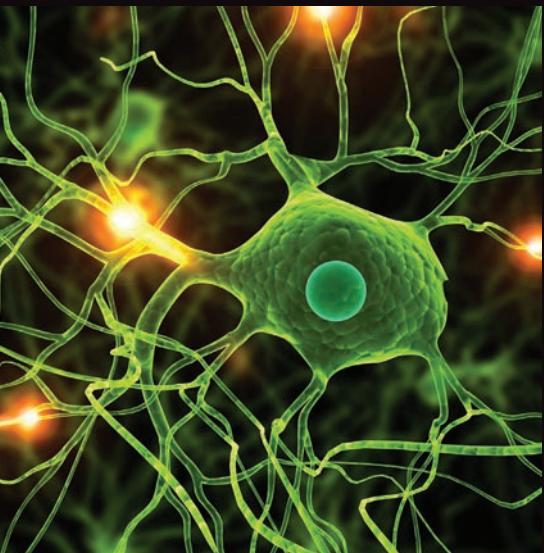# NJIT
New Jersey Institute of Technology

A World-Class Technological Research University

IN THIS ISSUE

Developing long-life, low-cost batteries

Improving diagnoses and therapies for heart disease

Using big data to prevent power outages

Fine-tuning membrane filters

Recognizing excellence in research

Q&A with Farzan Nadim

200,000
SQUARE FEET

of education and research space renovated
and added to the NJIT campus in the last year

20

new labs created in the past three years

Developing long-life, low-cost, durable batteries

The widespread use of lithium-ion batteries in the early '90s ushered in our current age of smart phones, laptops and electric vehicles. And while still the lightest, most compact rechargeable batteries available, lithium-ion's limitations in terms of capacity, durability and safety now stand in the way of new applications.

To break this technology roadblock, **Siva Nadimpalli**, assistant professor in NJIT's Newark College of Engineering, is spearheading research that could lead to a new generation of high-capacity, affordable and long-lived batteries. Funded by a multiyear Faculty Early Career Development (CAREER) Program grant from the National Science Foundation (NSF), Dr. Nadimpalli is using innovative techniques to study the breakdown of materials and interfaces inside a working battery rather than examining them after they have degraded.

An expert in fracture mechanics (the study of how cracks spread in materials), Dr. Nadimpalli has also formulated mathematical models to predict how mechanical forces impact chemical reactions in battery materials.

Improving diagnoses and therapies for heart disease

In petri dishes in her lab at NJIT, **Alice Lee**, assistant professor of biomedical engineering, is developing colonies of cardiac cells that grow chambers and pump and contract like a human heart. Derived from stem cells, these primitive organs are helping Dr. Lee study in microscopic, real-time detail how the heart repairs itself after injury. It's research that's critical in the fight against heart disease, which claims an estimated 2,200 Americans daily.

Dr. Lee induces a "heart attack" by damaging the tiny proto-hearts with a frozen rod. The attack mobilizes cell-based repair crews that clear the injury site of debris, and then in a second phase, recruit materials and tools from the neighboring tissue to mend the damage. By developing diseased-tissue models, she will be able to test drugs and treatments that cannot yet be used on patients and gain insights to improve diagnoses and therapies for cardiac diseases.

Earlier this year, Dr. Lee received a five-year Faculty Early Career Development (CAREER) Award from the National Science Foundation (NSF) to advance understanding of the underlying mechanisms of heart tissue repair by cell-based therapy.

Using big data to prevent large-scale power outages

An associate professor in NJIT's Martin Tuchman School of Management, **Maggie Cheng** is leveraging the power of big data analytics to create a "smart" electric power grid. Her goal is to help prevent large-scale power outages by using real-time data to detect, diagnose and interpret changes in the network.

The significance for society and for the power industry is profound. The Northeast Blackout of 2003 — the biggest in North American history — began as a string of local events in Ohio that spiraled into a massive problem affecting 50 million people in eight U.S. states and the Canadian province of Ontario. Its economic impact in terms of losses to U.S. workers, consumers and taxpayers was estimated at $6.4 billion. Since then, an increased reliance on variable energy supply sources has made system understanding and situational awareness of the complex energy system even more challenging.

Dr. Cheng's work on real-time anomaly-detection technology using measurement data would allow control centers to take appropriate actions in response to alerts of faults or disturbances, and prevent minor events from turning into major power outages.

Fine-tuning membrane filters for optimal performance

Membrane filters are thin sheets of porous material that remove particles from a fluid that passes through them. They're also part of a multibillion-dollar industry — used, for example, to purify water, treat radioactive sludge and remove cloudiness from beer during brewing.

But a membrane filter's characteristics — its behavior and performance — are not constant. Over time, particles foul and degrade the filter's performance.

To mitigate this costly problem, NJIT researchers **Linda Cummings** and **Lou Kondic**, math professors in NJIT's College of Science and Liberal Arts, are developing mathematical models and simulations that enable membrane designs to be finely tuned for optimal performance.

Funded by the National Science Foundation (NSF), the team is also collaborating with an industrial partner to maximize the chances of translating their theories into real-world applications.

Recognizing excellence in research at NJIT

Dr. Tara Alvarez, professor of biomedical engineering and director of the Vision and Neural Engineering Lab, was recently awarded the 2017 Excellence in Research Prize and Medal, one of NJIT's highest honors.

Dr. Alvarez specializes in building innovative, sophisticated instrumentation to understand and treat vision problems. One area of her research is convergence insufficiency (CI), a visual dysfunction characterized by the inability to align the eyes on a close target. CI is present in 12 million to 24 million people in the United States alone. Among people with traumatic brain injuries, including concussion, the percentage may be as high as 50 percent. A person with CI cannot read a book or look at a computer, smartphone or tablet for more than 20 minutes without experiencing a headache as well as blurred and double vision. The impact on cognition and learning can be severe, particularly for children.

With funding from the National Science Foundation (NSF), Dr. Alvarez first developed an instrument to detect the subtle, but significant differences in how eyes track near objects. The device is groundbreaking in simultaneously measuring eye movement and accommodation (the ability to see images clearly) in a system that has no moving parts. She and her team are now working on translating it into a portable device, using a laptop and a head-mounted display. The new instrument would be invaluable in the field for diagnosing moderate traumatic brain injury in athletes and soldiers as well as vision dysfunction in youngsters in children's hospitals across the nation.

Beyond the diagnostics of CI, Dr. Alvarez is also reengineering the therapy. Although CI is highly treatable, traditional vision therapy is expensive and often ineffective because exercises prescribed for the home aren't followed. Dr. Alvarez has been collaborating with clinicians, engineers, game designers, artists and software programmers to create virtual reality games that can deliver those therapies at home in ways that are fun and engaging. The innovative solution captures data on eye movements as well as the amount of time played so clinicians can follow their patients' progress remotely. The team has won two grants as well as venture capital funding to begin commercializing their work.

PROFESSOR WINS DARPA YOUNG FACULTY AWARD

Associate Professor of Computer Science **Kurt Rohloff** won a 2017 Young Faculty Award from the Defense Advanced Research Projects Agency (DARPA) to pursue ways to rapidly deploy open-source software on custom hardware, with specific applications for cryptography and cybersecurity.

The award recognizes rising research stars at U.S. academic institutions and provides funding, mentoring and networking. The goal is to help awardees frame their research ideas in the context of defense and national security needs.

Dr. Rohloff received a two-year grant of $898,435 for his proposal, "Improving Utilization of Open Source Software; MARSHAL: Modular Adaptive Reuse of Secure and High-Performance Advanced Libraries." The research aligns with DARPA's new initiative to lay the groundwork for the next era of world-changing electronics and microsystems.

The prestigious award is a first for the university and reflects the growing recognition of the transformative research being conducted by the faculty at NJIT.

Research Snapshots

Improving Software Updates

Iulian Neamtiu is working to reduce both the occurrence and financial costs of software bugs and incorrect software updates. Commonly, software continues to evolve long after the first version is released. Problems arise when changes made to source code to fix bugs and add features, for example, end up producing unintended results. This hurts both software developers and consumers. Dr. Neamtiu's goal is to make the semantics of software changes more explicit and reveal certain kinds of errors before software is deployed. His effort, funded by a Faculty Early Career Development (CAREER) Award from the National Science Foundation (NSF), will benefit both the research and software development communities.

Paving the Way for 5G

Joerg Kliewer is studying ways to reduce the amount of data transmitted over communications networks. His new and innovative architectural paradigms and error-correcting codes may hold the key to enabling the existing infrastructure to support the vast data increase projected for 5G mobile communications: 10,000 times more traffic and as many as 100 times more devices than today's 4G network.

Making Strength-Building Fun

Digital designer **Taro Narahara** has joined forces with biomedical engineer **Richard Foulds** to help teenagers with muscular dystrophy slow muscle deterioration through fun strength-building exercises. They link an NJIT robotic arm with a virtual reality gaming platform to enable the teens to experience the weight of the objects they're handling, as well as movement and direction. The design team's programs include an egg-throwing game that can bend the rules of physics.

Changing an Environmental Threat into a Resource

Xianqin Wang is exploring how to convert carbon dioxide, a damaging greenhouse gas, into high-value, useful chemicals. If successful, her work would transform an environmental threat into an economic resource and help fuel the growth of a low-fossil-fuel economy. Dr. Wang's study of advanced nanomaterials as catalysts is relevant for air purification, water treatment, clean energy production, and biological and pharmaceutical engineering.

Searching for the Culprit Behind Jet Lag

Yong-Ick Kim is working to better understand our 24-hour circadian clock on the molecular level. He's doing this by probing the primitive biological timekeeping system in cyanobacteria, a microorganism. His work on the biochemical building blocks of circadian rhythm may reveal clues — and possibly effective treatments — for sleep disorders, digestive problems and the cognitive impairment that jet-lagged travelers experience. His research also has possible implications for other medical problems such as cancer, obesity and diabetes that may be correlated with disruptions to the circadian clock.

317
U.S. patents and patents pending

4,000
students and teachers annually take part in NJIT's pre-college educational programs, the pipeline for STEM

Keeping Online Learners Engaged

Michael Lee created Gidget, an online educational game designed to teach introductory computer programming concepts through debugging puzzles. With funding from the National Science Foundation (NSF), he now wants to develop ways to identify struggling and disengaged learners and provide them with the right kind of help. For some, this help may be more practice with certain difficult concepts; for others, it may be just-in-time feedback to stimulate and re-engage their interest. Dr. Lee's research will show the effectiveness of these techniques on engagement and outcomes. It also has broad implications for teaching computer programming in an age when more people are going online to learn these skills.

Exploring the Role of Axons in Neural Signaling

Dirk Bucher is researching the propagation of electrical signals generated by nerve cells for transmitting and processing information. With funding from the National Institutes of Health (NIH), he hopes to better understand how properties of the membranes surrounding axons — the primary transmission lines of nerve cells — can shape and alter patterns of neural activity. His work could provide valuable insights into the causes and progression of a range of diseases that change the electrical properties of nerve cell membranes.
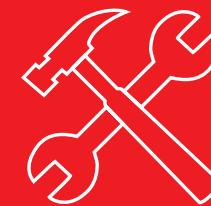
Strengthening Teamwork

Haisu Zhang aims to strengthen product development teams by understanding more clearly how the sharing and use of information among team members affects team decision-making. He also is looking closely at how functionally diverse teams affect information sharing. Dr. Zhang's research has value for managers who need to assemble decision-making teams, lead team communication efforts and encourage divergent thinking.
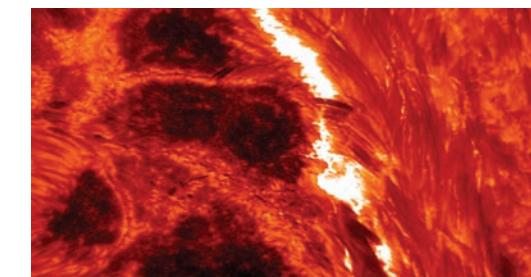
Predicting Solar Flares

Images captured by NJIT's recently renamed Goode Solar Telescope at Big Bear Solar Observatory, complemented by novel microwave data from the university's new Expanded Owens Valley Solar Array, provide some of the first detailed views of the mechanisms that may trigger solar flares, the releases of magnetic energy in the Sun's corona that are capable of penetrating Earth's atmosphere and disrupting orbiting satellites and electronic communications on the ground. Scientists from NJIT's Center for Solar-Terrestrial Research are studying small-scale pre-flare brightenings as a possible precursor of a solar flare. The research, funded by NASA and the National Science Foundation (NSF), is critical to accurate forecasting of space weather.

$10 MILLION
in support from the State of New Jersey for Makerspace at NJIT, set to open in 2018

Q&A

Farzan Nadim
Co-director of the Institute for Brain and Neuroscience Research at NJIT

As an NJIT faculty member for 20 years, how has the university evolved in general with respect to research?

The short answer is that our evolution has been very positive. I was the first tenure-track member of the Department of Biological Sciences, which is federated with Rutgers-Newark. NJIT's biomedical engineering program, today a department, was also at a formative stage. Each department now has a dozen or more tenure-track faculty and very substantial funding for research.

NJIT has made the same investment in every area of science and technology, and just as importantly, in areas that include the humanities, design, computing and management. Our diverse strengths make us very attractive to industry as a source of assistance with numerous commercial challenges. The continuing evolution in research, which is closely linked to our educational commitments, is very exciting.

In what way does the new Institute for Brain and Neuroscience Research, the IBNR, represent a major stage of this evolution?

The IBNR is a major advance because it is NJIT's first inter-college institute, focused on both research and education in basic and applied science. The IBNR brings together faculty and students from all disciplines to promote interdisciplinary research in neuroscience and traumatic brain injury. This is our primary goal in the promotion of the basic science and engineering involved and, we hope, in therapeutic progress too.

How does the IBNR's research mission complement NJIT's undergraduate and graduate educational mission?

In a general sense, it reflects NJIT's strategic commitment to education as well as research in the life sciences. One part of our IBNR vision is a truly interdisciplinary Ph.D. program, a program to educate students in areas that include neuroscience and neural engineering, also computational and mathematical neuroscience. I really don't see anything like this elsewhere in the country. I believe the IBNR will lead in preparing the innovators who will build the therapeutic and engineering solutions needed to help people with injuries and disease.

NJIT also encourages all undergraduates to take advantage of opportunities for research as part of their experience at our university. Like many faculty in biology and biomedical engineering, I have already worked with undergraduates on various research projects. The IBNR will expand the opportunities for interdisciplinary learning that, increasingly, is essential for academic and career success. For example, biomedical engineering students will be able to interact with biology faculty and math faculty. Similarly, biology students will interact with biomedical engineering and chemistry faculty. Our goal is the richest possible educational experience for all students interested in brain and neural science.

To what extent is the IBNR engaging with other institutions to achieve its goals?

Close cooperation with similar institutions, especially in New Jersey, is very important. Even before the IBNR was established, we worked with the Brain Health Institute at Rutgers, the Neuroscience Institute at Princeton, and the Kessler Neuropsychology and Neuroscience Laboratory. Our Princeton colleagues, for example, were interested in NJIT's computational and engineering strengths, and Rutgers colleagues were interested in scientific and educational collaboration, areas of shared concern that continue to be very significant. With the establishment of the IBNR, we will now have the organization and even more comprehensive resources to collaborate as an equal partner in raising the profile of NJIT and New Jersey in neuroscience.

With appointments in the Federated Department of Biological Sciences and the Department of Mathematical Sciences, Professor of Neurobiology Farzan Nadim is co-director of NJIT's Institute for Brain and Neuroscience Research. He is also a member of the STG Laboratory based on the NJIT campus, where he is helping to investigate neural activity related to afflictions such as depression, schizophrenia and Parkinson's disease.

One of the nation's leading public technological universities, New Jersey Institute of Technology (NJIT) is a top-tier research university that prepares students to become leaders in the technology-dependent economy of the 21st century. NJIT's multidisciplinary curriculum and computing-intensive approach to education provide technological proficiency, business acumen and leadership skills. With an enrollment of 11,400 graduate and undergraduate students, NJIT offers small-campus intimacy with the resources of a major public research university. NJIT is a global leader in such fields as solar research, nanotechnology, resilient design, tissue engineering and cybersecurity, in addition to others.

NJIT
New Jersey Institute of Technology