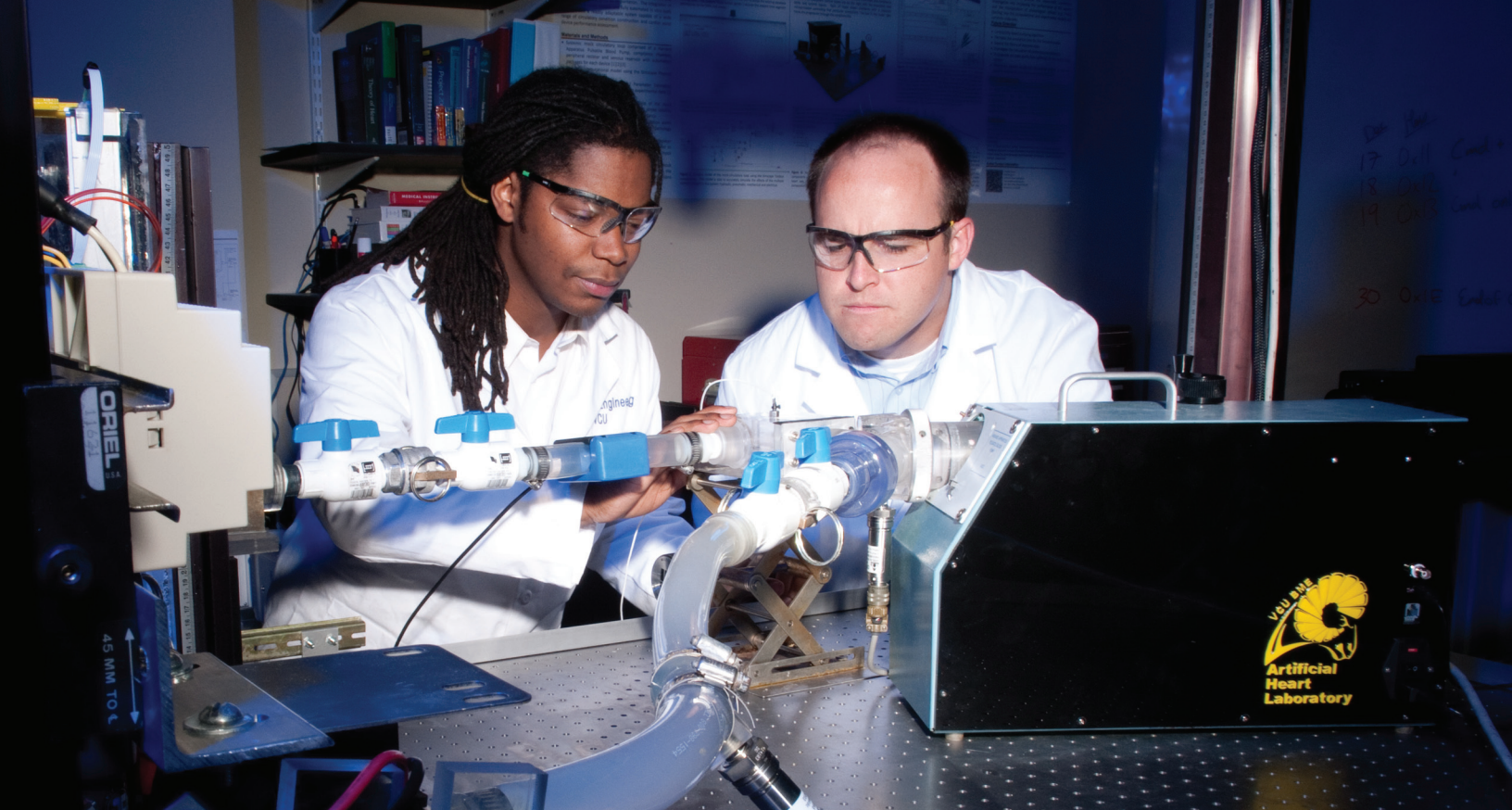
In a senior design project, Hilbish and his class of 2010 teammates Lee Stewart and Andrew Good, along with senior advisor Vennie Filippas, Ph.D., associate professor at the VCU Department of Electrical and Computer Engineering, created a prototype of an optical guitar pickup, a device that detects each guitar string's vibrations through optical components and combines them, converting the whole to a polyphonic sound. A standard electric guitar pickup uses a magnet to capture the strings' vibrations. Both systems convert the vibrations into electrical signals for amplification and recording. Hilbish went on to receive his master's from the VCU School of Engineering.

The advantage of the optical guitar pickup is that it captures mechanical vibrations using infrared light to produce the electrical signals and, unlike the magnetic pickup of the standard electric guitar, preserves the natural harmonics of the string, allowing for a more focused and cleaner sound.

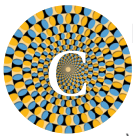
"People are intrigued by the sounds that an artist produces," Hilbish said. "The strings on an acoustic guitar are different than those on an electric guitar. The optical pickup allows an electric guitar to produce an acoustic sound."



"People are intrigued by the sounds that an artist produces. The optical guitar allows an electric guitar to produce an acoustic sound." — Nathan Hilbish '10



Making an Impact *in the Medical Device Community*



Charles Taylor (pictured at right), a doctoral student in the Virginia Commonwealth University School of Engineering's Biomedical Engineering Department, is changing the way artificial heart pumps are tested in the laboratory. The results could be lifesaving.

"I wanted to make an impact on the medical device community by delivering a testing solution that would allow for previously unachievable simulations to be performed," Taylor explains. Until recently, he's been the lab's sole researcher. "The challenge was the empty table. I've learned how to build a research lab, from the table up, into an emerging research competitor in this field."

Not only has the lab proven to be a rising competitor in the artificial heart pump field, but it's the only lab in the country with a mock circulatory loop system that controls arterial

properties in real time to produce these realistic cardiovascular conditions.

"The loop can be scheduled to execute setting changes that work to construct events and conditions that reflect the pump-body interaction," according to Gerald E. Miller, Ph.D., professor and chair of the VCU Department of Biomedical Engineering. "From a heart attack or a burst aneurism, the system will change in less than half a second to mimic exactly what's inside the body. No other school in the country is working on this level."

Taylor's fully automated mock circulatory loop delivers performance and versatility never before seen in the field.

"Encompassing this field science in my work has been a unique and enriching graduate study under Dr. Miller," Taylor said. "The mock circulatory loop is positioned to research groups and device companies as a testing solution to replace antiquated systems currently in place."

The development of this platform, Miller says, provides a unique, real-time system to evaluate blood pumps for a wide range of pathophysiological conditions with an on-the-fly ability to change cardiovascular conditions which mimic rapid changes in the human circulation under emergency settings.

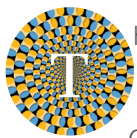
"The work by Charles Taylor is an opportunistic marriage of engineering control systems with cardiovascular medicine."

"The work by Charles Taylor is an opportunistic marriage of engineering control systems with cardiovascular medicine."

— Gerald E. Miller, Ph.D.



Bringing Gardens to Bloom *for the Blind*



The colors, textures and landscaping at Richmond's Lewis Ginter Botanical Garden is all but hidden from people who are blind and visually impaired.

But not for long.

Christina Walinski, a Virginia Commonwealth University engineering student, and her professor, Dianne T.V. Pawluk, Ph.D. are creating a device that could aid those with impaired vision to experience the garden on their own.

The project began when officials approached Pawluk, an associate professor in VCU's Biomedical Engineering Department and an expert in developing devices and software programs for assistive technology applications for people who are blind and visually impaired.

Pawluk saw in the garden's inquiry an opportunity for a senior design project. Walinski, one of Pawluk's former rehabilitation engineering stu-

dents, now a senior, was the ideal candidate.

"I love nature," Walinski said. "The opportunity to share nature with others through a wireless device is a demonstration of my engineering education."

With Pawluk's guidance, she is honing her concept of a wireless garden device that would use radio frequency identification (RFID) and its electromagnetic fields to transfer data from a tag to an RFID reader. This technology would allow an individual to listen to pre-programmed information about plants and flowers.

"We are looking at creating an application for a hand-held, auditory-based device that uses radio frequency identification with tags placed in key locations in the garden," said Pawluk. "The successful design of this prototype has the potential to make a difference in the lives of blind and visually impaired people."

Making a difference also is a goal for the garden, said Randee Humphrey, director of education at Lewis Ginter Botanical Garden.

"A device that could allow us to share our garden with people who are blind and visually impaired is aligned with the garden's education mission and our passion for connecting people and plants to improve our community," said Humphrey. "This is one of several partnerships between the garden and VCU and we're grateful to the university for sharing its expertise."

"The opportunity to share nature with others through a wireless device is a worthwhile demonstration of my engineering education."

— Christina Walinski

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Research Topics:

- Algorithms and systems development of brain-computer interface
- Human motor control physiology
- Development of brain-computer interface-based device for patients with movement disorders
- System development of imagery-based motor learning for stroke rehabilitation
- Development of algorithms and graphic-user interface for investigation brain neuronal connectivity
- Development of algorithms and systems for computer-aided diagnosis
- Algorithm development of neurophysiological signal processing and classification
- Multimodal functional neural imaging

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Focus Areas:

- Device Design and Development Processes
- Entrepreneurial Business Strategy and Development
- US FDA Quality System Regulations and ISO Medical Device Standards

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Research Topics:

- Angiogenesis
- Bone tissue engineering
- Hemostatic devices
- Electrostatic endothelial cell seeding techniques and transplantation/transfection
- Development of novel tissue engineering scaffolds via electrospinning
- Vascular tissue engineering

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Research Topics:

- Tissue engineering
- Response of cells to biomaterials
- Mechanisms of action of hormones and growth factors in chondrocytes and osteoblasts
- Normal and pathological calcification

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Research Topics:

- Bioinstrumentation
- Telemedicine
- Magnetic resonance imaging (MRI) techniques for studies of vessel properties and vascular hemodynamics
- Ultrasonic imaging techniques for studies of cardiovascular dynamics
- Technologies for radiation oncology

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- Pulmonary mechanobiology
- Tissue engineering
- Smooth muscle cell signaling

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Research Topics:

- Innovation and entrepreneurship
- Leadership of teams in ambiguity
- K-12 STEM education

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Research Topics:

- Non-invasive cerebral spinal fluid pressure device
- High noise speech communication system (Northrop Grumman Inc.)
- Baby echolocator a device to allow deaf babies to "see" acoustically facilitating perceptual motor development. (NIH)
- Military echolator (DHS)
- Baby multimodal (bone conduction and vibrotactile) hearing aid using algorithms to track mother's voice
- Tinnitus (phantom sound perception) management system using high frequency stimulation and custom actuator (US ARMY)

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Research Topics:

- Mechanobiology
- Extracellular matrix biology
- Cellular traction forces
- Cell mechanosensing

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Research Topics:

- Rehabilitation engineering-analysis and design of devices to aid the disabled
- Man-machine interfacing-analysis and design of voice-recognition systems
- Artificial hearts-analysis and design of a multiple disk centrifugal blood pump

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Research Topics:

- Haptic displays for blind and visually impaired individuals
- Human factors analysis during minimally invasive surgery
- Haptic technology for engineering education
- Haptic devices for rehabilitation
- Tissue modeling for surgical stimulators

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Research Topics:

- Experimental and computational modeling of diarthropal joint function
- Structural performance of fixation constructs
- Articular Cartilage: normal function, reparative techniques, tissue engineering

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Research Topics:

- Eye tracking systems and eye movement analysis
- Effects of neurological diseases on eye movement control
- Visual task analysis

- Physiological instrumentation and signal processing systems
- Human-machine interfaces based on eye and head movement

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Research Topics:

- Biomaterials
- Cancer research
- Dendrimer
- Drug Delivery
- Gene therapy
- Nanoparticles
- Nanoscience and nanotechnology
- Smart polymeric materials and structures
- Tissue engineering

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Research Topics:

- Behavior and plasticity of stem cells
- Interactions of stem cells with microenvironments
- Clinically applicable stem cell therapy and translational stem cell research
- Stem cells and cancer
- Nanotechnology

CHEMICAL AND LIFE SCIENCE

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Research Topics:

- Systems biology
- Synthetic biology
- Evolutionary biology
- Metabolic engineering
- Computational modeling

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Research Topics:

- Cross-coupling catalysis
- Flow chemistry/continuous chemical processing
- Organic synthesis in pharmaceutical applications

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www.vcu.edu/vcures/research/materials/index.html

Research Topics:

- Phase behavior and modeling of polymer solutions at high pressures
- Phase behavior studies and fluid properties of mixtures at geologically relevant pressures and temperatures
- Novel materials for biomedical and pharmaceutical applications
- Supercritical fluid solvent technology utilized for processing natural and synthetic materials
- Scattering phenomena in polymer solutions at high pressures

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Research Topics:

- Small molecule drug synthesis
- Cellular therapeutics
- Real-time biomolecular simulation
- Vascular tissue engineering
- Stem cell engineering

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Research Topics:

- Stem cell bioprocessing
- Biomaterials
- Biomarkers and cell-based assays
- Pluripotency
- Cancer stem cells
- Cellular reprogramming
- Neural differentiation
- Cellular engineering
- Regenerative medicine

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Research Topics:

- Biomaterials
- Tissue engineering
- Regenerative medicine
- Stem cell biology and engineering
- Biofabrication
- Drug testing, screening, and delivery
- Biomedical devices
- Bioreactor
- Nanotechnology
- Cancer Experimental Therapy

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Research Topics:

- Polymer surface science
- Fluoropolymer science
- Silicone science
- Functional polymer surfaces including biocidal polymers and self-stratified coatings for easy release of ice and fouling
- Nonlithographic patterning of functional polymeric materials

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Research Topics:

- Single molecule biophysics
- Protein-protein and protein-surface interactions
- Optical biosensors
- Functional biomaterials
- Micro-and nano-fabricated devices
- Biophotonics

COMPUTER SCIENCE

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Research Topics:

- Computer security
- Medical applications
- Semi-real-time algorithms
- Performance evaluation
- Graphics
- Database and networks

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Research Topics:

- Computational analysis of complex metabolic networks to study robustness for evolutionary related/distant species
- Predictive modeling of complex biological processes from expression data and prior knowledge using machine learning
- Computational and statistical exploration of rules that govern evolution of proteins
- Development of pattern recognition and machine learning methods for applications in biomedical informatics

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Research Topics:

- Machine learning
- Computational neuroscience
- Bioinformatics

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Research Topics:

- Systems Biology: stochastic modeling and discrete event simulation, reverse engineering, analysis and visualization of gene regulatory networks (GRNs)
- Graph theoretic analysis of protein interaction networks to identify functionally significant modules
- Mobile, ubiquitous and grid Computing
- Optimization problems in wireless networks

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Research Topics:

- Machine learning, data mining
- Bioinformatics, biomedical informatics
- Fuzzy logic modeling
- System dynamics modeling and analysis
- Algorithms for parallel, GPU based and cloud computing

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Research Topics:

- Software analysis, testing, verification, and reliability

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Research Topics:

- Biomedical signal and image processing
- Biomedical informatics

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Research Topics:

- Database design
- Fuzzy database
- Missing Information in relational database

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Research Topics:

- Programming languages
- Compiler design
- Automatic generation of software

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Research Topics:

- Operating system and virtualization security
- Cloud computing security
- Security of networked systems

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Research Topics:

- Wireless network security
- Security of mobile cloud and mobile systems
- Cognitive Radio Networks, smartphones, and mobile cloud


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- Research Topics:*
- Microelectromechanical systems (MEMS)
 - Biochips
 - Sensors and actuators
 - Smart materials
 - Micro/nano fabrication

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Research Topics:

- Self-assembly of nanostructures
- Spintronics
- Quantum computing
- Architectures for nanoelectronics and circuit design
- Quantum devices and single electronics
- Hot carrier transport in submicron devices and quantum wires
- Nanoelectronics

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Research Topics:

- Nanofabrication techniques
- STEM education

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Research Topics:

- Medical image processing
- Signal processor architectures
- Document compression for archiving
- Efficient, error-resilient, network-optimized image and video coding

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Research Topics:

- Computer architecture
- Big data analytics
- High performance and reliable I/O systems
- I/O architecture and data storage
- Cluster virtualization

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Research Topics:

- Numerical analysis techniques and software development for analysis and design of microwave and RF structures
- Signal processing and nonlinear statistical analysis techniques

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Research Topics:

- GPS applications
- Neural networks
- Linear and nonlinear control theory
- Robotics for nuclear waste handling

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- STEM education
- Medical image and signal processing
- Artificial neural network applications
- Science and technology in international development

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Research Topics:

- Hardware/software system design
- Embedded system performance modeling and design
- Unmanned aerial vehicle (UAV) flight control system design and testing
- UAV payload design, integration, and testing

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Research Topics:

- Group III-V semiconductors
- Light emitting diodes
- Nitride semiconductor heterostructures
- Oxide electronics
- Microcavity lasers

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Research Topics:

- Sensory intelligence
- Medical imaging
- Computer vision
- Robotics
- Online machine learning
- Adaptive target tracking

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Research Topics:

- Statistical signal processing and communications
- Data fusion and distributed signal processing in sensor networks
- Detection, estimation, and tracking
- Dynamic resource management in networked systems
- MIMO radar networks
- Compressive sensing

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Research Topics:

- Group III-nitride and zinc oxide optoelectronics
- Nonlinear optics
- Ultrafast spectroscopy
- Near-field optical microscopy
- Nanophotonics

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Research Topics:

- Real-time and embedded systems
- Worst-case execution time (WCET) analysis
- Computer architecture and compiler
- Low-power computing

MECHANICAL AND NUCLEAR

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Research Topics:

- Hybrid spintronics-straintronics for ultralow power memory, logic and higher order information processing
- Nanoscale magnetization dynamics
- Optically induced magnetization reversal in nanomagnets
- Magnetostrictive, piezoelectric, magnetoelectric materials and devices
- Fabrication of MEMS devices

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Research Topics:

- Nanotechnology
- Powder and spray technology
- Particle sampling and characterization
- Particle instrumentation
- Filtration and separation
- Air pollution control
- Atmospheric aerosol
- Indoor air quality control
- Health effect and toxicity of particles
- Drug target delivery and release control
- Synthesis of particles for pharmaceutical and biomedical applications
- Micro-contamination control in semiconductor manufacture processes
- Multiphase flow and reactors

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Research Topics:

- Experimental and computational thermal-hydraulics, two-phase flow and heat transfer for nuclear applications, including the development and verification of suitable thermal-hydraulic and heat transfer correlations
- Modeling of advanced nuclear systems and applications with subchannel, system and computational fluid dynamics (CFD) codes
- Design of advanced nuclear power plant concepts that rely on sophisticated thermal-hydraulic phenomena (e.g., natural circulation, supercritical water systems, molten salt systems, liquid metal systems)
- Nuclear safety and severe accidents
- Energy and environmental policy, energy planning and nuclear infrastructure development, in support of emerging and expanding nuclear programs
- Public perception, as well as education, communication and outreach in the area of nuclear science and technology.

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Research Topics:

- Fluids in motion
- Flow control
- Viscous pumps and microturbines
- Micro-and nanotechnology
- Large-Scale Disasters

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Research Topics:

- Engineering education
- Process control engineering
- Total quality management

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Research Topics:

- Monte Carlo and finite element simulation of composite material's response to electromagnetic fields, stress and strains, and mass transport to emulate environmental degradation
- Mechanisms of polymer coating degradation and corrosion protection
- Nuclear power plant design, thermal hydraulics, and radiation transport for shielding design
- Radiation safety and aspects related to health physics

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Research Topics:

- Multiphase biofluid transport with applications to respiratory and cardiovascular therapies
- Transport of toxic and therapeutic aerosols and vapors in the respiratory tract
- Multiscale modeling of respiratory dosimetry down to the cellular level
- Development of next-generation inhalation devices for therapeutic aerosol delivery
- Simulating the role of particle hemodynamics in vascular diseases
- Microcirculation transport and thrombosis occlusion models
- Optimal design of vascular prostheses (grafts & stents)

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Research Topics:

- Photovoltaic materials and devices
- Power generation
- Energy conversion systems
- Engineering education
- Optical characterization of semiconductor materials

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Research Topics:

- Micro/nano-scale heat transfer
- Thermal management of electronic components and systems
- 3D Solid modeling and Computer Aided Thermal Design & Analysis
- Computational Fluid dynamics (CFD)
- Heating, Ventilation and Air-Conditioning (HVAC)

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Research Topics:

- Electrical and mechanical characterization of smart materials and their applications in aerospace, automotive, medical, and electrical fields
- Materials and their response to different environments and the variation of their properties under different temperatures and boundary conditions (fluid mechanics, controls, equivalent circuits, mechanic of materials)
- Energy scavenging using pyroelectric and piezoelectric materials for low-power electronics

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Research Topics:

- Design innovation through arts
- Computational mechanics
- Corrosion engineering
- Biological composites
- Micro devices for health care application
- Neural networks and computational intelligence
- Nanotechnology and biomolecular motors
- Sustainability
- STEM Education
- Smart materials and structures

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Research Topics:

- Response dynamics and vibrations of offshore drilling and production systems and equipment arising from various sources of excitation (wind, waves, currents, seafloor soil conditions, fluids, pressure, thermal, floating platform motions)
- Deepwater marine riser systems and the various nonlinear effects arising from the six degree-of-freedom motions of ships and floating platforms, vortex-induced vibrations, axial dynamics, and three-dimensional nonlinear interactions of the riser systems
- Simulation and control of sophisticated, high-capacity tensioning systems with mechanical, fluid, and thermal transients and floating platform motions are examined by computational methods for operational situations

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Research Topics:

- Smooth muscle biomechanics
- Developing robotic devices for medical applications

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Research Topics:

- Nanoelectromechanical systems (NEMS)
- Electrokinetic nanoengineering
- Nanomaterials
- Nanofabrication
- Advanced microscopy
- Nanomechanics
- Small-scale energy storage/harvesting/generation

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Research Topics:

- Superhydrophobic surface
- Multi-phase fluid transport in fibrous porous media
- Aerosol flows and nanoparticle filtration
- High-speed jets and nozzle design
- Heat and mass transfer in porous media
- Molecular dynamics simulation

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Research Topics:

- Chemical sensors
- Nanomaterials
- Radiation detectors
- Functional coatings
- Electroprocessing of polymers

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Research Topics:

- Experimental and computational fluid dynamics
- Turbomachinery design and applications
- Bench-to-bedside development of medical devices
- Artificial organs research, especially for the pediatric population
- Prediction and quantification of blood trauma and thrombosis in medical devices
- Cardiovascular modeling and univentricular fontan physiology

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Research Topics:

- Actinide bearing ceramic nuclear fuel
- Nuclear structural materials
- High temperature materials processing and mechanical testing
- High temperature irradiation behavior of ceramics including mechanical properties and microstructural changes
- Materials-coolant interaction
- High temperature deformation mechanism maps
- Neural networks for probabilistic risk assessment
- Design of nuclear materials irradiation experiments
- Nanofluids for reactor applications
- Computational methods in nuclear reactor physics and advanced nuclear reactor design

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