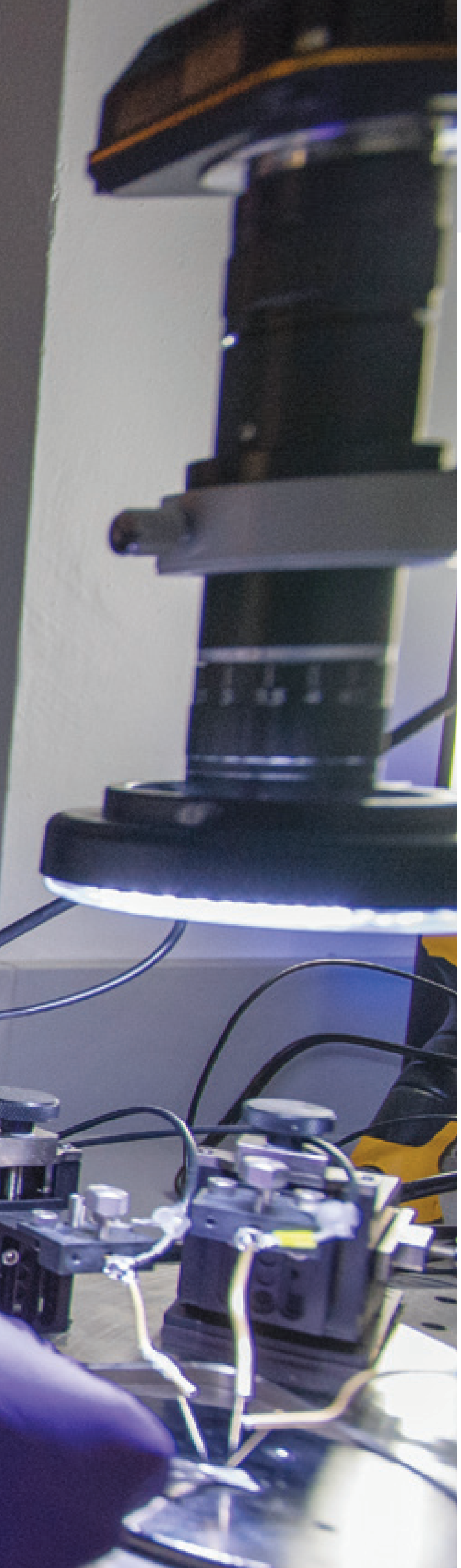
NEW JERSEY INSTITUTE OF TECHNOLOGY

RESEARCH



NJIT

LINKING LABORATORIES TO LIVES



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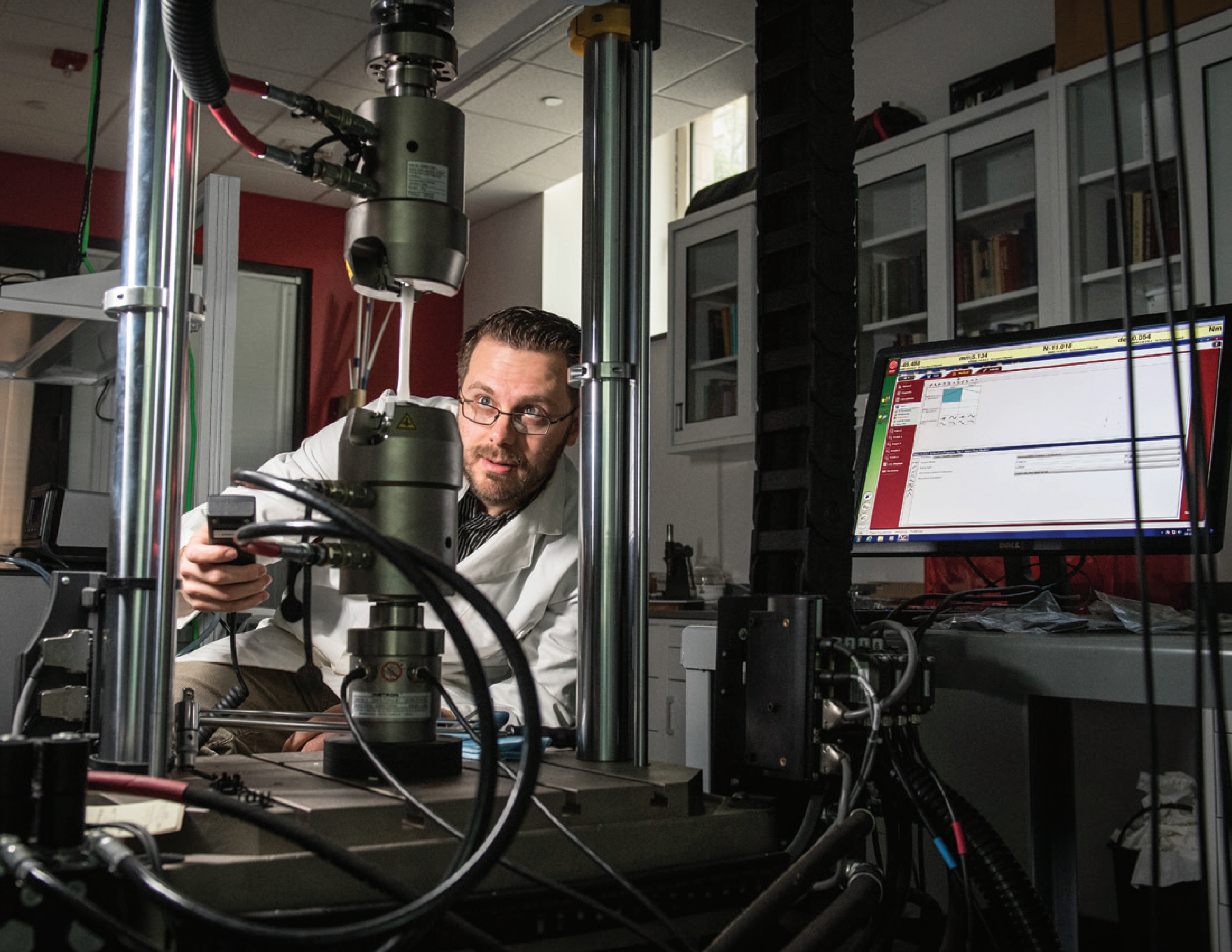


From the Vice Provost for Research and Development

Delivering life-enhancing therapies to the aging, disrupting the chemical pathways of addiction and mitigating the effects of neurological diseases and traumatic brain injuries are some of the monumental health care challenges of the 21st century. But thanks to landmark achievements in the field of neuroscience, the brain's mysterious operations are starting to reveal themselves and we are, accordingly, setting ourselves ambitious goals.

By connecting researchers across disciplines and institutions, we strive for significant breakthroughs that will help maximize human potential: to enable children born with neurological disorders to thrive in classrooms, to ensure that the young paralyzed in accidents walk again before they reach their prime and to return blast-injured veterans to productive life.

In this inaugural issue of New Jersey Institute of Technology (NJIT) Research Magazine, we focus first on the work of three hubs in our newly established Institute for Brain and Neuroscience Research. As with the field itself, the university's expanding cluster in this area includes an array of biochemists, physicists, mathematicians, biomedical engineers, biologists and computer scientists with diverse perspectives but complementary goals. Experts in imaging technologies work hand in hand, for example, with neurorehabilitation engineers to determine how visual and aural therapies impact neural pathways.

We first highlight the efforts of NJIT's Center for Injury Biomechanics, Materials and Medicine, which is investigating the effects of shock waves on the brain in order to design and test helmets that can withstand penetrating blasts from weapons such as improvised explosive devices (IEDs).

Secondly, we present the applied research of the Rehabilitation Engineering Research Center, where faculty and graduate students are designing and building the next generation of robotic exoskeletons to improve mobility and to enable safer, more independent functioning for people with spinal cord injuries, Duchenne muscular dystrophy and stroke.

And lastly, we look at the overlapping research of a group of mathematicians, physicists and biochemists who are exploring the circadian rhythms that harmonize animal and plant behavior with the daily cycle of daylight and darkness and seasonal change. Increasingly, these patterns are disrupted by modern urban culture, including the omnipresence of artificial light and frequent travel across time zones.

Elsewhere in this issue, we include snapshots of our current research in many other areas: in solar physics, which focuses on the dynamics of the Sun's explosive magnetism as seen through images captured by the university's Big Bear Solar Observatory, which are the highest resolution to date; in pharmaceutical research aimed at improving the manufacturing processes and delivery mechanisms of drugs through particle engineering at the nanoscale; and in the development of new, sustainable materials for civil infrastructure capable of withstanding earthquakes and volatile weather.

Our researchers take a problem-focused approach to their projects, which are identified in many cases in conjunction with our partners in hospitals, rehabilitation centers, the military, state transportation planners and federal policymakers on space weather, to name a few. So that our students are prepared to join high-level research teams in graduate school or industry, our faculty work with more than 300 undergraduates each year on independent research initiatives, often incorporating them into the work of their own laboratories.

Atam Dhawan
Vice Provost for Research and Development
Distinguished Professor of Electrical and Computer Engineering

Translating the Language of Neural Circuits Into Personalized Care

Recent breakthroughs in imaging technology and biomolecular research are together shedding new light on the brain's fundamental operations, revealing the mechanisms by which thoughts are generated, emotions triggered and movements coded. Aided by high-powered microscopes and phosphorescent tracking, neuroscientists can now observe, for example, the activation of cells in the cerebral cortex that equip animals to navigate within territorial grids, and trace the formation of a sea slug's memory of a predator's attack.

These same technological advances are revealing the routes by which genetic mutations unravel executive functioning, including the accretion of protein fragments that clog neural pathways and erase memories in people with Alzheimer's disease. The World Health Organization calls neurological disorders — from strokes, to dementia, to traumatic brain injuries, to Parkinson's disease — "one of the greatest threats to public health." With aging populations throughout much of the developed world, their incidence is rising.

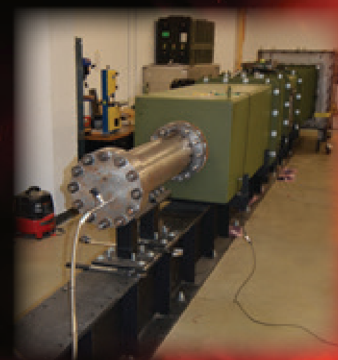
Researchers at NJIT take a multi-pronged approach to understanding neural circuits and their disruption. Neurobiologists **Farzan Nadim**, **Dirk Bucher** and **Gal Haspel** examine the simple nervous systems of animals such as crustaceans and worms, while mathematicians **Casey Diekman** and **Horacio Rotstein** develop models of neuronal patterns. Biochemist **Yong-Ick Kim**, who conducts laboratory analyses of the biochemical building blocks of the circadian clock, works with them to examine hypotheses about entrainment mechanisms — the means by which brainwave oscillations synchronize with external stimuli.

We are equally committed to mitigating the effects of disabling neurological disorders and injuries by designing devices and therapies that help people function to their full potential. In these efforts, our neurorehabilitation and biomechanics engineers work closely with imaging experts such as **Bharat Biswal**, whose early work gave rise to important research in clinical neuroscience, including the mapping of brains affected by diseases such as Alzheimer's and developmental conditions such as ADHD and dyslexia. Biswal examines, for example, the rerouting of brain patterns in response to the visual and hearing disorder therapies developed, respectively, by biomedical engineers **Tara Alvarez** and **Antje Ihlefeld**.

We work closely with clinicians in our region. Biomedical engineers **Richard Foulds** and **Sergei Adamovich** partner with the Kessler Institute and hospital-based rehabilitation centers to develop exoskeletons and other devices that will help people with neurological disorders participate in classrooms and in workplaces. **Namas Chandra** and **Bryan Pfister**, who study traumatic brain injury, collaborate with New Jersey-based physicians and medical researchers on their work for the U.S. Department of Defense.

Treena Arinzeh, professor of biomedical engineering, researches applied biomaterials and tissue engineering. Among other projects, she is exploring several methods for regenerating nerve tissue using stem cells.

Daphne Soares, assistant professor of biology (right), with Alex Bradbury-Wallad '16. Soares studies neuroecology, the synthesis of neuroethological and ecological principles, to understand how different species' neural circuits have evolved in response to their environments.



Protecting Soldiers From the Shock Waves of Modern Warfare

Battle-inflicted head injuries are as old as war itself, evidenced by the copper helmets worn by Bronze Age soldiers to deflect blows from spears and axes. Over the ensuing millennia, as weapons evolved, so did armor. Today, the powerful explosive devices of 21st-century warfare have once again raised the stakes, prompting urgent efforts to reengineer protective gear.

With major grants from the U.S. Department of Defense (DoD), NJIT's Center for Injury Biomechanics, Materials and Medicine (CIBM3) is investigating the effects of shock waves on the brain in order to design and test helmets that can withstand blasts from weapons such as improvised explosive devices (IEDs) that send waves hurtling faster than the speed of sound, as well as penetrating shrapnel.

"Helmets designed to protect against bullets and other impacts are unproven against shock waves from IEDs," says **Namas Chandra**, the center's director and the principal investigator for four recent grants from the military totaling nearly $4.5 million.

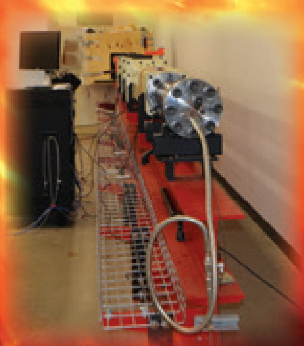
Studies from recent conflicts indicate that 20 percent of the U.S.-deployed force suffer from traumatic brain injury (TBI), and that in Afghanistan and Iraq about two-thirds of military personnel with TBI were wearing protective equipment when they were hurt. Indeed, scientists and engineers still do not understand what physical component of the IED blast induces TBI or the delayed, secondary biochemical damage at the cellular level.

Chandra and his colleagues will determine these mechanisms of injury while also shedding light on the capabilities of protective devices such as helmets, body armor and goggles under blast-loading conditions. Their goal is to develop specifications that would guide the development of new personal-protection systems for soldiers.

Michael Leggieri, director of the DoD's Blast Injury Research Program, noted that the agency's medical research community has asked for guidance on building combat helmets to protect against blast-related brain injury, but added that "we can't give it until we understand the injury mechanisms."

"Understanding the underlying mechanisms of blast-related brain injury is a critically important problem that we've been after for years, but have yet to solve," he said during a first visit to the center.

CIBM3's biomedical engineers are collaborating with biologists, neuroscientists and computer modelers at NJIT, as well as clinicians at regional medical schools and Veterans Administration facilities to establish metrics that will allow field doctors to determine if a soldier has sustained a brain injury, exactly where in the brain it occurred and its degree of severity, from mild concussion to serious TBI.



Over the past decade, the DoD reported more than 200,000 head injuries sustained in battle and in non-combat settings. More than 150,000 of these personnel were diagnosed with mild traumatic brain injury and post-traumatic stress disorder, while exhibiting a wide range of neurological and psychological symptoms.

Using physiological parameters, Chandra and his colleagues have recently developed a new assessment tool for categorizing injuries from blast overpressures that will allow them to predict whether they will result in mild, moderate or severe TBI. Damage from these highly energized pressure waves that follow explosions was recognized during World War I as a separate neuropathological condition and dubbed "shell shock." The soldiers afflicted with it on the battlefield sustained a variety of neurological deficits and sometimes died without any visible injuries.

In the university's blast simulation lab, Chandra and his team are examining the connection between the strength, distance, speed and positioning of a blast, and the type and degree of injury it causes. They are also assessing the physical damage to both the structure of cells and their capabilities, including the ability to transmit signals.

To study these impacts, researchers release compressed gases such as helium to create air shocks that race down an enclosed "shock tube" at speeds of up to 1,300 miles an hour toward a helmet outfitted with pressure gauges. Over the course of the project, they will test different types of helmets in the chamber, as well as live biological tissues to explore the actual mechanisms of injuries.

"In our multi-scale analyses, we study everything from neurons in a dish, to animal models, to full-scale inanimate human models," notes **Bryan Pfister**, the associate director of the center and chairman of the biomedical engineering department, who researches injuries to neurons and the connections called axons, which comprise the nervous system's communications infrastructure.

In addition to TBI among soldiers and veterans, the center also researches mild TBI and concussion that result from other forms of physical trauma, such as sports injuries.

"When two soccer players collide, we call this blunt trauma. In many cases the cells continue to live, but they may not be working well," Pfister says. "The axons may not be signaling properly, for example, and the connections between neurons are thus lost."

Working with other departments across the campus that are also focused on brain health and science, CIBM3 sees its role as contributing to technological advances with implications for brain imaging and neurophysiology as well, including the diagnosis and characterization of neurological diseases such as strokes, epilepsy and Parkinson's disease.

Prolonging Independence for Young People With Muscular Dystrophy

For young people with Duchenne muscular dystrophy in wheelchairs, the progressive loss of strength in their arms is an expected but troubling development that upends daily life and threatens their independence.

"Eating started to become challenging and I was struggling to brush my hair and teeth — the basic stuff people can do," recounts Zachary Smith, a 23-year-old Floridian who, after he began experiencing these symptoms four years ago, researched rehabilitation devices to see whether a passive arm support could be adapted for his use. "I thought that if supports like these were used in factories to reduce workers' muscle fatigue, why not on a wheelchair."

In the next few months, Smith will be the first person to test a motorized exoskeleton that incorporates technology designed at NJIT — an embedded computer, software, a force sensor and a motor — into an existing passive, spring-loaded device developed by Detroit-based Talem Technologies. This past December, he put the passive device through its paces shooting pool, flipping burgers on the grill and playing fetch with his dog in the backyard.

NJIT and Talem recently launched a 30-person beta trial to work out unforeseen glitches in what would be the first device to provide intuitive, motorized assistance to people with Duchenne, allowing them to continue to use their arms as their muscles weaken.

Madeline Corrigan, a doctoral candidate in biomedical engineering and co-principal investigator of the study, explains, "The exoskeleton operates on admittance control, a robotics-control paradigm in which the motion of the robot is controlled by the magnitude and direction of the force applied by the user's arm. Compared to passive arm supports that require the user to have sufficient strength to move them, admittance-controlled devices significantly minimize friction and inertia, providing more precise compensation against gravity, and reducing the exertion necessary to move a limb, particularly vertically."

The team is now recruiting up to 30 non-ambulatory individuals living with Duchenne from across the country to use the device and report back regularly on their experiences incorporating it into their daily lives. Participants in the study, funded by Parent Project Muscular Dystrophy, a nonprofit research and advocacy organization, will receive a pair of wheelchair-mountable passive arm supports to be used regularly inside their homes, as well as in classrooms, workplaces and other community settings. After a few months, each participant will receive a modular upgrade to partially motorize their arm support.

"We will start with the passive device and then seamlessly add vertical assistance as an initial step. Our studies show this is often the first degree of freedom to be limited in the case of progressive diseases," says **Richard Foulds**, co-director of NJIT's Rehabilitation Engineering Research Center and a co-principal investigator of the study.

NJIT is also working with the Kessler Foundation to develop other wearable robotic exoskeleton devices with a $5 million federal grant from the National Institute on Disability, Independent Living and Rehabilitation Research. Their focus is to improve mobility and enable safer, more independent functioning for people with spinal cord injuries and stroke, as well as Duchenne. The project marries NJIT's expertise in advanced robotic engineering with Kessler's biomechanics and neuromuscular physiology research.

"The interaction of investigators from Kessler Foundation, NJIT and users with disabilities across projects is genuinely distinctive," notes Foulds.

Sergei Adamovich, associate professor of biomedical

engineering at NJIT and a co-principal investigator for the grant, is leading a project involving Kessler Foundation researchers, faculty from the Rutgers University Department of Rehabilitation and Movement Sciences and NJIT graduate students to extend their earlier work linking robotic exoskeletons with virtual reality platforms to improve neurorehabilitation therapy for people with limited arm movement due to a stroke. They are developing an upper-extremity exoskeleton based on an earlier model of the Duchenne device that incorporates virtual reality and can be used at home.

In addition to the robotic arm support, Foulds is working on a robotic device that would assist people with spinal cord injuries to walk. Key to this work is a new approach that allows the user to voluntarily control the exoskeleton movements to yield more natural, intuitive and flexible ambulation by basing stride — the length and height of steps — on movement intention signaled by hands and fingers.

Engineering for a Community

As a teenager growing up in Minnesota, MADELINE CORRIGAN volunteered for a Muscular Dystrophy Association summer camp and "fell in love with a cause and a community of people." As chance would have it, she was paired her sophomore year in college with a roommate with a rare neuromuscular disorder. They quickly became best friends. Her death shortly before graduation both devastated and motivated Corrigan.

"I developed a deep-rooted personal and professional commitment to help individuals with muscular dystrophy live more independently so they can put their energies toward pursuing life instead of managing disease," she recounts. Of her roommate, she notes, "She was a go-getter with so many goals. She lived life fully."

RICHARD FOULDS, associate professor of biomedical engineering, vividly recalls his interview with Corrigan, soon after she applied to NJIT's biomedical engineering graduate program.

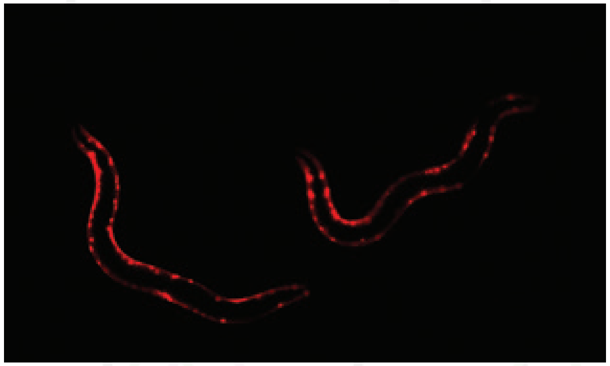
"While we had worked with people with a wide range of disabilities, we had never considered applying our technology to those with Duchenne. So the interview roles were essentially reversed," explains Foulds. "Madeline had real knowledge of the disease and wanted to see if we would be interested in developing a new research focus. We essentially made a deal. She would come to NJIT if I found funding to start a new robotics initiative."

The principal challenge of Duchenne for an engineer, Corrigan says, is the progressive and variable nature of the disease.

"The physical capabilities of the user are constantly changing. And with progressive muscle loss, there are secondary health complications such as atrophy from disuse, contractures and scoliosis that further contribute to functional loss. The rate of progression varies widely, so engineers must accommodate these differences, while providing everyone with a similar degree of independence. To do this, we adopted a modular approach to our device."

Looking back over the past five years, she notes, "As is so often the case in engineering, our approach has evolved. While the core ideas remain, we had to be willing to adapt quickly in the presence of new information. For me, input and feedback from users are at the core of the development process. It is crucial that they are involved at every step to ensure we're creating a product that meets their real daily needs. My unique background and experience, including 13 summers at the camp for kids with muscular dystrophy, have led me to understand that a willingness to listen to, adapt to and understand the needs of the user is fundamental to successful engineering. I find it important to never make assumptions about someone else's needs."

Decoding the Mechanisms Behind Jet Lag



More than two billion years ago, a blue-green microbe began filling up Earth's carbon-dense atmosphere with oxygen produced through photosynthesis, giving rise to life as we know it. The disruptive microorganism, cyanobacteria, endures in abundance today, and is a subject of study for scientists who explore its primitive biological timekeeping system for clues to our own.

NJIT mathematicians have teamed with biochemists and biologists to study the bacteria's circadian clock. In humans, this neural timekeeper harmonizes our sleep, temperature and endocrine cycles, as well as our behavior, with the daily cycle of daylight and darkness and with seasonal transitions. Increasingly, these patterns are disrupted by modern urban culture, including the omnipresence of artificial light and frequent travel across time zones.

Mathematicians **Casey Diekman** and **Horacio Rotstein** are developing mathematical models of the clock's biological oscillations, or rhythms. Biochemist **Yong-Ick Kim**, who conducts laboratory analyses of the biochemical building blocks of the cyanobacterial circadian clock, works with them to examine hypotheses about entrainment mechanisms — the means by which oscillators synchronize with external stimuli.

Kim is particularly interested in the disruption of entrainment.

"Many medical problems are attributed to either internal disturbances of the circadian clock or to asynchrony between the clock and the daily cycle of night and day," Kim says. "Jet lag is a common problem for frequent flyers who travel between time zones and experience sleep disorders, digestive problems and cognitive impairment as a result. Health problems such as cancer, obesity, diabetes, fatigue and mood disorders may also be correlated. By understanding the molecular mechanism of the 24-hour circadian clock, we expect to obtain critical clues for the treatment of medical problems related to its disruption."

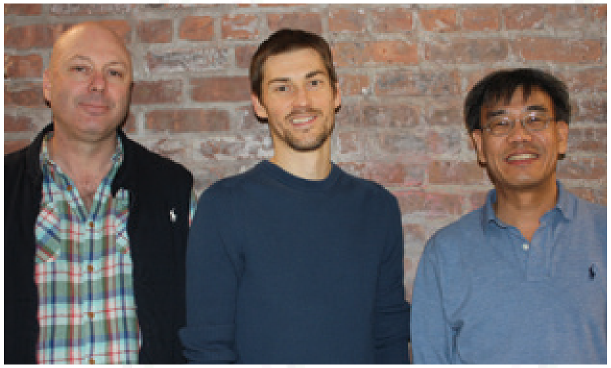
He is studying the bacteria's circadian oscillator, encoded by three genes whose protein products associate and disassociate to generate a 24-hour rhythm, by mixing purified forms of these proteins with the energy molecule ATP to examine their phosphorylation, or enzyme regulation. "We can add other light-sensitive co-factors to study the entrainment of the circadian clock. We can also solve the mechanism of the circadian clock by computational simulation with the data sets from the in vitro experiment."

In addition to cyanobacteria, Diekman is studying circadian rhythms in mice and the fruit fly, Drosophila. The circadian clocks in these species rely on rhythms in the electrical activity of networks of neurons. In work supported by a National Science Foundation CAREER grant, he is bringing together techniques from applied mathematics, statistics and neuroscience to create new tools for building mathematical models directly from observed time-course data. He hopes to use these novel data-assimilation algorithms to assemble a neurophysiological model of the Drosophila circadian clock network from voltage trace recordings.

The predictions this model makes about the biological mechanisms underlying jet lag will be tested in flies through

"I'm attracted by the challenge of using math to understand a system as complex as the brain. Many of its components, such as the ion channels in neuronal membranes, can be described with detailed biophysical models. It is impossible, however, to model the whole brain with its billions of neurons and trillions of synaptic connections at this level of detail. So we need mathematical theories and other mathematical tools to develop simplified models, and help figure out how the components interact across spatial and temporal scales to enable the brain to produce various functions and behaviors."

- Casey Diekman, mathematician



Horacio Rotstein (left)
Casey Diekman (middle)
Yong-Ick Kim (right)

"There is so much talk about big data, but people don't realize how much information there is in the visual environment that the brain is taking in, interpreting and acting on constantly. The brain is a major communications center. These are big issues in electrical engineering, where I got my start as an undergraduate, and the brain fascinates us because in terms of complex systems, it's the master. Similar to any therapy, the repetitive nature of the vision exercises we research leads to a sustained reduction in symptoms, suggesting that the brain has rewired or changed in some way."

- Tara Alvarez, biomedical engineer

behavioral experiments that simulate travel across time zones.

The fly clock network has much in common with the central circadian pacemaker in mammals, the suprachiasmatic nucleus or SCN. The SCN is a group of about 20,000 neurons in the hypothalamus that can keep time on its own, but also receives information about the daily light-dark cycle through the retina. The circadian system may have enabled mammalian ancestors to spend daylight hours inactive in dark spaces to avoid predators and emerge at night to forage safely for food.

The problem of jet lag can be thought of as a conflict between this evolutionary strategy and the modern world, Diekman notes.

"You want a system that is robust enough so that the internal sense of time will override confusing 'noise' in the environment, such as heavy cloud cover, yet at the same time respond appropriately to changes in the environment," he explains. "So we experience jet lag because the robustness of the clock that serves us well under some circumstances when it comes to 'noise' also has 'inertia' which can cause us to lag in adjusting to environmental changes."

He and other NJIT neuroscientists are also pursuing research indicating that circadian rhythms are integral to the physiology of cells throughout our body, not just in the SCN. These pervasive rhythms, involving variations in cellular activity, could explain why certain cancers seem to be more susceptible to chemotherapy at particular times of the day, and why sudden cardiac arrest appears to occur more frequently late in the morning and early in the evening.

"The circadian clock can be found in almost all organisms from bacteria to human beings. Although the detailed molecular mechanisms are different among the species, overall concepts are conserved in all of them. The gene expression, metabolism, physiology and behavior of almost all light-perceiving organisms living on Earth are governed by the circadian clock. I study the cyanobacteria, a microorganism that is more than two billion years old and produced the oxygen that gave rise to life as we know it. What interests me as a biochemist is that I can study this ancient clock and apply what I learn to the human brain."

- Yong-Ick Kim, biochemist

John Carpinelli

Improving Medications Through Manufacturing Innovation

In the race to design therapeutic bullets for diseases such as cancers, bacterial infections and obesity, drug researchers are paying ever-closer attention to the mechanisms that fire them. Their effectiveness is improved significantly, for example, when they can be safeguarded from the stomach's acidic environment and delivered directly to the site of an infection for controlled release.

But a primary hurdle is making sure they are released into the bloodstream at all.

"The challenge of modern pharmaceuticals is that they're often not water soluble," says **Rajesh Davé**, distinguished professor of chemical, biological and pharmaceutical engineering. "Newly discovered molecules with the desired mechanisms tend to be larger and have higher hydrophobicity. And since blood is largely composed of water, such drugs do not get absorbed and so cannot reach their targets. Our task is to make them soluble enough to be available in the bloodstream."

Davé, who specializes in particle engineering, has spent the last several years grinding drugs into ever-tinier bits to enhance solubility and then coating each one with nanoparticles to prevent them from being degraded before they reach their targets and to optimize their flow. The coating adheres to the drug particles, which may be as small as 50 microns, after they are shaken together at a 100 g-force.

In a recent project funded by the U.S. Food and Drug Administration, Davé has been asked to come up with another delivery platform, which involves spreading soluble nanoparticles of medications uniformly across a thin film. While it would benefit people who are unable to swallow, such as Alzheimer's patients, this platform is also thought to be a highly efficient way to deliver drugs because it keeps them from agglomerating. Clumping negates the advantage of nanoparticles, he notes, since the clumps behave as very large particles with a lower available surface area for adsorption. A significant amount ends up being excreted.

"Particle engineering allows for the proper dispersion of nanoparticles and therefore a higher utilization rate. This also means we can use a smaller amount of medication," Davé says. "And we don't need to use liquids or solvents or any other added ingredient to deliver these drugs, which, among other benefits, allows us to eliminate the pharmaceutical residue that is normally excreted as waste, contaminating the water supply."

He adds, "We're trying to push the limits of how much we can put on a tiny film so the system becomes useful for a larger variety of therapeutics, such as pain relief, while achieving a predictable performance."

Davé is currently the site-leader and one of the founders of the National Science Foundation (NSF)-funded Engineering Research Center on Structured Organic Particulate Systems, which focuses on manufacturing processes for the pharmaceutical industry. Collaborators include NJIT, Rutgers University, Purdue University and the University of Puerto Rico at Mayaguez. Last year, Davé received his ninth patent for coming up with a manufacturing process for coating fine particles less than the diameter of a human hair that does not require water, organic solvents or heat.

In 2015, Davé won a major career award from the American Institute of Chemical Engineers, the organization's Lectureship Award in Fluidization, for a process for agitating solids such as powders and particles in order to make them behave like liquids. By fluidizing particles, engineers are able to adapt their structure and behavior to improve products ranging from cement, to cookies, to fuel, to cancer medications, to sunscreen, while making it faster and more efficient to manufacture them.

Rajesh Davé

Srinivasan Shanmugam

Among other processing improvements, he has developed methods to mask the bitter tastes of drugs to make them more palatable for children, as well as for adult patients who have difficulty swallowing.

His colleague, **Xiaoyang Xu**, assistant professor of chemical engineering, designs therapeutic mechanisms that navigate the body by mimicking its environment, thus eluding the immune system's sometimes over-attentive sentinels, stopping at a precise location for a specified period, and then biodegrading. Xu's focus is nanomedicines, high-concentration therapies delivered in millions of tiny packets that coat their target. Antibiotics are a good example of this approach, he notes. Effectively delivered, an anti-infection agent should kill the disease before it has time to develop resistance.

Paulina Alvarez

Nurturing STEM Dreams With Real Science

MINA ARMANI (left) and PAUL ORBE spent years as industry scientists before deciding to become high school teachers, and they've both experienced first-hand the thrill of discovery in the lab. Now in the classroom, they know how generic experiments with predictable results can quickly quench that excitement for students.

So for the past couple of summers, they have spent six weeks doing pharmaceutical research with professors and graduate students in labs on campus, helping to advance the effectiveness of medications while also gathering material and lesson plans that will energize their high school classes in Union City. The program, the National Science Foundation's Research Experiences for Teachers, provides funding for about a dozen teachers to come to work in NJIT labs each summer.

Armani's goal, she says, is not just to invigorate her classes with current science and scientific methods, but to produce scientists. Outside of her chemistry, AP chemistry and organic chemistry classes, she is a coordinator for a summer research program that gives economically disadvantaged students opportunities to work alongside scientists on research projects.

In the lab, she and Orbe are helping to prepare fast-dissolving drug nanoparticles for testing. This past summer, they worked on drugs in the amorphous form, which dissolves faster than the crystalline version, enhancing the effectiveness of the drug.

Back at his high school, the Academy for Enrichment and Advancement, Orbe's students conducted a series of experiments in chemistry class this fall, producing crystals from different sources, comparing and contrasting their size and shape, and exploring the effects of concentration and solubility in the time required to form crystals.

"Lab experiments can seem abstract to students and hard to visualize, but so many people take medication at some point in their lives. We're bringing back hands-on science experiments with real applications that we can recreate in the classroom," says Orbe, a biochemist who teaches biology, honors-level chemistry and environmental science.

Developing Infrastructure to Last More Than a Century in a Changing World

For an enterprising civil engineer in search of a challenge, there is no shortage of opportunities in the 21st century. The severe demand placed on the country's infrastructure by booming urban populations, environmental conditions related to climate volatility and years of disinvestment, strains not only time and resources, but imagination and forecasting ability as well.

Indeed, rethinking the material building blocks of civilization — the asphalt, concrete and steel that compose roads, bridges and tunnels — now requires an added dimension: the ability to make durability projections not just for the standard 50 to 75 years of service life, but into a future in which climate change has made performance dynamic and unpredictable, notes **Matthew Adams**, assistant professor of civil engineering. Some larger projects, such as hydroelectric power dams or iconic bridges, are expected to last up to 150 years, despite growing uncertainty over what environmental conditions those years may bring.

Adams has joined forces with **Matthew Bandelt**, assistant professor of civil engineering, to attack the problem on two fronts. They are assessing the soundness of massive backlogs of infrastructure projects expeditiously through experimental testing across multiple scales, in combination with creating robust computational models to predict the durability of new construction materials under scenarios that vary widely in temperature, weather volatility, chemical applications such as de-icing salts and loading conditions.

They are currently taking part in a Federal Highway Administration research program designed to produce tools to conduct large-scale assessments of bridge infrastructure performance by analyzing data from a representative sample of highway bridges nationwide. The aim is to improve durability by using predictive and forecasting models on deterioration and maintenance that will optimize the management of bridges.

Their collaborators and lead investigators on the research project, dubbed the Long-term Bridge Performance Program, are asset management specialists at the Center for Advanced Infrastructure and Transportation at Rutgers University, who have been collecting data on corrosion from bridges across the country using non-destructive testing instruments that examine reinforcements and concrete.

"The goal is to better statistically model how bridges will behave based on observed chemical and mechanical loading," Bandelt says. "Most assessments done now are based on observation — it takes time to conduct scientific tests. We will evaluate their condition on a scale of one to 10 and then examine mechanical and chemical factors. Taking their environmental loading into account, we will measure how bridges have actually weathered as compared to predictions."

Adams will use this long-term performance data to determine how quickly various deterioration processes (corrosion, drying shrinkage, atmospheric carbon dioxide absorption, de-icing chemicals) and environmental loading (freeze-thaw cycles, temperature swings, proximity to salt water) affect the integrity of the bridges. Bandelt will use this information to create verified deterioration models for existing infrastructure that can then be applied to other systems across the country. "These models can also be linked to structural loading models to determine the impact of loads such as traffic on these systems as they deteriorate," he notes.

Outside of the bridge project, Adams and Bandelt are examining fundamental questions about infrastructure performance.

"How do we create infrastructure capable of surviving a

Matthew Bandelt (left)
Matthew Adams (right)

catastrophic event? How do we expeditiously replace it if it fails, and, more generally, how do we design and sustainably construct it with materials that are both cheaper and more durable?" Adams says. "Going forward, we can use computer models to see how stress builds up and materials deform as a result. This will let us design the appropriate materials for particular settings.

"The novelty here is our collaboration," he adds. "Historically, this work has been done in silos, but we're trying to link across scales to characterize and quantify distinctions between the impacts caused by environmental conditions and mechanical loading, for example."

Bandelt focuses on large-scale structures and component analysis, such as how building materials and structures respond to physical stress or "the damage a hurricane might cause." He is creating computational models to determine how structural components will behave under a variety of loading scenarios, while also trying to predict where they function best.

Adams looks at smaller-scale factors, such as the interactions over time of chemical systems in concrete and their impact on long-term durability and resiliency.

"I'll put samples through 300 freezing and thawing cycles in a matter of weeks," he says.

He looks at the use of new combinations of construction materials, including recycled concrete aggregates (RCA) functioning as the rocks in new concrete, and their impact on drying shrinkage, for example, which occurs when concrete loses water.

"Our results have shown that when you use RCA, systems can actually sustain higher levels of shrinkage prior to cracking. My hypothesis is that this is due to a deformation compatibility between the RCA and the new concrete. This means that we may actually be able to use RCA, a sustainable material, to create a more durable concrete. More generally, the new forms of fiber and recycled materials we put into concrete can affect both its internal chemistry and its physical structure and we need to know how it will perform," Adams says. "Matt Bandelt has the ability to model some of these dynamics in ways that we can't physically test, so that we can see how and when cracking occurs in different scenarios."

Adam Baba Abdulai (left), a master's student from Ghana, and Mandeep Pokhrel, a Ph.D. student from Nepal, both pursuing degrees in civil engineering, at work in the new materials lab.

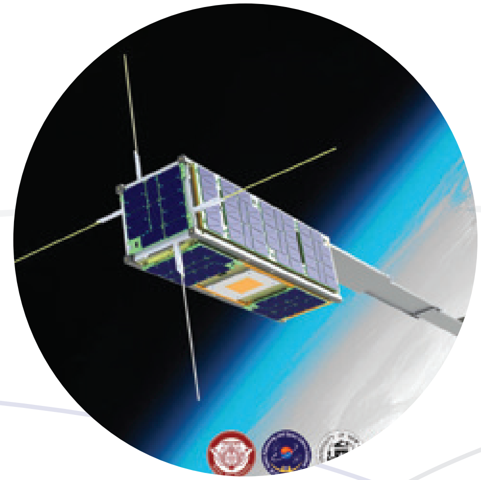
In their newly refurbished laboratory, Adams and Bandelt can simulate up to 50 years of wear-and-tear under various environmental conditions such as freezing and thawing or exposing concrete to dry conditions. They have also acquired a new Forney compression machine that exerts up to 700,000 pounds of pressure to test strength as well as to look at the chemistry of a system.

Beyond simple strength testing, the compressor is able to "squeeze the juice," as they describe pore solution, out of concrete samples. Using spectrometry, they can measure ionic activity, thus allowing them to track chemical changes in the system over time that result from their various conditioning methods.

"Making predictions when we don't know what climate or loading conditions the infrastructure will experience is difficult," Bandelt says. "However, because concrete is used all over the world, existing bridges, roads, tunnels and buildings comprise a very useful laboratory for letting us know how concrete will perform in all sorts of conditions. Combining this with information from climate- and traffic-prediction models developed by other scientists, we can begin to develop high-quality assumptions on what will happen to our new infrastructure."

Solar-Terrestrial Research

From the South Pole to the Magnetosphere, Shedding Light on Space Weather



With the launch this year of CubeSat SIGMA, a lunchbox-sized satellite that will orbit Earth in the ionosphere, NJIT's Center for Solar-Terrestrial Research (CSTR) will operate instruments in space and on the ground collecting data on solar radiation and space weather from every major region between our planet and its star. Riding aboard the newest CubeSat will be the university's "Minigate," a device that measures magnetic fields and their fluctuations, which allows scientists to better understand how energy is exchanged between the Earth's ionosphere and magnetosphere. Altogether, the instruments and observatories of CSTR are shedding light on the Sun's little understood physical processes, from the energy transfer occurring between convulsing layers below its surface, to the explosions that send radiation and charged particles hurtling into space, to the impact these massive energy bursts have on biological life and man-made infrastructure on Earth. As **Andrew Gerrard**, CSTR's director, puts it, "We are now able to explore the many roadways between the Sun and the Earth, and track solar events from their source to their final destination in Earth's atmosphere."

Big Bear Solar Observatory

The 1.6-meter New Solar Telescope at Big Bear Solar Observatory (BBSO) is penetrating deep below the Sun's corona to capture the first high-resolution images of phenomena such as the flaring magnetic structures known as solar flux ropes at their point of origin in the Sun's photosphere, or solar surface. These bundles of magnetic fields together rotate and twist around a common axis, driven by convection deep within the Sun. The new images offer powerful new clues about the initiation of flux ropes and other phenomena and their relationship to solar flares and coronal mass ejections, massive energy releases that occur when magnetic field lines with powerful underlying electric currents are twisted beyond a critical stress point. The point of eruption can now be seen — and measured — by the number of turns in the twist. "One of the exciting things about our new capability is that we can distinguish between mild twists and those severe enough to cause space weather," says **Haimin Wang**, distinguished professor of physics, who likens the eruptions to earthquakes, energy releases following the build-up of tension as tectonic plates rub against each other along fault lines. The BBSO team is now developing tools to predict space weather from solar observations and modeling.

Expanded Owens Valley Solar Array

One of the central mysteries of solar flares is the mechanism by which these massive explosions produce radiation and accelerate particles to nearly the speed of light within seconds. The most powerful blasts dispatch energized particles that can penetrate Earth's atmosphere within an hour, disrupting orbiting satellites and electronic communications on the ground. Optical telescopes yield insights by providing images taken from the visible part of the spectrum. Solar radio telescopes complement them by collecting critical data from radio wavelengths that allow physicists to determine more precisely when, where and how a flare originates, while also shedding light on parameters like magnetic field strength, temperature and the density of the flare region on the Sun. In a recent paper in Science magazine, NJIT solar physicists **Dale Gary** and **Bin Chen** were able to describe the formation, disruption and reformation of a termination shock — a powerful cascade of energy that occurs when high-speed jets expelled from the explosive energy-release site of a solar flare collide with stationary plasma below — and were also able to link it with particle acceleration. The university's recently completed Expanded Owens Valley Solar Array (EOVSA) will be able to capture tens of thousands of images per second through various frequencies, giving researchers information on solar dynamics that was previously untapped.

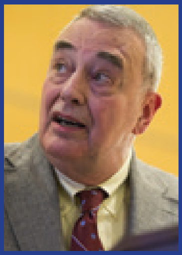
Antarctica/Polar Engineering Development Center

A team of NJIT engineers recently returned from their annual journey to Antarctica, where they repaired and modernized various solar instruments at South Pole Station, McMurdo Station and five automatic geophysical observatories located in the deep field across the Antarctic iceshelf. They are among the NJIT instruments spread across the world's southernmost continent, where Earth's magnetic field lines funnel solar radiation into the atmosphere; they include magnetometers, which capture fluctuations in the magnetic fields caused by solar wind, photometer systems that measure energy from the Aurora Australis, and riometers, which measure radiation absorbed by the atmosphere. "These instruments are important because they give us continuous data sets of the larger geospace environment, which you can't do in space because spacecraft are continuously orbiting," Gerrard notes. "Supplying continuous power year round that will persist through the dark months of winter is also no small feat and has inspired engineering innovations such as upgrades to wind turbines to operate at low temperatures and novel methods to service them remotely." Soon, Gerrard says, CSTR will install the first solar radio telescope at the South Pole. "We want to know how waves in the Sun's atmosphere heat the corona, which of those waves gets into the solar wind, and if and how those waves impact our near-space environment."

Van Allen Probes

Since 2012, NJIT research instruments housed on two spacecraft have been orbiting in the Earth's magnetosphere, exploring the composition of the Van Allen radiation belts — bands of highly charged particles that encircle the planet — and the mechanisms that energize and control the particles that form them, as well as the belts' response to the Sun's eruptions and to the ambient plasma wave environment. Among other discoveries, NJIT instruments detected an invisible force field located just below the Van Allen belts that is blocking high-energy "killer electrons" emitted by the Sun from damaging orbiting spacecraft and preventing dangerous radiation from reaching the planet's surface. The shield prevents the highly energized particles from penetrating below altitudes of 7,200 miles from Earth. NJIT scientists noticed the force field in data collected by an environmental-radiation monitor attached to their Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE) instrument, which coincided with separate observations by other solar physicists. Awarded a three-year extension, NJIT's Van Allen mission will now focus on injections of plasma, matter composed of positively charged ions and free electrons, into the magnetosphere, and particularly on the flow of these particles into and out of Earth's atmosphere.

Space Weather Pioneer



The specter of a geomagnetic solar storm with the ferocity to disrupt communications satellites, knock out GPS systems, shut down air travel and quench lights, computers and telephones in millions of homes for days, months or even years has yet to grip the public as a panic-inducing possibility.

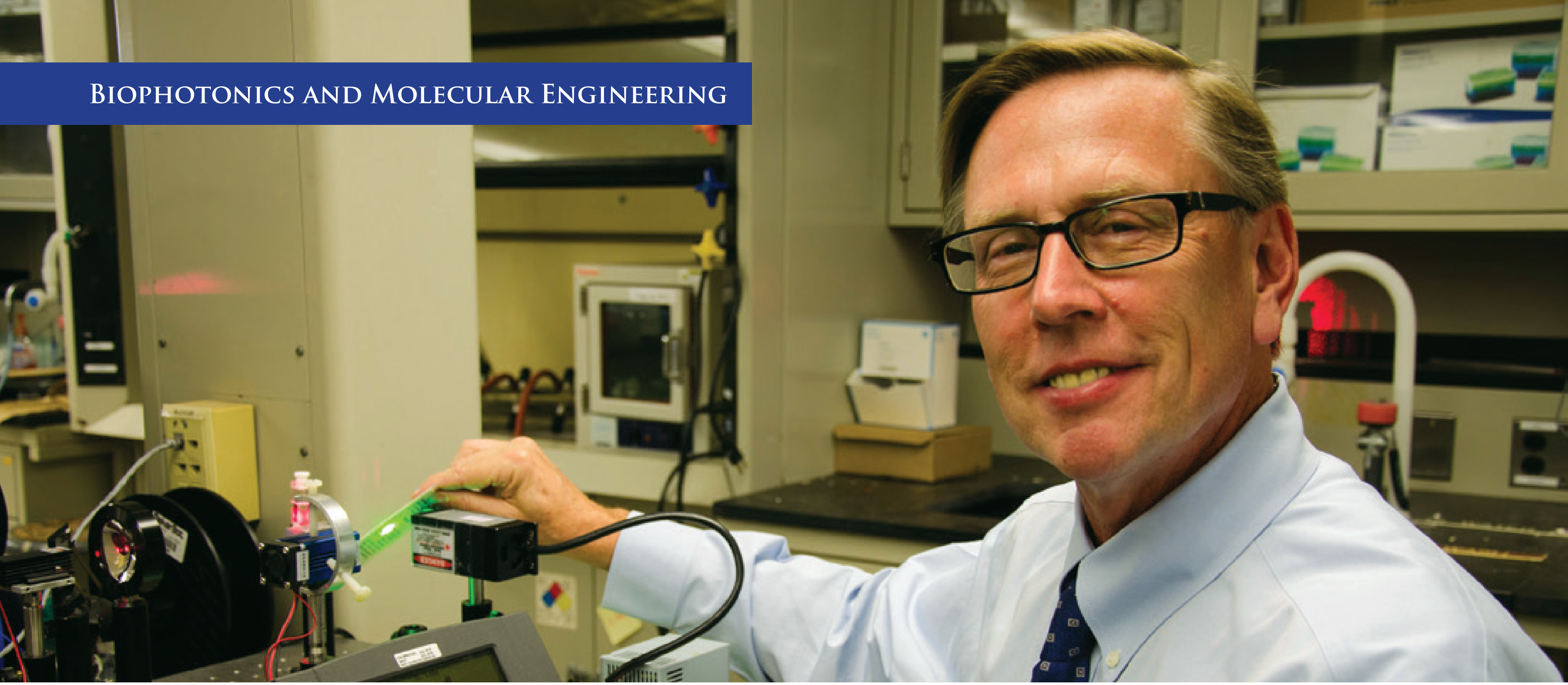
But it is a scenario that space scientists, global insurance corporations and government agencies from the U.S. Department of Homeland Security to NASA take seriously, calling it a "low probability but high-impact event" that merits a substantial push on several fronts: research, forecasting and mitigation strategy.

One of those scientists is LOUIS LANZEROTTI, distinguished research professor at NJIT's Center for Solar-Terrestrial Research, who is a pioneer in the field of solar storms and the founding editor of the American Geophysical Union's journal Space Weather: The International Journal of Research and Applications.

Lanzerotti, who got his start at Bell Labs in the mid-1960s preparing some of the country's first communication satellites for space travel, has been called upon twice recently to advise policymakers on the stakes of a crippling storm and on methods for mitigating the potential damage, including as a panelist at the conference "Space Weather: Understanding Potential Impacts and Building Resilience," convened in Washington, D.C. under the auspices of the Executive Office of the President of the United States.

"Since the development of the electrical telegraph in the 1840s, space weather processes have affected the design, implementation and operation of many engineered systems, at first on Earth and now in space," Lanzerotti says. "As the complexity of such systems increases, as new technologies are invented and deployed, and as humans have ventured beyond Earth's surface, both human-built systems and humans themselves become more susceptible to the effects of Earth's space environment."

While there is still much to be done, Lanzerotti applauds recent efforts to accelerate the pace of analyses and coverage of the measurements, data and models that will be required "to ensure security under space weather events of all types – from huge geomagnetic storm-produced telluric currents initiated by coronal mass ejections, to solar radio-produced outages of GPS receivers, to radiation effects by magnetosphere, solar and galactic radiation, to satellite drag effects from Earth's atmosphere and ionosphere."



Kevin Belfield

Detecting Early-Stage Disease With Molecular Tracking Probes

A sudden proliferation of new blood vessels inside the body can bode well or poorly for a patient. If recovering from a wound, the faster new networks form the better. But an unusual growth spurt can also signal the presence of an aggressive cancer.

Kevin Belfield, dean of the NJIT College of Science and Liberal Arts and professor of chemistry and environmental science, is developing minimally invasive methods to monitor both: the pace at which wounds heal and the effectiveness of therapies that inhibit the expansion of blood vessels that feed cancerous growth. His probes, which use molecular tracking devices, aim to improve targeting selectivity, homing in exclusively on new blood vessels to detect tumors or monitor wound-healing progression at a very early stage.

To heal, lesions depend on the formation of new blood vessels to deliver oxygen and nutrients that support cell growth and tissue regeneration. When the process is well regulated, scars and infections are less likely to occur.

Belfield uses two-photon fluorescence microscopy (2PFM) with fluorescent dyes, or probes, to image living tissue with unprecedented resolution at depths up to 2 millimeters in a variety of tissue types. The images, available in subcellular resolution in three dimensions, are captured by transmitting near-infrared light through the wound and, in the case of internal lesions, through an optical fiber. The fluorescent probes, which are injected into the bloodstream, include a biomarker-targeting peptide that binds with a specific protein associated with endothelial cells in new blood cells.

"What we're looking for is high levels of a particular integrin protein, integral to motility and adhesion, that is expressed at elevated levels in endothelial cells in new blood vessels," he says.

The images also provide qualitative information on the blood vessels themselves; chaotic vessel morphology is characteristic of tumors, for example, while vessels in healthy tissue and wounds that are healing are more orderly and symmetrical. Image analysis over time provides quantitative information on blood vessel density as a function of time, information that can be used to assess the success of growth factor, an agent designed to promote blood vessel growth.

"The ability to assess a lesion intact offers an advantage over conventional histological techniques in which the wound is biopsied and thin slices are analyzed," Belfield says, "because the gelatinous nature of wounds at early stages often results in soft, nascent tissue being removed, providing an incomplete picture of critical early stages of wound healing."

The aim of anti-angiogenic cancer therapies, which curb blood vessel expansion, is to starve a tumor. Without new blood vessels to feed them, they will only grow 1 to 2 millimeters in size before they run out of oxygen. Currently, anti-angiogenic agents are being explored in conjunction with other chemotherapy agents.

Belfield views 2PFM as a potentially powerful tool for the detection of early-stage cancers, including lung cancer, which is most often discovered when it is late-stage and incurable. He also views it as a possible improvement over mammography screenings, which are unable to detect tumors that are less than a centimeter in diameter, whereas 2PFM can image as little as 2 millimeters of muscle tissue or blood vasculature.

"Well over 50 percent of cancers are not detected until they are at stage three or four," he notes.

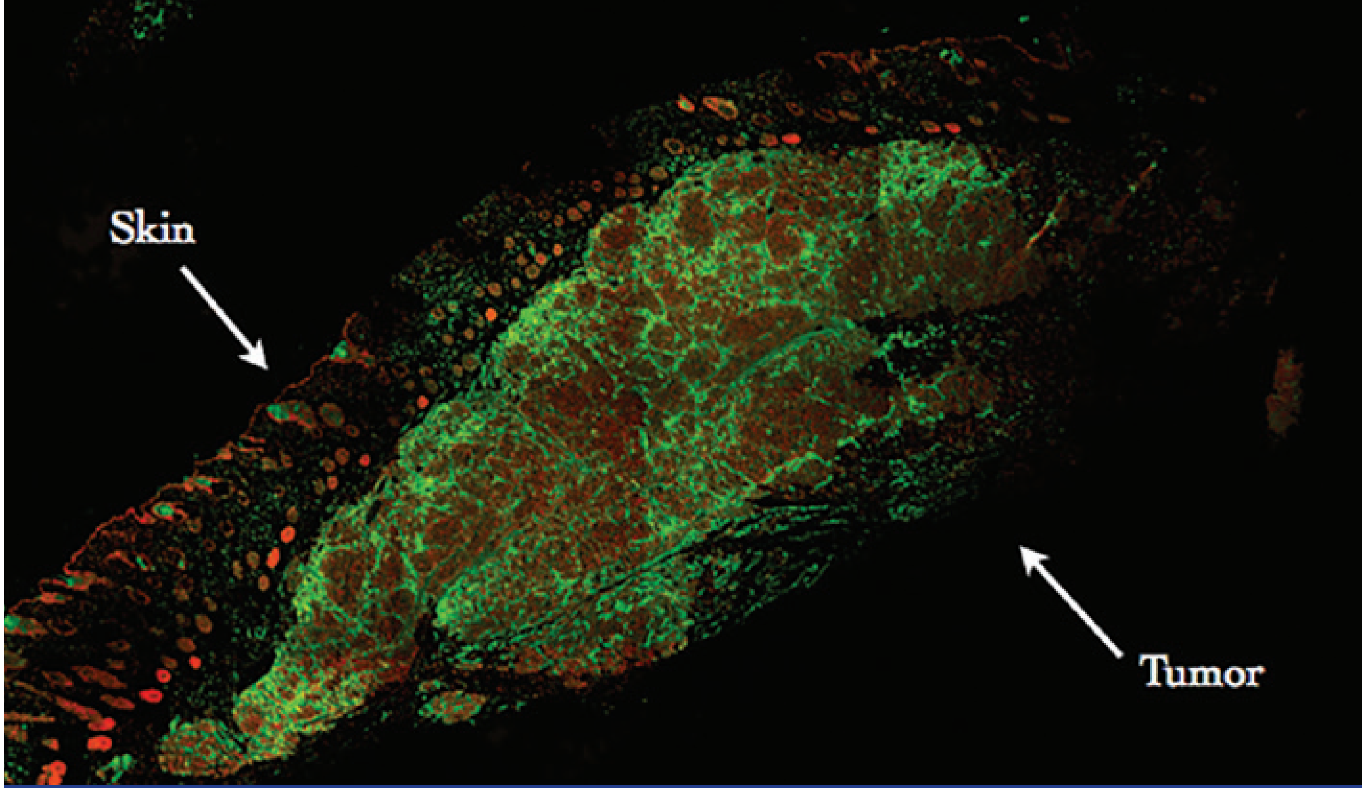
Belfield is collaborating with scientists at the University of Tampere in Finland on wound-healing angiogenesis and with researchers at the Sanford Burnham Prebys Medical Discovery Institute in Orlando on blood vessel growth in tumors.

He has studied other methods for treating cancers that involve the use of light, including the deployment of cell-killing agents whose toxic power can be controlled by light, which activates the release of an acid compound that creates a pH imbalance in the cancer cells. Localizing the cell toxicity to those regions where the light detects cancer limits the collateral damage, greatly reducing harmful side effects.

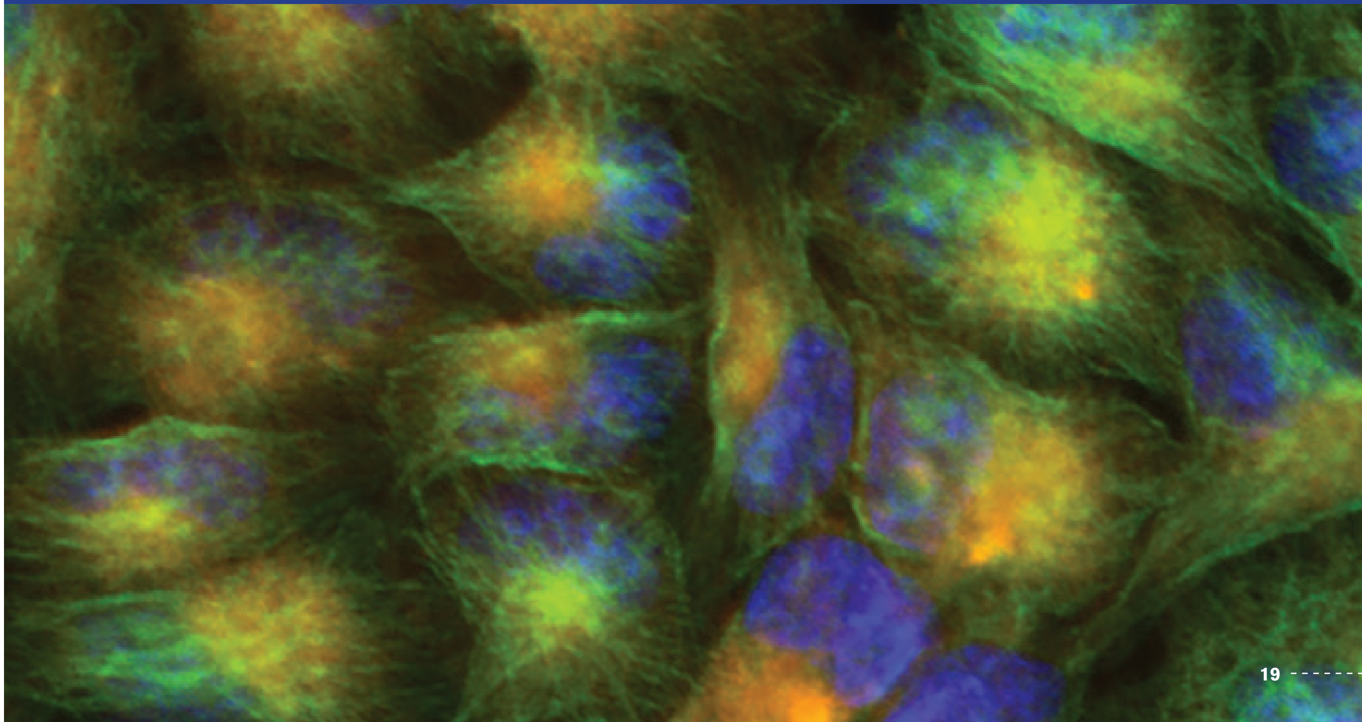
"We're targeting imaging agents to biomarkers as another platform for photoreactive therapies," he says. "This will combine both the ability to image the tumor and treat it through a light-activated agent. These advances — in our knowledge of how to target tumors and design imaging probes and photodynamic therapy agents — coincide with the push for precision medicine, which makes our work timely."

He added that researchers are also looking at 2PFM for use in endoscopy, colonoscopy and bronchoscopy.

"It's a way to gather critical information from any site in the body that can be reached by a thin, flexible optical fiber," he adds. "There are so many applications for this technology in neuroscience as well, including the detection of plaque build-up in the brain. In time, we will have a diverse palette of very useful probes."



ABOVE: The subcellular components of human colorectal cancer cells are distinguishable with differently colored fluorescent probes: the cell nucleus with a traditional DAPI stain (blue), mitochondria (red) and microtubules (yellow) with new fluorescent probes developed in Kevin Belfield's laboratory that allow enhanced time-lapse imaging. BELOW: Two-photon fluorescence imaging which provides a detailed picture of a tumor in a mouse can be employed to monitor morphological changes in the tumor as it grows or responds to cancer therapy.



Protecting Assets Proactively Through Real-Time Assessment

Kurt Rohloff (left)
Reza Curtmola (right)

Almost daily, there are reports of attacks on the security of the computing data and interconnected devices that make up the digital nervous system of our society, from the computers critical to the functioning of government and business, to information stored in the cloud, to cellphones more powerful than the systems that helped send Apollo astronauts to the moon.

NJIT's Cybersecurity Research Center was established in 2015 to develop cybersecurity technologies that will protect data from inception to end use, beginning with the production of software to manage it to its remote storage in the cloud.

Broadly, the center identifies systemic weaknesses that make cyber systems vulnerable to attack, designs systems to make them more secure and hardens cyber infrastructure that has already been deployed. More specifically, its researchers develop and apply new approaches to practical encryption, securing cloud-computing services, improving secure software development techniques, data encoding and communication protocols, and researching human factors relevant to cyber technology.

The center is currently working on methods to improve the security of the entire software supply chain.

"Modern software development has a number of stages involving multiple programmers who create several versions of a product during the development process. At any point in this process bad things can happen. Along the way, malicious code can be inserted, for example," says **Reza Curtmola**, co-director of the center and associate professor of computer science who focuses on applied cryptography, the security of cloud services, software security and privacy in computing.

Curtmola and colleagues are developing a framework for providing greater developmental transparency that has attracted several major open-source software organizations as potential early adopters. The idea is to collect metadata from the various stages of the software development chain and expose it to the end users.

"At present, end users have little idea as to how secure the product they have downloaded may be," Curtmola says. "Our goal is to give them a better end-to-end guarantee. Important considerations are knowing how many developers have been involved in reviewing the source code — and at what points, what tools were used for testing and what other organizations the supplier used in creating a product."

Key funders of their projects include the National Security Agency (NSA), the Defense Advanced Research Project Agency (DARPA), the National Science Foundation (NSF), and the Intelligence Advanced Research Projects Activity (IARPA) of the Office of the Director of National Intelligence.

Two projects in progress with DARPA funding involve securing intellectual property and protecting proprietary software.

The center's SafeWare initiative is focused on thwarting the reverse engineering of software that is used, for example, in a particular manufacturer's cellphones. At present, this is quite easy to do. This multi-year, multi-million-dollar project aims to produce obfuscation technology that would render the intellectual property in software — proprietary algorithms, for instance — incomprehensible to a reverse engineer, but allow the code to otherwise run normally. The SafeWare effort is tackling the main practical obstacles to implementing this technology so that software can run efficiently for users while remaining safe from reverse engineering.

Collaborations

To take on multi-angled technology problems, the center assembles teams of NJIT colleagues and experts from partner organizations, notes **Kurt Rohloff**, the center's co-director and associate professor of computer science at Ying Wu College of Computing who specializes in encrypted computing, distributed information management, high-assurance software and digital privacy.

Rohloff, who joined NJIT from Raytheon subsidiary BBN Technologies, where he was a senior scientist in the distributed computing group, draws on his defense industry contacts to foster the center's collaborations with academia, industry and government.

Collaborators include researchers at MIT, New York University, the University of California-San Diego, Raytheon BBN Technologies, Applied Communication Sciences, Lucent and SPAWAR Systems Center Pacific. The productivity of these partnerships is enhanced by the center's library of open-source code developed for encryption projects, established with the support of the university's administration.

"On campus, we are also fortunate to have a number of programmers with industry experience. We follow industry-standard software development practices with some of the best programmers in the world," Rohloff adds.

Science and Society

The mission of the Cybersecurity Research Center is social and educational, as well as technical. Developing new encryption technology is a major component of the center's work. "We're in the business of finding new and better ways to secure and share data," Rohloff notes. "We want to make the systems used by virtually every type of organization more secure, so that there is greater security for medical files, legal files, financial files — at lower cost for the hosting organization and ultimately its customers.

"But our work also raises questions about the critical balance between practical technical security and personal privacy. I think we also have to do what we can to make sure that policymakers in Trenton or Washington have a more nuanced understanding of the social issues involved, the tradeoffs between public security and privacy, and to help people in general understand those issues."

Recently, a device as seemingly innocuous as Amazon's Echo, the speaker and personal assistant that communicates with Amazon servers, ignited legal debate about privacy when police in Arkansas asked Amazon to release a recording that may have been inadvertently made and stored during a crime. In the 21st century, even digital novelties such as Echo add to the critical mass of cybersecurity and privacy issues that reverberate far beyond a request for a favorite song.

Cybersecurity Education


Vincent Oria

There will be no quantum leap in data protection without a critical mass of highly trained programmers, engineers and technology developers steeped in the field. With that concern in mind, the National Science Foundation last year awarded NJIT's Ying Wu College of Computing a $4 million CyberCorps®: Scholarship for Service grant to expand the pipeline of cyber professionals.

The grant backs the university's Secure Computing Initiative (SCI), a program that provides three-year scholarships to NJIT students and others that support them through the last year of a bachelor's program, followed by two years in one of the two master's programs in cybersecurity available at NJIT, Cybersecurity and Privacy and Information Technology Administration and Security. The university currently offers more than 40 courses that focus on cybersecurity or include it as a significant component.

U.S. Senator Cory Booker called the initiative "an important step to help develop the technologies needed to protect our nation's cyber infrastructure."

Slated to run for five years, SCI also includes outreach activities, such as enrichment programs for high school students, and provides college students across the country opportunities for training via online courses and mentoring, flexible curricula and other means.

"We'll expose students to the latest technologies and advances in the field of cybersecurity," said VINCENT ORIA, professor of computer science and the principal investigator for the grant.

NJIT was also recently recertified as a Center of Academic Excellence in Cyber Defense Education by the National Security Agency and Department of Homeland Security, and houses New Jersey's Homeland Security Technology Systems Center.

Revealing Patterns of Human Behavior to Aid Business Decisions

Today's business executives, policymakers, researchers and consumers operate in an environment that is not only infused by information gleaned from big data, but increasingly directed by it. As decision makers turn to big data analytics tools to shape and support their initiatives, companies rely on it to hone and optimize their operations and shoppers to guide purchasing decisions.

Martin Tuchman School of Management (MTSM) has aligned itself accordingly with several initiatives to support big data research, something of a new direction for the school. Just this past fall semester, MTSM opened two new labs — the Ray Cassetta Financial Analysis Laboratory and the Business Analytics Laboratory — and launched a Ph.D. program in business data science that is one of the first in the country to integrate business analytics and management-systems theory with statistics, computing science and engineering.

To advance these programs, MTSM has brought two new investigators into the fold: Associate Professors **Dantong Yu** and **Maggie Cheng**. Both are computer scientists with extensive experience in big data with applications in industry, scientific research and health care.

Cheng, who comes from Missouri University of Science and Technology, has been involved with two National Science Foundation-funded projects that use data analytics — one to develop algorithms to detect and diagnose in real time disruptions in electric power systems caused by outages and line-tripping, and the other to examine and predict the cyber behavior of individual users.

The algorithms she has developed for power systems "can also, with minor modification and extension, be applied to business," says Cheng, noting that her contribution to MTSM's big data effort lies in "the integration of foundational research with the development of practical tools and software platforms" necessary to collaborate with colleagues who provide domain expertise for real-world business problems.

She is currently working with two Ph.D. students on methods for detecting fraud in the credit card and health insurance businesses, such as stolen cards and forged prescriptions. Changes that deviate from a customer's habitual usage patterns can be detected with what is known as the change-point detection method, triggering further investigation. While some large organizations currently use anomaly-detection technology, there is still room for improvement on speed and accuracy. She is looking into effective real-time methods to alert the system as the first step, and down the road to develop means to distinguish between true fraud and false alerts.

Yu previously led the computer science group at Brookhaven National Laboratory's (BNL) Computer Science Center, where he developed both novel data-mining algorithms that detect hidden interactions, patterns and anomalies in complex systems from the climate to genetics, as well as ultra-fast cloud-based data-transfer software. At NJIT, he is working on another BNL research award that deals with high-performance data sharing. In his research, he uses manifold-based spectral data analysis to detect anomalies and then taps his domain expertise to interpret them.

"I use deep-learning tools to discover patterns and classify digital images in the same way as domain experts," says Yu, "I use this knowledge to guide and steer scientific experiments."

For MTSM, he will study time-sequence data related to the stock market and consumer sentiment. Temporal data is "powerful on the science side, but also on the business side," Yu comments, noting that it can be used as a tool to predict financial bubbles and market volatility.

The key to their success will be accessing sufficient data. The new Ray Cassetta lab will play an integral role in providing rich data, including temporal information about stock options information streaming in through the lab's Bloomberg terminals.

Yu and Cheng both take an interdisciplinary approach to their research. He is on a team of physicists, experimentalists and computer scientists automating data processing and analysis with machine learning. She is the lead investigator on a team of mathematicians, engineers and computer scientists in her power-system research.

Learning about how other investigators view the world and gaining cross-disciplinary knowledge is vital to successful research, shares Yu. "Then you can actually solve a problem and define, understand and appreciate the results."

Diverse Domains

CHASE Q. WU (left), associate professor of computer science and co-director of NJIT's Center for Big Data, is working with colleagues across disciplines to build a unified platform with a rich set of big data-enabling technologies and services to advance collaboration and scientific discovery in a number of domains, from financial analytics, to life sciences, to homeland security.

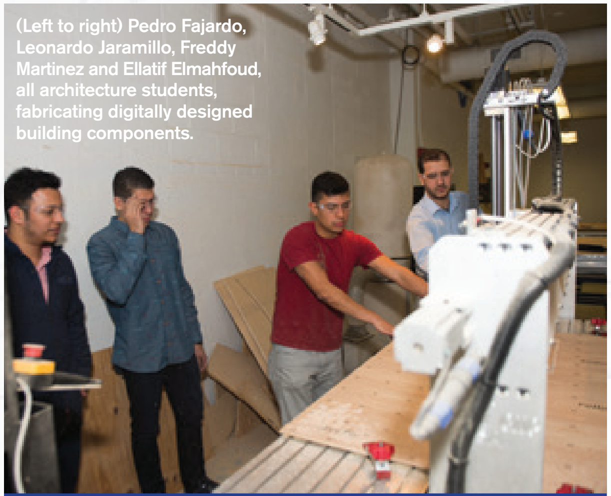
In collaboration with Oak Ridge National Laboratory and Argonne National Laboratory, Wu heads a high-performance networking project to develop fast and reliable data transfer methods to help diverse users move big data over long distances for collaborative data analytics. More specifically, he is also leading a U.S. Department of Homeland Security project in collaboration with partners at Oak Ridge to design network algorithms to quickly and accurately detect and localize low-level radiation sources based on a large volume of sensor readings.

"Our aim is to develop big data services that will be broadly applicable and we will work closely with a range of scientists to exploit them," says Wu. "For example, we developed a platform for analyzing user-contributed social media data to identify adverse drug effects, a leading cause of death. In an entirely separate area, we are also developing data-driven methods to analyze web-page browsing to better understand user needs as well as the revenue models that sustain the free web."

In a separate project backed by the National Science Foundation, Wu is developing processes to optimize the performance of large-scale scientific workflows in heterogeneous computing environments. His research is focused on developing cost-effective techniques to improve the execution and energy efficiency of big data workflows comprised of MapReduce and Spark programs in Hadoop ecosystems using virtualized resources in the cloud. These techniques have the potential to "shorten the computation-computing cycle," he says, in extreme-scale e-sciences such as climate modeling and supernova simulations that generate, process and visualize big data in scientific domains.

YI CHEN, associate professor of management and the center's other co-director, researches a number of information discovery technologies, from social computing to workflow management and information integration, with applications in business, the web and health care domains. Their colleague ZHI WEI, associate professor of computer science, specializes in bioinformatics and computational genetics.

Designing and Fabricating a House in the Cloud



(Left to right) Pedro Fajardo, Leonardo Jaramillo, Freddy Martinez and Ellatif Elmahfoud, all architecture students, fabricating digitally designed building components.

Maria Silva

Through digital technology and manufacturing efficiencies employed by sectors such as the aerospace and automotive industries, **Adam Modesitt**, assistant professor of architecture, is bringing new direct-to-fabrication, advanced process integration and customizable workflow capabilities to NJIT's College of Architecture and Design.

In an earlier stint as a project director at SHoP Architects, prior to founding his own New York firm, MORE, Modesitt led large-scale projects ranging from the redesign of LaGuardia Airport to the development of a master plan for Konza City, Kenya, a planned municipality outside of Nairobi designed as a sustainable city, technology hub and economic driver for the country. He also led the design, implementation and fabrication of the weathered steel panels that form the façade of the Barclays Center Arena.

Through the Dassault Systèmes "3dExperience" platform, donated to the department shortly after he arrived at NJIT last fall, he has wasted little time immersing his classes in these new design, workflow and fabrication models.

In a future-focused, transpacific partnership, a team of his students designed a multi-generational Chinese house, marrying ancient cultural traditions with 21st-century technology, to be digitally fabricated and constructed by collaborators nearly 7,000 miles away in Dezhou, China.

The 35-member, discipline-spanning crew of architecture, interior design, industrial design, graphic design, civil engineering, environmental studies, sustainability, concrete industry management and business majors works remotely with a group of engineers at Fujian University of Technology who are competing in the 2017 Solar Decathlon China.

Following a visit last summer by five undergraduate architecture and industrial design students to Dezhou, dubbed China's "sun city" for its growing solar industry cluster, the team members say they wrestled with three core challenges: how to incorporate not just energy efficiency, but also "the entire life cycle of sustainability that anticipates the next technological innovations" into the design; how to develop a process that is both replicable and adaptable, "thus commercially viable"; and, critically, how to "make a house feel like a home by engaging culture and history."

What they came up with is D.O.T.T.I.E. (digitally operated tectonic integrated environment), a single-family sustainable house that integrates the digital and the analog, local traditions and global considerations. The designers and engineers from the U.S. and China worked together in real time in a cloud-based design environment. Their Chinese partners will enter the house in the July decathlon, launched by China's National Energy Administration and the U.S. Department of Energy.

Each design must follow basic rules. It must be a two-story, solar-powered house with a ground area of 120 to 200 square meters. Every house must be equipped with all of the necessary household appliances, such as a television, refrigerator, cooktop, dishwasher, dryer and computer, and provide a household electric vehicle as well as its matched charging device.

Judges at the decathlon — China's second — will evaluate the entries on the basis of cost feasibility, power efficiency, generation capacity and environmental adaptability, among other considerations. Architecture, market appeal, engineering, communications, innovation, and quality of home life are among the 10 specific contest categories.

"The main goal for our design was to explore how four generations could live and coexist harmoniously together," says **Kimberley Gokberk**, a fifth-year architecture student. "The layout is based on traditional Chinese dwellings with a modern approach. The central, double-height space in the house acts as a meeting place. A 'memory wall' that is directly connected to the central space displays cherished objects that symbolize the harmony between the generations."

After settling on a design, the team sketched every detail of the house numerous times to create a workflow that would allow them to develop it in the most logical way. Conceived in terms of components, with rules and information about fabrication and construction incrementally embedded in the digital model, D.O.T.T.I.E. is both designed and constructed entirely in a cloud-hosted virtual environment. The process permits the design to adapt to new information as it is introduced.

The team implemented and managed the project through the platform donated by Dassault, one of the largest computer-aided design and 3D digital mock-up companies in the world. The system allows them to integrate sustainability and energy-usage performance parameters into the digital model, with the goal of measuring in real time performance factors such as the amount of energy consumed in production to thermal issues. They are able to simulate and evaluate structure, assembly time, fabrication and material waste, among other aspects of design, as they move forward.

To test the system, they first built a 10 ft. by 5 ft. by 5 ft. structure with whimsical geometric shapes dubbed the "Folly," made of traditional Japanese building material, Shou-Sugi-Ban ("charred wood"), donated by a Pennsylvania manufacturer, reSAWN Timber Co. Using robotics, they were able to digitally simulate and fabricate complex geometries unachievable by other means.

The students say their goals for the project extend beyond the creation of the end-product — a highly efficient and innovative "machine for living" to hand over to the Chinese team — as they will also measure their own success in creating an innovative, replicable process that relies on component modularity and digital fabrication. D.O.T.T.I.E. aspires, they say, to a highly scalable workflow that can be easily ramped up for larger production with many possible variations in its design and systems.

In the first week of April, Modesitt and architecture student **Elmahfoud Ellatif**, will travel to Milan to take part in Dassault's "DESIGN In the Age of Experience" conference to test a new software prototype.

"It's a hackathon of sorts in which we'll be trying out the company's next-generation of design-to-fabrication software alongside architecture firms such as SHoP, London-based Zaha Hadid Architects and Kengo Kuma, Japan," he says, adding, "We'll all be designing buildings or building components at the conference. It will be exciting for El and me to see this software used by a range of architects, urban planners and technologists in new and exciting ways, and to bring our experience back to the studio."

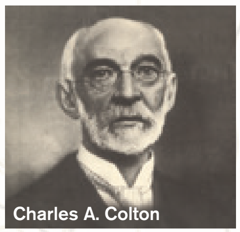
Ellatif, who worked on the fabrication of the Folly, says he began in the architecture program "focused on traditional architecture."

"But over time, I've become really interested in dynamic design models and new directions in pre-fabrication," he notes. "I especially like the way software allows you to build more efficiently. There are no limits to what you can design if you proceed in a logical way."

The "Folly," a 10 ft. by 5 ft. by 5 ft. structure designed by a team of students, that was digitally simulated and fabricated using robotics.

Our Roots in the Golden Age of Manufacturing Innovation

In 1881, the city of Newark was a hotbed of manufacturing innovation. Home to an exceptionally wide range of industries, from the producers of steam engines, to clocks, to chemicals, local entrepreneurs also created the first malleable iron and patent leather. There were nearly 30 companies fabricating products for the new age of electricity in the immediate orbit of Thomas Edison's laboratory and workshop on Ward Street. In one year alone in the prior decade, more than a hundred patents were issued to people either living or doing business in Newark.


Charles A. Colton

It was an ideal setting for a technical school. And so that same year, **Charles A. Colton**, prompted by regional business and political leaders eager to accelerate the pace of prosperity, welcomed 88 students to pursue courses in "Science, Mathematics and Drawing" tuition-free at the newly founded Newark Technical School. Such institutions, Colton opined, were "the outgrowth of the demands of an advanced civilization, valuable in proportion to the degree to which the graduates are able to apply their instruction to useful ends."

More than a century, numerous inventions and two names later, New Jersey Institute of Technology still enthusiastically embraces that mission.

"Even though we didn't begin to speak of ourselves as a research university until much later, our earliest predecessor, Newark Technical School, was created to support industrial innovation — and you cannot separate innovation from research," says Provost and Senior Executive Vice President **Fadi Deek**.

"From the beginning, our programs have been translational," notes **Atam Dhawan**, vice provost for research and development and distinguished professor. "The expectation has always been that our graduates would be skilled in bridging the experience of research on campus with practical applications that represent the 'next best step' in many fields after graduation and that benefit society."


Eberhardt Hall

Today, NJIT research is concentrated primarily in four areas: data science and information technology, the nexus of life sciences and engineering, sustainable systems, and a transdisciplinary category that addresses the large systemwide challenges of "smart cities" and other complex organizations. While the university's research in these fields seeks to address present and emerging societal needs, it is directly linked to priorities established decades ago.

THE NEW JERSEY KNEE

In the late 1970s, an orthopedic breakthrough offered relief from pain and mobility problems — the New Jersey Low Contact Stress, Total Knee Replacement System, more widely known as the "New Jersey Knee." Co-developers of this pioneering joint replacement were **Michael J. Pappas**, NJIT professor of mechanical engineering, and **Frederick F. Buechel**, professor of orthopedic surgery at the University of Medicine and Dentistry of New Jersey. In 2001, the Department of Biomedical Engineering was established within Newark College of Engineering (NCE) as the new focal point for research such as that pursued by Pappas and his colleagues. Today, the university's biomedical engineers are working on devices such as robotic exoskeletons, cardiac devices and prosthetics which they will showcase this spring at the annual Northeast Bioengineering Conference, hosted by NJIT.

The 'Lively Great-Great-Grandmother of All Virtual Communities'

Beginning in the 1970s, digital capability fundamental to the internet as we know it today was also created at NJIT with funding from the National Science Foundation. **Starr Roxanne Hiltz** and **Murray Turoff**, subsequently emeritus distinguished professors of information systems, developed the Electronic Information Exchange System (EIES), the first computer-mediated communications technology for distance learning, conferencing and cooperative research. Hiltz and Turoff pursued this work as members of the nascent Department of Computer Information and Science — then part of the "Third College," which was later named the College of Science and Liberal Arts. A new generation of NJIT researchers now specializes in developing novel methods for mining digital data important to sectors ranging from business and finance to health care, while others are working on methods to protect information in this dynamic environment.

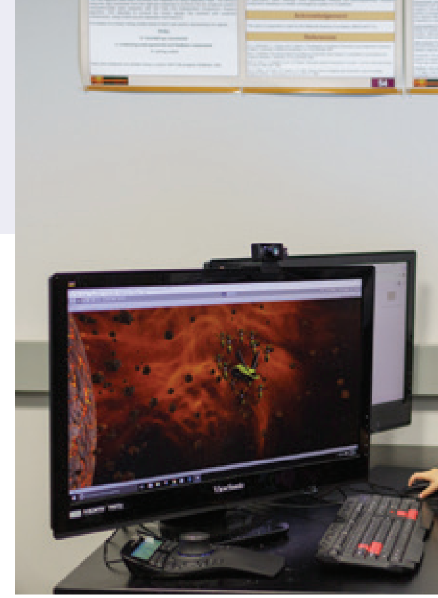
Delivering Pure Water Amid Dire Shortages

The world is beset by an increasingly dire shortage of pure water, and for several decades researchers at NJIT have been working to improve technologies to meet this challenge, including through innovations in membrane separation. Not only an economical and efficient method for the desalination of seawater, membrane technology is also integral to many other processes: producing the pure water required by many industries for high-tech manufacturing and helping people contend with kidney disease through hemodialysis. Recently, **Kamalesh Sirkar**, distinguished professor of chemical engineering, was named a fellow of the National Academy of Inventors for his innovations in industrial membrane technology used to separate and purify air, water and waste streams and to improve the quality of manufactured products such as pharmaceuticals, solvents and nanoparticles. The previous year, **Somenath Mitra**, distinguished professor of chemistry and environmental science and also an academy fellow, was awarded a patent for his carbon nanotube-immobilized membrane, a water desalination and purification technology that uses uniquely absorbent carbon nanotubes to remove salt and pollutants from brackish water and industrial effluent for reuse by businesses and households.

Interdisciplinary Research Is the Future

A $300 million capital campaign, currently underway, is transforming research on campus. Key to this initiative is the construction of a new life sciences and engineering building that will promote collaboration and convergence within fields ranging from biomedical engineering and the biological sciences to electrical engineering and health care technologies. With a particular focus on biotechnology, biosensors and medical devices and nanotechnology, the long-term goal is to come up with new applications in clinical health care, therapeutic interventions and pharmaceutical drug development. Some specific research areas include: cellular and tissue engineering-based regenerative medicine aimed at repairing traumatic injuries to the brain and spinal cord; combining nanoscale electronics, biologics, bioengineering and high-speed computation to develop biologically-powered devices capable of running pacemakers; and nanotechnology-based probes to detect and monitor cellular-level abnormalities, identify biomarkers of disease, and develop point-of-care devices that will help people recognize early symptoms and optimize their therapy.

Central King Building



For Student Researchers, the Sky Is Not the Limit

MAKING EYE THERAPY FUN

A student-designed 3D-gaming device that immerses players in contests against ogres, aliens and menacing spiders to correct a vision disorder that causes blurriness and headaches has caught the attention of prominent eye therapists around the country who are now testing it in clinical settings, beginning at The Children's Hospital of Philadelphia.

What has everyone excited is the device's potential to transform therapy by allowing people to improve their vision on a computer or television screen at home. Designed by **Robert Gioia '17**, a video game designer, and **John Vito D'Antonio-Bertagnolli '16**, a biomedical engineer, the game is played by the eyes, while a hidden camera records and measures their movements.

The project began taking shape several years ago when **Tara Alvarez**, a biomedical engineering professor who studies convergence — coordination between the eyes as they turn inward to focus on a near object — became interested in people whose eyes wouldn't cooperate. Because each of their eyes sees the image separately, they experience double and blurred vision and have difficulty concentrating, a disorder known as convergence insufficiency that saps attention and, ultimately, learning capacity.

To measure it, she first adapted a haploscope, a multi-part instrument that uses mirrors to send each of the eyes an image separately to see how well they converge — meet by crossing — to see a single image. Occupying much of a room, it succeeded as a diagnostic device, but was too large and immobile and the exercises too monotonous to replicate at home. She says she chose the Oculus Rift, a virtual reality headset she learned about from students, as an ideal technology to replace it, adding, "Then I was in search of a team to run with it."

D'Antonio-Bertagnolli sums up the problem succinctly. "The eye-tracking device we had was the size of a dorm room, but we needed it to fit in a hand," he recalls. "We estimated it would cost $10,000 to shrink it and we decided to do it ourselves, aiming to spend less than $500." He and Gioia then applied for — and won — a grant for that sum from the IEEE program, Engineering Projects in Communities (EPIC), to radically redesign it.

"The core requirement was that an object move toward the person playing. To succeed at zapping it, they need to stare at it, converging their eyes correctly. But it also had to be entertaining or people won't use it," Gioia recounts. "So John and I put our heads together and came up with the idea of classic arcade games like Galaga, a two-dimensional shooter game." He has since created several versions to appeal to different tastes, from air hockey, to attacking zombie hordes, to a firefly "catch-and-release" game for the youngest players.

D'Antonio-Bertagnolli, now a master's student at NJIT, designed the hardware and the eye-tracking algorithm and the team is also building a database that captures eye movements as well as the amount of time played. To their delight, the device continues to find backers. The students won a National Science Foundation I-Corps grant through NJIT that got them out of the office talking to potential customers and toy businesses, and last fall Alvarez secured $50,000 in development capital from the New Jersey Health Foundation.

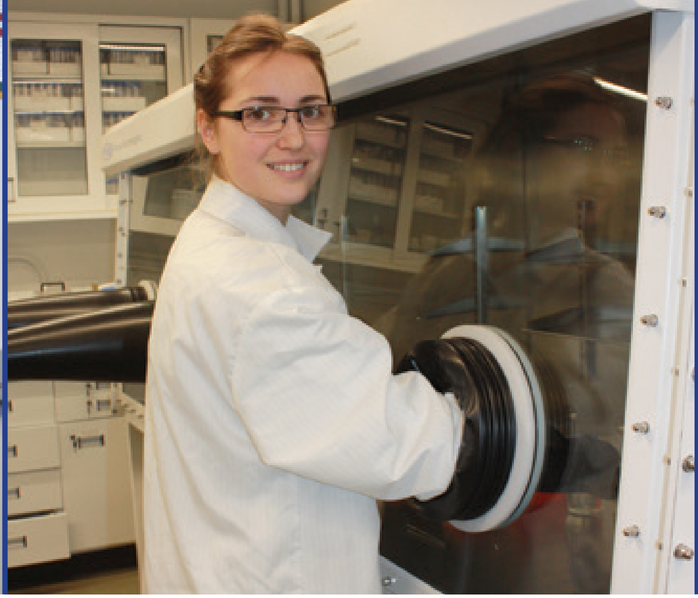
'LAB-ON-A-CHIP' AIMS FOR SPEEDY, ACCURATE PATHOGEN DETECTION

Conventional methods for pathogen detection are time-consuming and expensive and require well-equipped laboratories with trained personnel. In health care settings with limited resources, specimens must be transported for testing, which can delay the identification of transmissible diseases and their containment.

With these constraints in mind, **Natalija Tasovac**, an NJIT junior and chemical engineering major, has been developing a portable "lab-on-a-chip" device to provide rapid and cost-effective pathogen detection that does not require experienced medical workers or transport for utilization.

Tasovac's three-tier device incorporates an interdigitated gold electrode — a conductive component — on top, microscope slides on the bottom, and a gold-coated polycarbonate membrane in the middle. The design allows the user to collect a large number of antibodies on the membrane's

Robert Gioia



Natalija Tasovac

Chrystoff Camacho and Abbas Taiyebi

surface and then inspect the device using electrochemical impedance spectroscopy (EIS), a technique that measures electrical changes resulting from chemical reactions, and an optical microscope.

"The gold membrane is especially important because it can be easily functionalized, meaning we can increase its ability to bind to other molecules, in this case antibodies," says Tasovac, who has been working with **Sagnik Basuray**, assistant professor of chemical, biological and pharmaceutical engineering and lab-on-chip specialist, on the design. "Having more antibodies attached to the membrane's surface will increase the amount of target pathogen finally detected."

In her research, Tasovac uses EIS to determine the concentration level of the target pathogen. "Different concentrations of the target pathogen generate different signals. Thus, based on the signal obtained, we can accurately determine the concentration levels of our reactants."

The pathogens are identified optically, using a modified enzyme-linked immunosorbent assay (ELISA), a test that records the final stage of the chemical reaction. While ELISA is safer to use than conventional immunoassays, which sometimes depend on radioactive substances, its reliance on enzymes curtails antibody activity. To overcome this and other challenges associated with ELISA, including the need for large sample volumes, Tasovac has modified surfaces in the device to reduce the chances of contamination.

She notes, "With these modifications, we hope to extract equally reliable information from smaller samples or, in other words, have a highly sensitive device."

Taking to the Skies to Replenish the Earth

Few landscapes speak more hauntingly of environmental distress than bleak expanses stripped of trees. Felled for farming, fuel and export, their depletion leaves the land prey to topsoil erosion and moisture loss. In the most extreme cases, they become virtual deserts.

Chrystoff Camacho '17, an engineering technology major, would like to reforest the world's barren acres in a hail of rejuvenating missiles. His biodegradable capsules, containing packets of seeds and mineral-rich soil, would be dropped by planes and drones, perforating the flat, dry ground where they land so it retains water to nurture the seedlings.

The Aerial Reforestation Capsule (ARC) won him and his all-student team – three engineers from NJIT and two business majors from Rutgers University-Newark – a spot last year in both regional and national CleanTech University Prize competitions sponsored by the U.S. Department of Energy.

Matthew Mann '17, a mechanical engineering major, has been tinkering with the capsules' design, varying their weight to optimize velocity, as he projects their path and impact in different geographical locations. They will range in size from 5.5 inches to less than an inch, depending on where and how they are dropped. The larger capsules will be deployed by airplane and the smaller by drone.

"We're looking at penetrating two different types of soil, including clay silts and grainier turf with debris," he notes. Having purchased an octocopter drone at the end of the summer to test it, the team is making modifications to perfect precision planting. **Abbas Taiyebi '17**, a biology major, is working in the lab on the growth medium, including soil mixes.

The Rutgers students — junior **Alec Ratyosyan** and junior **Kira Antoine** — bring expertise in marketing and corporate responsibility/social impact, respectively.

Camacho's start-up, ParaTrees: Technology by Nature, received a National Science Foundation I-Corps grant for $3,000 to further develop the prototype and to seek out advice and customers through regional business accelerators. It has also caught the attention of tech entrepreneurs, prompting a $30,000 infusion from an angel investor to develop a drone platform and business structure.

"I come from the tech side of things and business was foreign to me at first. I realized that if I were serious, I couldn't do this by myself. And when it comes to engineering applications, it's important to have multiple minds," Camacho says, adding that he is also now thinking about community development and land stewardship as part of what he calls a "post-care" phase after the plants reach maturity.

New Faculty

In its mission to translate scientific discovery into beneficial applications and devices to meet pressing needs, NJIT focuses on four areas of multidisciplinary research that represent the university's core strengths: data science and information technology, the nexus of life sciences and engineering, sustainable systems, and a transdisciplinary category that addresses the large systemwide challenges of "smart cities" and other complex organizations. To make good on this promise, the university's strategic plan, *2020 Vision*, calls for a multiyear hiring effort that will expand the faculty from 280 in 2014 to 345 by 2020. Here are the most recent additions:

College of Architecture and Design

Adam Modesitt, assistant professor of architecture and design, brings direct-to-fabrication, advanced-process integration and customizable workflow capabilities to the field of architecture through digital technology and efficiencies gleaned by sectors such as the aerospace and automotive industries.

Mathew Schwartz, assistant professor of art and design, bridges science and engineering with art and design, making use of robotics and motion-capture technology to mimic human characteristics he then incorporates into commercial applications, architecture and models for scientific research.

Gernot Riether, associate professor of architecture and design, explores the relationship between public spaces and information technology. He develops novel spaces that invite people to interact with cities in new ways, such as digitally created surfaces to display interactive art projects and sculptural urban furniture.

Martin Tuchman School of Management

Dantong Yu, associate professor of management, works on machine learning, data mining, high-speed networking and high-performance data storage. He hunts for hidden interactions, patterns and anomalies in complex systems, providing biologists, for example, a more precise understanding of gene interactions.

Maggie Cheng, associate professor of management, develops data-analytics algorithms for complex systems such as the internet, the electrical grid and social networks. She seeks to detect and diagnose anomalies in the power grid in real time, for example, such as weather-related power outages.

Ying Wu College of Computing

Hai Nhat Phan, assistant professor of information systems, focuses on data science, machine learning, and privacy and security, especially for health informatics and social network analysis. His neural network-based human behavior models predict whether individuals will engage in physical exercise and social activities.

Senjuti Basu Roy, assistant professor of computer science, works on big data management of structured and unstructured data with a focus on exploration, analytics and algorithms with applications in social networks, health care and crowdsourcing.

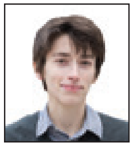
Qiang Tang, assistant professor of computer science, develops new standards for so-called "post-Snowden era" cryptography, which assumes that networks may be subverted by hardware and software providers. He works to secure information through the use of cryptographic techniques to discourage data sharing, among others.

College of Science and Liberal Arts

Yixin Fang, assistant professor of mathematical sciences, develops methods for extracting health information such as disease patterns, risk factors and the effectiveness of behavioral interventions from large medical data sets.

Yong Yan, assistant professor of chemistry, pursues chemical approaches to produce sustainable and renewable fuels, with a particular emphasis on the design and development of inorganic catalysts, photoelectrocatalysts and other strategies to convert carbon dioxide into fuels such as methanol.

Yuanwei Zhang, assistant professor of chemistry, focuses on organic chemistry and nanotechnology, with an emphasis on biological and biomedical applications such as disease diagnosis, drug delivery and therapies that use light, as one example, to activate inert immune cells to attack cancer cells.



Calista McRae, assistant professor of humanities, specializes in 20th- and 21st-century American literature, lyric poetry and the philosophy of humor. Her current book project, “Lyric as Comedy,” explores humor in five recent American poets, including Robert Lowell and Terrance Hayes.

Benjamin Thomas, assistant professor of physics, focuses on experimental optics and laser-based spectroscopy applied to the remote sensing of atmospheric aerosols and trace gases in order to measure air quality and climate change.

Newark College of Engineering

Gary Liu, assistant professor of electrical and computer engineering, specializes in high-performance computing and big data with an emphasis on fast data storage and analysis with applications in diverse fields ranging from fusion energy, to high-energy physics, to weather modeling, to cancer research.

Gennady Gor, assistant professor of chemical, biological and pharmaceutical engineering, models materials on an atomistic or molecular level, including porous materials ranging from nanoporous adsorbents and catalysts, to polymer membranes used in batteries, to geological materials such as coal and shale.

Murat Guvendiren, assistant professor of chemical, biological and pharmaceutical engineering and biomedical engineering, develops diverse, novel substrates used in tissue engineering. He seeks to expand the current capabilities of 3D printing to include biomaterials.

Vivek Kumar, assistant professor of biomedical engineering, develops biomaterials and drugs to treat diverse diseases and conditions, such as chronic inflammation, cancer and cardiovascular disease, through methods ranging from nanotechnology, to enhanced drug delivery, to biologically-derived and synthetic biomaterials.

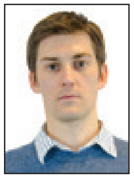
Dibakar Datta, assistant professor of mechanical and industrial engineering, focuses primarily on the modeling of energy systems such as the rechargeable batteries used in portable electronics; the mechanics of materials at nanoscale subjected to forces such as external loading; and modeling defects in materials under changing conditions.

Bruno Gonçalves da Silva, assistant professor of civil and environmental engineering, studies the fracturing mechanisms of various materials, including rock, construction and biological materials. Among other projects, he works on enhanced methods to better execute and control hydraulic fracturing in the field.

Saikat Pal, assistant professor of biomedical engineering, explores human movement and musculoskeletal disorders in order to develop next-generation orthopedic implants. He researches the causes of knee pain, for example, using biomedical imaging, motion analysis and multiscale computational simulations.

NATIONAL SCIENCE FOUNDATION CAREER GRANT RECIPIENTS

Alexei Khalizov, assistant professor of chemistry and environmental science, specializes is atmospheric mercury, a highly toxic pollutant released by fossil fuel combustion and waste incineration, primarily in the form of gaseous elemental mercury (GEM), and transported long distances and deposited in the ocean where it is absorbed by fish. This is the primary avenue of human exposure to mercury. His grant supports research on the chemical reaction rates and mechanisms of mercury bromide in the atmosphere. His goal is to improve the assessment of the environmental impacts of mercury and the development of better emission control policies.



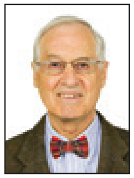
Casey Diekman, assistant professor of mathematics, researches the circadian clock, the neuronal timekeeping mechanism that aligns physiological processes with the appropriate time of day, for example, by stimulating the release of the sleep-promoting hormone melatonin in the evening and the wake-promoting hormone cortisol in the morning. The clock can be disrupted by environmental shocks such as rapid travel across time zones. He is pursuing a mathematical approach toward understanding the biology underlying jet lag by developing a detailed model of the circadian clock in Drosophila and systematically analyzing its disruption by sudden changes in the timing of the external light-dark cycle.

Iulian Neamtiu, associate professor of computer science, focuses on improving software evolution. Changes made to source code do not always have the intended meaning, to fix bugs or add features, for example, which can negatively impact both software producers and software consumers and carry a high economic cost. His work uses type theory and empirical software engineering to better understand and facilitate the process. The goal is to uncover certain kinds of errors before the software is deployed, and reduce the incidence of, and costs associated with, software bugs and incorrect software updates.

RECENTLY INDUCTED IEEE FELLOW

Osvaldo Simeone, promoted last year to full professor of electrical and computer engineering, specializes in wireless communications, information theory, optimization and machine learning. He has recently focused on the use of cloud processing for 5G systems to enhance wireless communications between mobile terminals and between machines in order to facilitate applications ranging from conventional data communication, to remote surgery, to alarm detection. He contends that radio access networks are the flexible and intelligent wireless system needed to integrate these technologies.

NATIONAL ACADEMY OF INVENTORS



Gordon Thomas, professor of physics and prolific, diverse researcher, transcends categories with inventions ranging from medical devices, to weapons sensors, to optical communications fiber. His creations include an implantable, wireless “Smart Shunt” to monitor and regulate the flow of cerebrospinal fluid in people with hydrocephalus and a tonometer to detect and monitor people with glaucoma. Over the course of his career, he also came up with a produce-recognition system for NCR's grocery check-out counters, a flexible sensor circuit to help prevent explosions and a related device for an ultra-sensitive sensor to measure and record vibrations designed for situational awareness of perimeter security.

Somenath Mitra, distinguished professor of chemistry and environmental science, is a groundbreaking researcher in the field of environmental monitoring best known for his work on trace measurements, including real-time monitoring of organic contaminants in air and water, and diverse nanotechnology applications ranging from flexible batteries, to solar cells, to sea water desalination. His work in the area of microwave-induced carbon nanotube purification and functionalization has wide-ranging applications in areas from polymer composites to thin films and nanoelectronics.

Atam Dhawan, distinguished professor of electrical and computer engineering, a pioneer in the field of point-of-care technologies in health care, focuses on optical imaging devices, such as a low-angle transillumination technology for examination of skin lesions that is used in the treatment of spider vein diseases and for the examination of lesions for diagnosis of skin cancers, specifically malignant melanoma. His research also includes a new method and instrumentation for in-situ measurements of concentrations of melanin, oxygenated hemoglobin, deoxygenated hemoglobin and glucose in the blood through skin-tissue imaging. He is in the process of commercializing a wearable, painless glucose monitor.

Kamalesh Sirkar, distinguished professor of chemical engineering, concentrates on industrial membrane technologies used to separate and purify air, water and waste streams and to improve the quality of manufactured products such as pharmaceuticals, solvents and nanoparticles. His many inventions include the concept of membrane contactors, a process that permits two phases that do not mix, such as two liquids or a liquid and a gas, to contact each other at the pores of a membrane — without dispersing into each other — in order to introduce or extract specific compounds across it. The technology is used, for example, to produce concentrations of oxygen at much less than one part per billion in ultrapure water needed for semiconductor production, and to extract valuable pharmaceuticals in aqueous-organic extraction systems.

George Sarton Medal

Zeynep Çelik, distinguished professor of architecture, received a George Sarton Medal in 2016 from the School of Engineering and Architecture of Ghent University for her outstanding work in the history of science. Çelik explores the meanings that buildings communicate about the cultures that create them by delving into relationships among politics, social issues and built forms. Four years earlier, she received a National Endowment for the Humanities fellowship for her project, "Empires and Antiquities: Appropriating the Past," a comparative study of claims to the past through the possession of antiquities in London, Paris, Berlin, New York and Istanbul around 1900.

For Three NJIT Women, Chemical Engineering Is Central to the Mission

Born in 1919, **Beatrice Hicks '39** knew by the age of 13 that she wanted to be an engineer. Decades into her pioneering career in sensor design, she urged "the young women of America" to follow in her footsteps lest the country miss out on their talents and suffer declining science standards as a result. Progress, she believed, depended on it. **General Ellen Pawlikowski '78**, who directs the 80,000-person Air Force Materiel Command for the U.S. Air Force, views her technical education as the foundation for learning how to solve problems — "to go into an area I know little about and, in a short period of time, translate that into making a contribution." **Elaine Gomez '14**, a graduate student who tests methods for reusing carbon dioxide that would otherwise be released into the atmosphere, sees chemical engineering as central to her mission. "We begin with chemical processes, which are small-scale, and engineering allows us to scale them up into power plants and chemical factories that make life better."

Beatrice Hicks '39

Beatrice Hicks '39, an inventor, business leader and urgent advocate for women in engineering, was a pioneer in the field of environmental sensing devices. At the helm of the New Jersey-based Newark Controls, Inc., she designed and manufactured gas density monitors, called switches, to detect potentially dangerous leakages around electronic equipment in missiles, jets and Air Force instruments. Her sensors could anticipate equipment failures, locate them and gather information to correct them. Sturdy enough to withstand vibrations, shocks and extreme temperature variations, they were used in the ignition systems on the Saturn V rockets that launched the Apollo moon missions, on Boeing 707 aircraft in antenna couplers involved in long-range communications, and for monitoring nuclear weapons in storage, among other applications. She patented a molecular-density scanner and developed an industry model for quality control procedures. Hicks also broke barriers for women in engineering. She was the first woman engineer employed by Western Electric who went on to run her own company and design sensors that made long-range air flight and space travel safer. She was the founding president of the Society for Women Engineers in 1950 and the chair of the First International Conference of Women Engineers and Scientists in 1964. At a space symposium for women, she told them, "The saying 'the world is yours to conquer' is no longer true. Yours is the universe." Her reputation and impact endure. This spring, she will be inducted into the National Inventors Hall of Fame.

"Women having a high level of engineering ability must be recruited today if we are to avoid a tacit acceptance of lower and lower scientific and engineering standards tomorrow. Considering the huge number of new engineers we require each year, mediocrity cannot be avoided unless the young women of America, among whom half of our present and potential scientific talent lies, recognize and accept their responsibilities to develop their engineering abilities."

Ellen Pawlikowski '78

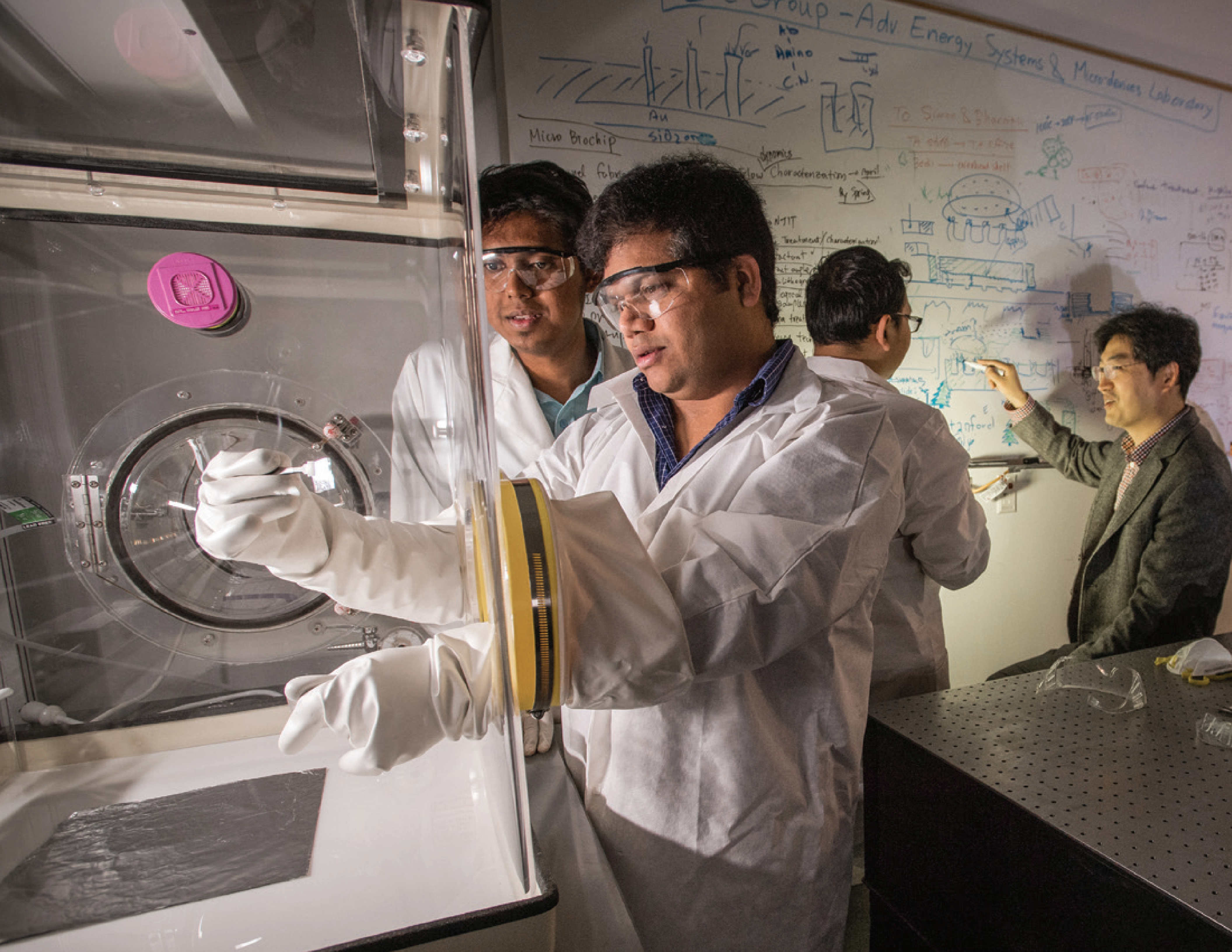
In 2015, **Ellen Pawlikowski '78** was promoted to the rank of four-star general in the U.S. Air Force. Just the third woman in the branch's history to receive a fourth star, she directs the 80,000-person Air Force Materiel Command, whose stated mission is to "deliver and support agile war-winning capabilities." In addition to managing city-sized military bases, she directs the Air Force's investment in weaponry technologies: hypersonics — the ability to travel at extremely fast speeds of Mach 5 or 6; directed energy — lasers and high-powered microwaves that allow the military to "get power on a target from a very long distance"; and automated devices that can not only operate on their own and think, but also interact as a human that flies as a wingman would in the plane. She looks to additive manufacturing as the way of the future to support U.S. installations and weapons systems so that they can produce needed supplies and parts at the right time and place. As she puts it, "We make sure everybody has food, but we're also deciding on the look of the jet my granddaughter's going to fly when she's 25 years old." During an earlier stint in the Office of the Secretary of Defense, she was responsible for chemical and biological counter proliferation during Desert Storm, "trying to figure out what we needed to do to protect against biological agents, and one of the answers was to vaccinate people… My job was to make sure we had the right technical information to guide the decision."

"For the most part, even though we like to say engineering is a male-dominated field, I can tell you that I've met very few engineers who cared whether you were a man or a woman. They just cared about your capabilities. People asked if I had a hard time in class. I will tell you, whether it was at graduate or undergraduate school, I never had trouble finding a lab partner."

Elaine Gomez '14

Elaine Gomez '14, a Ph.D. student at Columbia University, is researching methods to reduce the amount of carbon dioxide (CO_2) released back into the atmosphere by converting the greenhouse gas into useful feedstocks such as compounds to create liquid transportation fuels or high-value olefins, molecules used in products ranging from adhesives to fibers. "Rather than becoming costly waste, CO_2 has the potential to become a liquid fuel that not only is compatible with existing infrastructure, but also contains higher energy density than competing solutions," says Gomez. Backed by a three-year National Science Foundation Graduate Research Fellowship, she is working with Dr. Jingguang Chen, the Thayer Lindsley Professor of Chemical Engineering at Columbia, to devise processes that don't rely on expensive metal catalysts. "One of the challenges we face is that carbon dioxide is a very stable molecule and so developing a catalyst that makes the compound highly 'active' is really important." She is also combining CO_2 with propane to make propylene, which is a high-demand chemical building block. The goal, she says, is to identify processes that have a significantly higher CO_2 input than output, while also creating a value-added product. "I think our role as chemical engineers is to begin with the fundamentals and then work to apply them in many diverse fields, truly impacting everyday life," Gomez notes. "Among all the aspects of chemical engineering, my favorite is catalysis, which allows chemical processes that would otherwise occur at slow rates to occur at feasible production times and at large yields if needed. Catalysis plays an integral role in almost every chemical process we can possibly think of."

"The Intergovernmental Panel on Climate Change reported in 2014 that on our current trajectory we will reach a point where we will not simply have to curb emissions of carbon dioxide to avoid extreme ocean acidification, potentially catastrophic sea-level rise and severe impacts on human health. We will have to become carbon negative, meaning we will have to devise methods for removing it from the atmosphere and storing it. There are a lot of different avenues to accomplish this and I aim to strategically reuse CO_2 via alternative energy catalysis."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