2016 NJIT RESEARCH CENTERS AND LABORATORIES SHOWCASE

THURSDAY
NOVEMBER 17, 2016

NJIT
New Jersey Institute of Technology

As one of five critical priorities spelled out in NJIT's Strategic Plan, *2020 Vision*, scholarly research is at the very center of university life. It is integrated into everything we do, from the recruitment of new faculty, to the proliferation of research opportunities for our graduate and undergraduate students, to events like today's Research Centers and Laboratories Showcase, which is designed to foster collaborations that lead to groundbreaking new ideas and innovations.

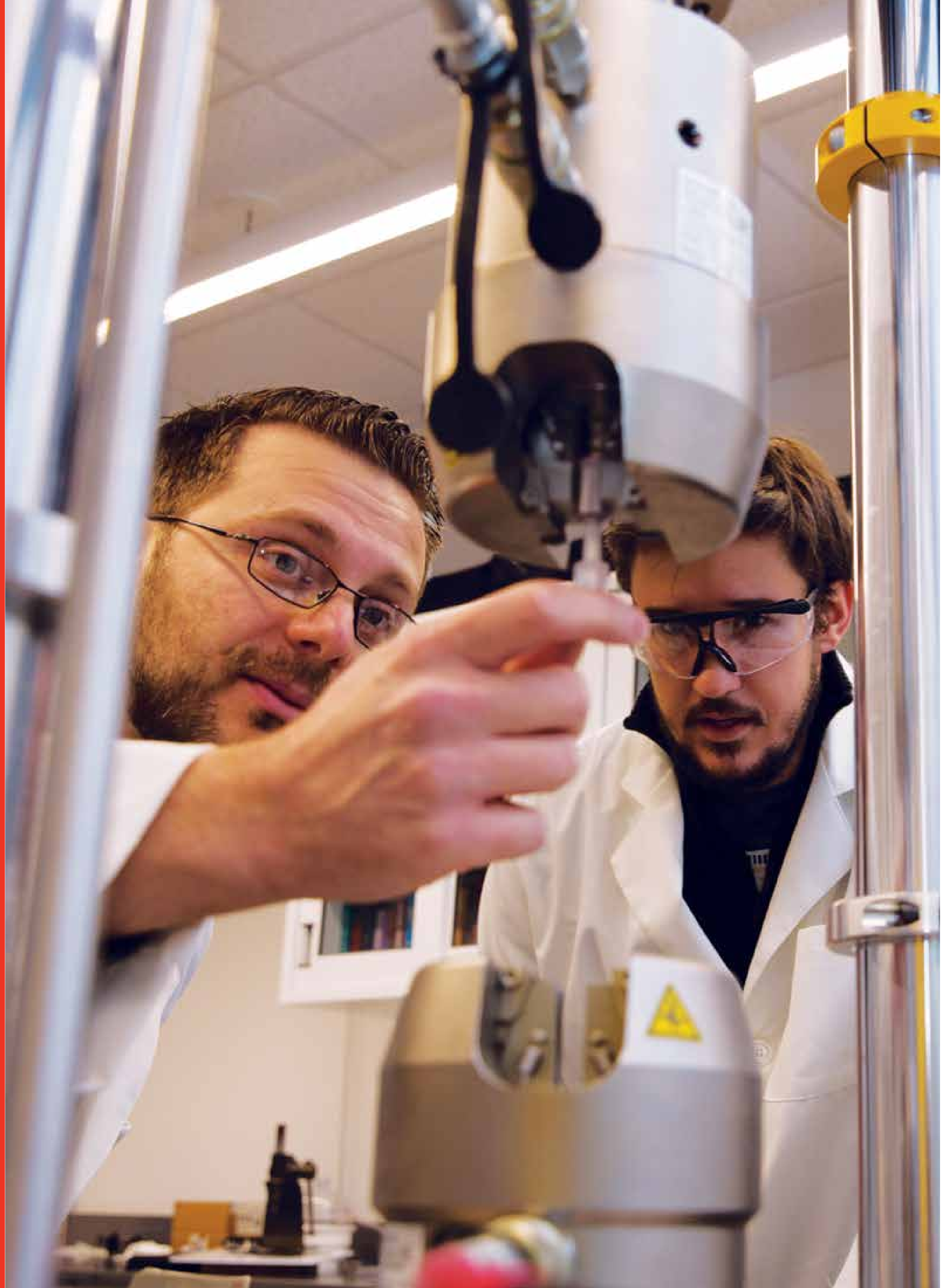
As NJIT moves into the ranks of premier research institutions, we do so strategically. Our mission is to play a leading role in four emerging areas of multidisciplinary research: data science and information technology, the nexus of life sciences and engineering, sustainable systems, and a transdisciplinary category that allows us to address the large systemic challenges of "smart cities," for example.

The university's research centers are the primary vehicles for tackling multifaceted societal problems and seeing them through to completion. By drawing on the insights and expertise of original thinkers across sectors, they achieve capabilities that are greater than the sum of their parts. NJIT is committed to supporting our researchers in several ways. In 1979, the university's research expenditures totaled $375,000; today they surpass $120 million. More importantly, over the next five years, we aim to double the number of awards our faculty secure from external funding agencies and private sector partners. In 2014, we inaugurated a seed-grant program to support interdisciplinary projects between fields as diverse as architecture and biomedical engineering and we are delighted to report that some of these initiatives have taken off and are now attracting outside funding.

With our ongoing $300 million capital-building program, we are transforming research and education on campus. The gut-level renovation of the five-story Central King Building and the construction of a new, 24,500 sq. ft. life sciences and engineering building are bringing our students and faculty new teaching and research labs, rooms to conduct projects and common areas where they can socialize and share ideas.

Just as exciting, we are broadening the scope of our research and building capacity through our people. Over the past five years, we have hired nearly 90 new faculty members as we deepen our capabilities across STEM and other disciplines. Under *2020 Vision*, we are beginning a multiyear hiring effort that will expand our faculty even further, from 280 in 2014 to 345 by 2020. For those who are new to the community, you are most welcome. We hope the research showcase opens up intriguing new vistas for you. Dive in!

Fadi P. Deek
Provost and Senior Executive Vice President



Welcome to the 2016 Research Centers and Laboratories Showcase, an annual celebration of NJIT's most potent and promising engines of innovation. The more than 50 centers and labs represented here today reflect the steady, strategic growth in the university's research enterprise. Over the past three years alone, more than 25 new labs have been created; by 2020, the annual research showcase will feature no fewer than 100.

We come together today, however, because these nodes of expertise do not exist in isolation. NJIT strongly believes that as researchers, we are most innovative and productive when we join together across disciplines to solve complex challenges that defy simple answers and niche know-how. By forming four research clusters around the life sciences and engineering, sustainable systems, data science and information technology, and a broader transdisciplinary category created to address problems such as intelligent transportation, systems resilience and point-of-care health devices, we invite collaboration with each other, as well as with partners in industry, government and peer institutions.

Our centers attract future-focused researchers, innovators and entrepreneurs across disciplines who work together to develop technologies capable of addressing a broad range of societal needs. The most recent addition, the Center for Big Data, illustrates this approach with its focus on devising novel methods to analyze data for diverse applications, including building intelligent transportation systems, characterizing traumatic brain injuries in comprehensive detail and keeping several steps ahead of financial bubbles. Its capabilities transcend conventional boundaries. By processing spectrum-wide data on the radiation hurled into Earth's atmosphere by solar storms, we will better understand the Sun's impact on the planet's people, animals and plants, as well as its man-made infrastructure and technologies.

We expect our Big Data researchers to work closely with colleagues in the Cybersecurity Research Center, another hub in the Data Science and Information Technology research cluster, on overlapping areas of interest, wherever the need to analyze complex data and protect it are both paramount. Faculty on our brain and neuroscience, material science and engineering teams have already formed powerful partnerships to advance research on traumatic brain injury and medication delivery systems.

So I urge you again, as I did at last year's inaugural showcase, to step out of academic silos, to delve into conversations with scholars outside of your disciplines and to seek inspiration in each other's work. You are guaranteed to walk away with new ideas, and, more than likely, future collaborators.

Atam P. Dhawan
Vice Provost for Research

Research is an integral part of a strong academic experience and a critical priority in NJIT's strategic plan, *2020 Vision*. The university aims for national and international prominence in research through new discoveries in areas ranging from robotics, to nanotechnology, to cybersecurity, to next-generation materials, among other topics of vital importance in basic, applied and translational research.

The nearly 90 new faculty members we have hired over the past five years strengthen our efforts considerably. They include experts on topics such as machine learning, data analytics, biomaterials and biomechanics. They arrive with impressive track records in securing grants from key funding agencies such as the National Institutes of Health, the National Science Foundation and the Department of Defense. We are confident that their participation in our multidisciplinary centers will help NJIT reach its ambitious funding benchmarks.

To achieve our research and educational goals, the university's strategic plan calls for seamless collaborations among faculty, staff and students, who all have a central part to play in advancing science, engineering and technology to fuel societal progress. *2020 Vision* organizes our core 13 research focus groups into four clusters. Comprised of an average of 20 active research members, they include:

LIFE SCIENCES AND ENGINEERING

This research cluster includes both basic and applied research in the areas of neuroscience, neural engineering, regenerative medicine and point-of-care technologies. Research at NJIT includes understanding functions of the brain and spinal cord under normal, injured and diseased states at molecular, cellular and functional levels through experimental, theoretical and computational methods. Regenerative medicine research involves the process of replacing dysfunctional cells with regenerating cells, tissues or organs to restore normal functions.

The Life Sciences and Engineering cluster also includes healthcare-information systems and management involving primary care, hospitals and emergency-care resources and protocols. A National Science Foundation (NSF) report on university research and development (R&D) notes the more than $20 billion in research funding from federal sources in these areas in 2011. The scope of the proposed cluster includes areas that are aligned with the National Academy of Engineering (NAE) and National Academy of Science (NAS) Grand Challenges in "reverse engineering of the brain," "tools for scientific discovery," and "engineering better medicine."

SUSTAINABLE SYSTEMS

This cluster represents research areas in urban ecology and sustainability, advanced materials and nanotechnologies, and smart manufacturing systems. The urban ecology and sustainability area emphasizes sustainable infrastructure, ecological communities, urban modeling and simulation. The area also focuses on the water-energy nexus and the impact of ocean levels on the environment, as well as the development of technologies for clean-water and energy resources, such as biofuel cells. The scope of nanotechnology research includes scientific and engineering phenomena at the minutest and most fundamental levels in order to develop technologies for environmental and pharmaceutical applications. The interdisciplinary group on engineered materials and particulates focuses on technology development for the preparation, processing and use of engineered-particulate materials and their composites for a spectrum of applications.

Research in the manufacturing systems group involves developing new methods and technologies for design innovation and process automation. A specific emphasis is to devise new processes and tools for pharmaceutical manufacturing. The NSF report shows more than $8 billion in university expenditures in 2011 for R&D on sustainable energy, renewable energy and community resilience. NAE and NAS Grand Challenges within the scope of this proposed cluster include solar energy, energy from fusion, clean water and urban infrastructure.

DATA SCIENCE AND INFORMATION TECHNOLOGY

This research cluster includes the study and practice of extracting information and knowledge from data that can be used for medical, financial, scientific and engineering applications. These groups conduct research on bioinformatics, medical informatics, image processing, data mining, solar-terrestrial physics, transportation, financial management, life sciences and healthcare.

The cybersecurity group studies how to design secure cyber systems and to improve cyber information and communications technology (ICT). ICT is shaping many aspects of society and the economy and is evolving rapidly, providing access to unprecedented amounts of information, anytime and anywhere, from any type of device. The NSF report indicates more than $13 billion in university R&D expenditures on cyber systems and information in 2011. Currently, there are 7.4 billion mobile devices connected globally with mobile-data traffic reaching 2.5 exabytes per month. It is expected that by the year 2050 more than 100 billion devices will be connected across the globe. The scope of this proposed cluster addresses NAE and NAS Grand Challenges, including secure cyberspace, virtual reality and tools for scientific discovery.

TRANSDISCIPLINARY AREAS

This cluster includes research centers focused on mathematical sciences and transportation systems, as well as societal impacts of science and technology. These three areas have a broader multidisciplinary and interdisciplinary scope with diverse applications in the life sciences and the design of smart cities, among other areas. The NSF report confirms university expenditures of more than $7 billion in 2011 in these fields. The scope of this proposed cluster addresses NAE and NAS Grand Challenges in urban infrastructure, smart transportation, tools for scientific discovery and advanced personalized learning.

PROGRAM

10:30 a.m. - 10:45 a.m.	**Introductions and Welcome**
10:45 a.m. - 12 p.m.	**Keynote Talk and Q&A:** **Dr. Nora Savage,** ***Program Director*** - Biological and Environmental Interactions of Nanoscale Materials - Chemical, Bioengineering, Environmental and Transport Systems - Engineering Directorate - National Science Foundation
12 p.m. - 12:30 p.m.	**Lunch and Networking**
12:30 p.m. - 2:30 p.m.	**Poster Session and Networking**

KEYNOTE SPEAKER

Nora Savage, Ph.D.

Program Director

Biological and Environmental Interactions of Nanoscale Materials
Chemical, Bioengineering, Environmental and Transport Systems
Engineering Directorate
National Science Foundation

Dr. Savage has worked for the federal government for nearly 20 years, helping the environmental nanotechnology research community to map out its research strategy. Before joining the Engineering Directorate of the National Science Foundation, she served as the team leader for nanotechnology in the Office of Research and Development at the U.S. Environmental Protection Agency, where she focused on developing a nanomaterial research strategy. Her primary responsibility in that role was to assist the agency in its efforts to protect human health and the environment as nanotechnology and other novel technologies emerged and evolved.

She has authored and co-authored numerous articles on nanotechnology and emerging technologies in leading journals, including the *Journal of Nanoparticle Research and Toxicological Sciences*. She served as lead editor for the books *Emerging Technologies: SocioBehavioral Life Cycle Approaches* and *Nanotechnology for Water Applications*, which is now in its second edition. She has contributed chapters to several other books, including the *Oxford Handbook of Nanoscience and Technology*, Vol. III.

Dr. Savage obtained a bachelor's degree in Chemical Engineering from Prairie View A&M University in Prairie View, Texas. She went on to earn two master's degrees, in Environmental Engineering and Environmental Science, and a doctorate in Environmental Science from the University of Wisconsin-Madison.

LIFE SCIENCES AND ENGINEERING

Center for Brain Imaging
Bharat Biswal, Director

The long-term goal of the Center for Brain Imaging is to better understand human brain function using integrative neuroimaging and statistical and computational modeling methods. We have four research themes: human brain functional patterns and their development; reliable neuroimaging measures; functional patterns in animal models; and a combination of the above information to explore how specific aspects of psychological processes associate with brain function and how mental and neurodegenerative diseases disrupt normal brain functioning. Our work is based on the principle that understanding the complexity of brain function and its development will prove helpful, and perhaps even necessary, in the search for effective treatments. We use modern neuroimaging techniques (MRI, fMRI, PET, fNRIS), and we map the three levels of the intrinsic architecture within brain function (i.e., region, subnetwork and entire brain). We then direct our investigations to brain development within different stages of life, to computational simulation of the brain's neural connections and to clinical psychology and psychiatry guided by our neuroimaging results. We are working on several disease models, including aging, Alzheimer's, schizophrenia and autism, as well as on spinal cord injury. Our research is currently funded by the National Institute on Aging and the National Institute of Biomedical Imaging and Bioengineering, which are both divisions of the National Institutes of Health, the National Science Foundation, the New Jersey Commission on Spinal Cord Research and the Governor's Council for Medical Research and Treatment of Autism.

Center for Injury Biomechanics, Materials and Medicine
Namas Chandra, Director

The Center for Injury Biomechanics, Materials and Medicine (CIBM3) is a multi- and interdisciplinary research center focused on understanding, diagnosing and treating brain injuries and concussions using experimental and computational methods. The Center is involved in both traumatic brain injury (TBI), a major concern among U.S. soldiers and veterans, and mild TBI and concussion in sports injuries, which also raise serious health concerns. Specifically, through novel blast-tube and drop-tower facilities, we examine what type of helmets, pads and configurations offer the right protection for soldiers and players. We study when and how concussions are caused and if there are simple diagnostic methods to determine concussions. We use animal models and mechanical surrogates to examine the role of blast pressures and the height of falls to relate injury to medical outcomes. Some of our recently funded efforts include examining the effect of blast overpressures on the dose-response curve of animal models and research into the mechanisms of blast-induced brain injury. In yet another project, we use experimental methods to study the effect of eyewear and hearing protection on the TBI susceptibility of warfighters. Namas Chandra, Bryan Pfister and James Haorah, along with colleagues from NJIT, medical schools and Veterans Administration facilities take a holistic approach to offer new measurement techniques, diagnostics and prognostic tools to address sports injuries and military medicine.

Center for Membrane Technologies
Kamalesh K. Sirkar, Director

The Center for Membrane Technologies investigates problems across multiple sectors that use membrane technologies to separate and purify water, air, industrial-fluid streams, solvents, pharmaceuticals, proteins, biopharmaceuticals, cells, particles and nanoparticles. Membrane synthesis, membrane modification and the development of novel membrane-based separation techniques are of particular interest. Two problems we are currently researching include solvent-resistant nanofiltration, with pharmaceutical applications, and the development of ultrathin membranes for use in gas separation. The organic synthesis of drugs involves many steps requiring frequent changes of solvents, the recovery of catalysts and the concentration of active pharmaceutical ingredients. Nanofiltration membranes capable of resisting solvents are of great value for such operations as they allow solvents to pass through but retain solutes with greater molecular weights. We are studying the behavior of novel, inert polymeric membranes for nanofiltration that permit solvent flow but reject the solutes. The rate of flow of gases through polymeric membranes depends, among others conditions, on the thickness of a thin active layer on top of a relatively porous support membrane. We are exploring novel techniques for making ultrathin films with considerable separation potential for various gas separations, such as carbon capture from power plant emissions.

Rehabilitation Engineering Research Center

Richard Foulds and Sergei Adamovich, Co-Directors

NJIT and the Kessler Foundation are collaborators in the Rehabilitation Engineering Research Center (RERC), working on wearable robots for independent mobility and manipulation for individuals with spinal cord-injuries and muscular dystrophy and who have had strokes. The Center has three research and two comprehensive development projects, plus a portfolio of training activities. Two of the research projects employ commercially available, lower-extremity exoskeletons currently in use at Kessler. One explores the potential of simultaneous spinal-cord stimulation to improve exoskeleton use by individuals with a spinal-cord injury. The second studies improvements in gait after a stroke by using exoskeletons early in the rehabilitation process. The third project, which employs a new exoskeleton being developed by NJIT, studies the benefit of home-based robotic rehabilitation of the upper extremities in people who have had a stroke. The first development project explores the application of robotic-admittance control as a means of allowing users of a lower-extremity exoskeleton to have complete control over the movement of their legs. The users make walking-like movements with their hands or fingers, which are sensed and used to control the movement of the exoskeleton legs. Haptic feedback of the leg movement, conveyed to the hands, provides essential feedback to the user. The project also explores the ability of additional powered degrees of freedom to allow a combination of autonomous and user-initiated balance. The second development project extends the NJIT-developed upper-extremity orthosis to meet the needs of children with muscular dystrophy and people of all ages with incomplete tetraplegia due to spinal-cord injury. The Center is developing a new continuing-education course for clinicians and physicians on wearable-robotic applications and a new graduate course for engineering students on the design of wearable robots. Material from the RERC will enhance NJIT's existing graduate courses on biorobotics, neuromuscular engineering and neurorehabilitation, as well as infuse wearable-robot experiences into master's theses, undergraduate capstone design projects and the mentoring of pre-college students.

Circadian Clock Laboratory

Yong-Ick Kim, Director

The Circadian Clock Laboratory researches the detailed biomolecular mechanisms of the circadian clock, the bodily and behavioral changes tied to the 24-hour daily cycle that respond to daylight and darkness. To explore the biochemical mechanisms that underlie these daily rhythms, we use the reconstituted in vitro circadian clock from a cyanobacteria, Synecochoccus elongates. The bacteria's central oscillator is encoded by three genes, kaiA, kaiB, and kaiC, whose protein products function together to generate a 24-hour rhythm of KaiC phosphorylation. The 24-hour KaiC phosphorylation rhythm is generated by the timely association and dissociation of these three Kai proteins. 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, including sleep deprivation and jet lag.

Computational Biophysics Laboratory

Cristiano Dias, director

Research in the Computational Biophysics Laboratory concentrates on the development of computational tools to answer complex questions at the interface of physics, biology, and chemistry for medical and industrial purposes. We focus on three areas: designing new biomaterials by aggregating proteins into extended fibril-like structures that are biodegradable and exhibit mechanical strength superior to steel; investigating the cell toxicity of amyloid proteins responsible for degenerative diseases like Alzheimer's and Parkinson's; and developing computational tools to predict how organic molecules in the cell modulate the stability of protein conformations. We use multiscale approaches to provide atomic resolution of macroscopic structures in order to understand and control systems, by self-organization or by design, from nanometer to mesoscopic scales. We use mechanistic insights from atomistic computer simulations to develop coarse-grained models with macroscopic resolution. Experimental methods used to validate our simulations include, but are not limited to, cell and single-imaging techniques as well as solubility experiments.

Laboratory of Environmental Microbiology and Biotechnology

Mengyan Li, Director

The Laboratory of Environmental Microbiology and Biotechnology seeks to make advances in the fields of applied microbiology and molecular biotechnology and to develop innovative techniques to mitigate and address environmental issues related to water and energy. We develop water-remediation techniques that deploy microorganisms to biodegrade organic pollutants of emerging global concern. We further research interdisciplinary methods to improve urban water- treatment technologies, including the application of nanotechnology to disinfect supplies contaminated with pathogens, and we use biomass-derived charcoal to remove metal toxins. We employ surrogate and indicator microorganisms to investigate the potential impacts of engineered nanomaterials and disinfection byproducts once they are released into the environment. To examine the microbial processes in natural and engineered systems, we integrate conventional culture-dependent approaches with state-of-the-art high-throughput molecular technologies, such as cloning, microarray, metagenomics and next-generation sequencing. We design innovative and inexpensive genetic forensic tools for the rapid quantification of microbial populations and functions in the environment. Other projects include mitigation of biofouling in membrane-treatment facilities, the control of microbe-induced corrosion and the identification of microbial enzymes for biofuel production.

Fluid Locomotion Laboratory

Brooke Flammang, Director

In the Fluid Locomotion Laboratory we take a multidisciplinary approach, integrating comparative anatomy and physiology, biomechanics, fluid dynamics, and biologically-inspired robotic devices to investigate the ways in which organisms interact with their environment and drive the evolutionary selection of morphology and function. By combining these different areas, we are able to approach broad-impact ecological and evolutionary questions from an experimental perspective and directly test the effective relationship between an organism and its environment. We use both live-animal and robotic models to investigate several ongoing research projects in our lab. One major initiative focuses on the functional morphology of the remora's adhesive apparatus with applications in defense, healthcare, and technologies and devices requiring long-term reversible attachment in wet conditions. Other projects include studying the swimming behaviors of sharks, reptiles, and robotic models to interpret the functional morphology of extinct ichthyosaurs, modeling the passive high-throughput flow dynamics of chondrichthyan egg cases, and investigating the adaptive morphology and comparative biomechanics of fishes that can walk on land.

The Keck Laboratory for Topological Materials

Camelia Prodan, Director

The Keck Laboratory for Topological Materials uses interdisciplinary research to investigate the existence of "topological phonons" in microtubules (MTs), a naturally occurring biological material. Our theoretical evidence suggests that topological phonons are integral to the function of MTs – a cytoskeletal component in all eukaryotic cells that is essential for many fundamental cellular processes, including cell division and movement. Inspired by the mechanical properties of the microtubules, we work on laying the theoretical and experimental foundation for a new class of engineered materials that exhibit the unique vibrational and thermal properties of topological phonon edge-modes. Such materials may find application in sound deadening and amplification and to manage heat flow.

Laboratory of Nanomedicine and Healthcare Biomaterials

Xiaoyang Xu, Director

The Laboratory of Nanomedicine and Healthcare Biomaterials aims to develop new biomaterials and nanotechnologies for a variety of medical applications, including diagnosis, bioimaging, controlled drug delivery and regenerative medicine. We look at both fundamental and applied questions in the crossdisciplinary fields of biomaterials, nanomaterials and medicine in order to develop novel therapeutic methods for the treatment of cancer, obesity, cardiovascular disease and many others. One specific goal is to develop multifunctional polymeric nanoparticles for medical applications, including drug-delivery mechanisms and regenerative medicine, such as the development of targeted nanoparticles to deliver therapies to the brain. Another major thrust of our work involves developing synthetic biomaterials and processing techniques to fabricate hydrogels and scaffolds with degradable and biocompatible properties for use in drug delivery and tissue engineering. In particular, we focus on biomaterial engineering to understand structure-function relationships and to investigate the effects of biomaterials characteristics on the deployment of therapies and on cell and tissue interactions.

Neural Basis of Locomotion Laboratory
Gal Haspel, Director

We study the neurobiology of locomotion: How do nervous systems generate coherent muscle activity to propel animals in their environment? In particular, we focus on the levels of neuronal-circuits coordination in the locomotion of the nematode, C. elegans. This 1-millimeter-long roundworm moves through its environment by counteracting muscle contractions activated by a nervous system, as do all other animals. The nematode also uses the same neurotransmitters, neuromodulators, as well as similar molecular and cellular mechanisms as other animals. It does, however, have several advantages as a research model: its nervous system is compact and includes only 302 neurons, it is small and transparent and fits under a microscope, and it is the only animal that has its genome and nervous system completely mapped. This allows us to use a combination of optical methods to record and control neuronal activity, and transgenic methods to direct these tools to their targets. We use focused laser light to precisely dissect neuronal processes to study the circuit response to injury and regeneration; we use high-resolution techniques to map neuronal connectivity. Our research goal is to determine rules that govern the connectivity, activity and robustness of neuronal networks that generate behavior.

Neural Dynamics Laboratory
Farzan Nadim, Director

Neurons and the circuits they form produce electrical activity in a fairly complex way that cannot be understood simply on the basis of a synaptic wiring diagram. Neuronal signaling is shaped by a multitude of nonlinear dynamic properties that operate on multiple time scales. The gating properties of ion channels, short-term synaptic plasticity, neuromodulation, as well as long-term regulatory mechanisms, all contribute to activity- and time-dependent changes in excitability. The lab uses various electrophysiological techniques, such as extra- and intracellular recording and voltage clamps, molecular biology, confocal microscopy, computational modeling and dynamical systems mathematical approaches to characterize these phenomena. We also perform cell ablations and have pioneered the use of realistic voltage waveforms in the measurement of ion channel and synaptic currents. We use both experimental and theoretical approaches to study the neurophysiology of the stomatogastric ganglion, a small central-pattern-generating (CPG) circuit in lobsters and crabs. CPGs are neuronal networks in the central nervous system that generate the basic patterned electrical activity underlying most rhythmic behaviors like walking and breathing in all animals. We take advantage of the experimental accessibility of the crustacean nervous system to uncover fundamental principles that govern neural processing across all animal and human nervous systems.

Neural Engineering for Speech and Hearing Laboratory
Antje Ihlefeld, Director

The Neural Engineering for Speech and Hearing Laboratory examines how the brain processes sound through psychophysical, physiological and computational modeling experiments. We focus in particular on the experience of people with hearing loss who use cochlear implants, electronic devices that function as the inner ear by sending sound signals to the brain. While these implants work well in quiet settings, they are much less effective in situations with background noise. Normal-hearing listeners overcome this hurdle by tracking quality differences between target voice and background interference, easily distinguishing, for example, between men's and women's voices. By contrast, cochlear implant users have poor pitch sensitivity and typically can't make these distinctions. Why is this gap critical? The inability to hear in daily social settings – restaurants, meetings and parties – can lead to isolation and depression. A recent landmark study showed it also causes cognitive decline. We aim to identify the behavioral and neuronal mechanisms for hearing disruption caused by background noise to advance our understanding of how hearing loss affects the capacity to ignore competing sounds –– and to develop remediation strategies that will improve cochlear implants.

Laboratory for Neuroethology
Eric Fortune, Director

Research in the Neuroethology Laboratory focuses on the interactions between sensory and motor systems that are used to generate and control animal behavior. Experiments in the lab focus on two main questions: how the rules for social interaction between members of the same species are encoded in the brain, and how sensory representations of movement are encoded by sensory systems and translated into motor commands. We use methodologies that cross levels of biological organization from the computational consequences of transmembrane molecules to the behavior of multispecies flocks. Our work includes field studies of natural behavior in Amazon basin habitats, highly-controlled behavioral studies in the laboratory, a variety of neurophysiological approaches including intracellular recordings of central nervous system neurons in animals, pharmacological studies and mathematical modeling.

RESEARCH CENTERS AND LABORATORIES 2016

Neural Prosthetics Laboratory
Mesut Sahin, Director

The primary research thrust of the Neural Prosthetics Laboratory is to develop novel and translational neural prosthetic approaches to help restore function in people with disabilities resulting from injuries to the central nervous system, such as a spinal-cord injury, traumatic brain injury and stroke. The accompanying neuroscience goal is to increase our knowledge about the role of the spinal cord and the cerebellum in motor coordination and sensory-motor integration. One of our current projects involves the extraction of volitional signals from the descending fiber tracts of the spinal cord. The goal is to utilize these volitional signals to allow spinal-cord-injury patients to control a computer. More recently, we are exploring the potential of applying a mechanical tap on the forelimb to evoke electrical signals on the cerebellar cortex, which we would record with multi-electrode arrays to monitor the progression of brain injury caused by trauma. The lab has also developed micro-devices activated using near-infrared light for wireless stimulation of the central nervous system.

Neuroecology of Unusual Animals Laboratory
Daphne Soares, Director

How do nervous systems evolve and adapt to extreme environments? Evolution through natural selection has shaped nervous systems to generate behaviors. However, there are very few opportunities to study neural-circuit evolution where the ancestral and derived forms, as well as the adaptive environment, are all known and accessible. The Neuroecology of Unusual Animals Laboratory studies the synthesis of neuroethological and ecological principles to understand the evolution of neural adaptation. In our research, we have a three-pronged approach that examines the evolution of circuitries, molecular mechanisms of behavior and sensory novelty. This integrative approach links a detailed characterization of the environment with the anatomy and function of neural systems within a phylogenetic context.

Opto and Microfluidics Laboratory from Diagnostics to Therapeutics
Sagnik Basuray, Director

The Opto and Microfluidics Laboratory establishes synergies among novel nanostructures, optics, biology and electrokinetics to develop disruptive new technologies in sensors, diagnostics, drug delivery and biofilms, using cost-effective tools. Our research advances the understanding of interfaces and surface physics. Current research includes developing a microfluidic organ-on-a-chip platform to study interactions between nanoparticles and the blood-brain barrier; combining surface dielectrophoresis, an electro-kinetic phenomenon, with 3-D printed microfluidic Lego blocks to create a sweat sensor; developing a platform for single-cell analysis using microfluidics, biomedical imaging, computation, drug delivery and galvanotactics. The lab will also develop a shear force-enhanced Lab-on-a-Chip device for monoclonal antibody purification without post-modifications in order to preserve antibody functions. Collaborators on a low-cost, portable nebulisation platform to deliver drugs to the brain include experts in acoustics and biofluids at RMIT in Australia and Technion – Israel Institute of Technology, respectively.

SwarmLab
Simon Garnier, Director

The SwarmLab is an interdisciplinary research unit that explores the mechanisms of Swarm Intelligence. We study how information is exchanged and transformed during interactions between members of a group and how this leads to "intelligent" group behaviors. We focus on the coordination of large animal groups, such as ant colonies, ungulate herds, baboon troops and human crowds. We use this knowledge to develop applications to problems such as the organization of pedestrian traffic and the control of miniature robotic swarms. We collaborate with biologists, social scientists, physicists, mathematicians and computer scientists around the world to elucidate the principles that underlie collective behavior across levels of biological and social organization. Current projects include research into the decision-making abilities of neuron-less organisms such as the slime mold; the organization of traffic and supply chains in leaf-cutting ants; the dynamic construction behavior of nomadic army ants; the role of vocal communication in the coordination of activities in mammal groups; the impact of poaching on movement decisions and social structure in African elephant herds; and the application of swarm intelligence principles to predictive policing software.

Tissue Engineering and Applied Biomaterials Laboratory
Treena Livingston Arinzeh, Director

The Tissue Engineering and Applied Biomaterials Laboratory develops functional biomaterials for regenerative medicine applications. Recent discoveries in the tissue-engineering field have shown that the microenvironment can influence stem cell self-renewal and differentiation, which has had a tremendous impact on identifying potential strategies for using these cells effectively in the body. This laboratory develops functional biomaterials that impart cues to stem cells, either already present within the body or implanted, to affect their behavior. These biological cues stimulate growth in bone and spinal-cord tissue, for example. Our laboratory has pioneered the use of bioactive ceramics and composites for use in bone-tissue engineering. Novel bioinspired materials such as glycosaminoglycan (GAG) mimetics and piezoelectric materials also are being developed for bone, cartilage and neural applications. GAG mimetics combine with growth factors to simulate tissue growth and piezoelectric materials provide electrical stimulation to cells. Current funding is from federal, state and private agencies.

Vision and Neural Engineering Laboratory
Tara Alvarez, Director

Convergence insufficiency (CI) is a prevalent binocular vision disorder that disrupts coordination of the eyes as they turn inward to focus on a near object. Symptoms, which include double and blurred vision, eyestrain and headaches during reading or other close work, negatively impact activities of daily living and can significantly impair a child's ability to focus and learn, for example. CI is present in four percent of the population; just over a quarter of these patients do not improve even with validated therapy. While office-based therapy is effective in about 75 percent of patients with CI, home-based therapies are no more effective than a placebo. Our NIH-funded project studies two potential mechanisms that may cause CI that we believe could be improved through therapy. This knowledge could lead to targeted therapeutic interventions, improved treatment success rates, reduction in the time to remediation and reduced healthcare costs. The laboratory is also funded by a life-science focused venture capital fund and through an IEEE EPICS grant to develop a virtual reality-game therapy device with NJIT's Computer Gaming Program, Salus University and The Children's Hospital of Philadelphia.

SUSTAINABLE SYSTEMS

Center for Building Knowledge
Deane Evans, Director

The Center for Building Knowledge (CBK) is a 25-year-old research, training and technical assistance institute affiliated with the College of Architecture and Design. CBK is dedicated to generating new knowledge to improve the built environment and enhance the planning, design, construction and operation of facilities. CBK's mission is to help individuals and communities make better-informed decisions about the performance, sustainability and resilience of buildings nationwide. Recently, the Center has focused on online tools to educate building professionals on how to improve the performance of the buildings they design and construct. The Certificate of Proficiency in Benchmarking program, for example, provides users with training on how to benchmark the energy use of a building using the U.S. Environmental Protection Agency's (EPA) Energy Star Portfolio Manager tool. The program, developed with support from the U.S. Department of Energy (DOE) and the cooperation of the EPA and the Natural Resources Defense Council, launched in 2015. The Certificate of Proficiency in Asset Score online program, a follow-on project funded by DOE, provides training on how to use a new tool from the agency that evaluates the energy efficiency of key physical "assets" within a facility – building envelope, lighting and HVAC systems – and tabulates an "asset score" for it. Developed with the Consortium for Building Energy Innovation, the program launched in April 2016. Currently, CBK is developing the Clean Energy Learning Center, a new online energy-efficiency training and resource platform for the New Jersey Clean Energy Program.

Electronic Imaging Center
Haim Grebel, Director

The Electronic Imaging Center is an interdisciplinary center focused on nanotechnology, spectral analysis with sub-wavelength structures and energy. Nanotechnology is a field dealing with underlined phenomena at the nanoscale. It covers diverse phenomena that encompass molecular/biological interactions, interfacial science, as well as bulk and surface properties. The field is fast expanding into agriculture, energy and pharmaceutical industries. Spectroscopy with sub-wavelength structures is a field important to pollution detection, remote sensing and imaging at resolutions surpassing the diffraction limits. It is related to nanoscale phenomena but can also find applications in the infrared and the THz frequency range. Energy is fast becoming a crucial commodity: its transmission, delivery and storage are key to the development of the U.S. economy and to the safeguarding of national security. Ongoing projects that focus on one or several aspects of the above include graphene-coated nano-optical antennas for molecular detection, tunable super-capacitors for energy storage, digital energy for efficient energy management and white-light sources.

The Elisha Yegal Bar-Ness Center for Wireless Information Processing
Alexander Haimovich, Director

The Elisha Yegal Bar-Ness Center for Wireless Information Processing (CWiP) researches diverse areas of communications, signal processing and radar. The Center is a hub for faculty, visiting scholars, postdoctoral fellows and graduate and undergraduates students. Principal areas of research include cloud radio-access networks, cooperative networks, distributed-radar and acoustics communications. Cloud Radio Access Network (C-RAN) refers to the virtualization of base-station functionalities in a cellular system via cloud computing. Our research explores novel cellular architectures and C-RAN inspired by network information-theoretic principles. In decentralized networked systems, one fundamental problem is to coordinate the activities of different nodes so they reach a state of consensus. We aim for a generalization of this problem with applications to distributed surveillance applications, automatic vehicle-control applications, and load-balancing with divisible tasks in large computer networks or power grids. In radar, distributed architectures offer wide coverage and improved performance against low radar cross-section targets. Our research focuses on the detection and tracking of ground-moving targets embedded in ground clutter with sensors that are time-synchronized but not phase-synchronized. The sensors communicate their observations to a central processing center. In the oil industry during drilling, for example, real-time transmission of data such as temperature, pressure, torque and drilling direction from downhole to the surface is vital. Since boreholes are typically very deep, wired communication is expensive and prone to failure. We research wireless communication by way of acoustic propagation to achieve high transmission rates.

Membrane Science, Engineering and Technology Center

Kamalesh K. Sirkar, Director

The Membrane Science, Engineering and Technology Center, a National Science Foundation Industry/University Cooperative Research Center (I/UCRC), conducts basic research and related development on innovative materials and processes that facilitate the use of membrane technology. The Center also provides timely and effective technology transfers between the Center's researchers and its sponsors, including both industry sponsors and U.S. government laboratories. With the research preformed primarily by graduate students, the Center promotes education in membrane science and technology. The research topics are decided by corporate members of the Industrial Advisory Board. This Center is located at three university research sites: NJIT, the University of Colorado at Boulder and the University of Arkansas at Fayetteville. NJIT faculty members from the following departments are active in this Center: chemical, biological and pharmaceutical engineering; chemistry and environmental science; civil and environmental engineering; biomedical engineering; and electrical and computer engineering.

Center for Natural Resources Development and Protection

Michel Boufadel, Director

The Center for Natural Resources Development and Protection (NRDP) investigates practical and efficient approaches to environmental and energy-resource utilization. Research projects include assessment and remediation studies of pollution in natural settings and the evaluation of natural resources for the potential production of energy, especially renewable energy. Current projects include determining the trajectory of the underwater oil plume in the Gulf of Mexico and evaluating remediation techniques for oil spills, including using microorganisms to break down the oil. Projects have been also initiated to study the impact of oil releases in high salinity (brine) pools, commonly encountered at depths exceeding a mile in the ocean and the Gulf of Mexico. Little is known to date about the effect of high-salinity water on the behavior of either oil or spill countermeasures, such as applied dispersants.

New Jersey Center for Engineered Particulates

Raj Davé, Director

Creation of advanced particulate materials and products through the engineering of particles is a major research focus of the New Jersey Center for Engineered Particulates (NJCEP). The Center's research combines experimental, computational and theoretical studies to achieve an understanding of particle properties at the individual particle scale to predict particle and product behavior at the macro-scale. Our work has industrial applications in the pharmaceutical, food, cosmetics, ceramics, defense, electronics and specialty chemicals industries. The Center's research infrastructure includes equipment for the characterization and processing of particles. Patented technology that has been licensed includes a solventless mechanical particle coating process. NJCEP is closely affiliated with the National Science Foundation – Engineering Research Center (NSF-ERC) and the Center for Structured Organic Particulate Systems (C-SOPS), a partnership among four universities, including Rutgers University, Purdue University, NJIT and the University of Puerto Rico at Mayaguez, that is focused on improving pharmaceutical manufacturing processes. Among our technology platforms, NJCEP has developed a stripfilm real-time release methodology for delivering nano and micron-sized very poorly water-soluble active ingredients in a well-dispersed state with full recovery of nanoparticles.

Center for Solar-Terrestrial Research

Andrew Gerrard, Director

The Center for Solar-Terrestrial Research (CSTR) is an international leader in ground- and space-based solar and terrestrial physics, with a particular interest in understanding the effects of the Sun on the geospace environment. CSTR operates the Big Bear Solar Observatory and Owens Valley Solar Array in California, the Jeffer Observatory at Jenny Jump State Forrest in New Jersey and the Automated Geophysical Observatories distributed across the Antarctic ice shelf. The Center also manages a large number of instruments at South Pole Station, McMurdo Station, and across South America and the United States. CSTR is one of the principal investigators in NASA's Van Allen Probes mission, which explores the radiation and plasma environment around Earth, and houses the Space Weather Research Laboratory, which does scientific research in the area of space weather with the mission to understand and forecast the magnetic activity of the Sun and its impact on Earth. Such instrumentation and data resources enable scientific studies ranging from the Sun's surface, to its extended atmosphere, and into Earth's atmosphere.

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Center for Solar-Terrestrial Research—Big Bear Solar Observatory

Wenda Cao, Director

The Center for Solar-Terrestrial Research operates Big Bear Solar Observatory (BBSO) in California, which houses the highest-resolution solar optical telescope in the world at 1.6 meters. With its state-of-the-art adaptive optics and scientific instrumentation, the telescope obtains high-resolution views of the Sun's surface features, such as sunspots, filaments, faculae, granulation, spicules and jets. Its instruments measure the magnetic fields and motions of these features to understand the basic physics of solar activity that affect the Earth and near-Earth technological systems. Through the BBSO telescope, NJIT scientists have explored how twisted magnetic fields interact to produce the sudden release of energy that powers solar flares, and the response of the solar plasma to such energy releases. Using data from multiple NASA solar spacecraft and advanced computer modeling, we are developing an understanding of fundamental processes that improves our ability to predict the occurrence and outcomes of such solar activity on Earth.

Center for Solar-Terrestrial Research—Expanded Owens Valley Solar Array

Dale Gary, Director

The Center for Solar-Terrestrial Research (CSTR) operates the Expanded Owens Valley Solar Array in California, which is nearing completion of a major expansion to become one of the most capable solar-dedicated radio arrays in the world. The array consists of 15 antennas and is used to image solar flares at hundreds of frequencies over the frequency range 2.5-18 GHz within one second. Its ability to follow evolving radio emissions with such high frequency and time resolution allows us to capture and quantify the energy release, acceleration and transport of energy in flares. In addition, the array will image the slower timescale emissions of sunspot regions on 30-minute timescales, and the full disk of the Sun on 6-12 hour timescales. Among other advantages, such data will provide the first daily coronal magnetograms, maps of magnetic-field strength 1500 miles above the Sun's surface, which will open a new window on the processes of solar activity. Our research has included the discovery that radio emissions from the Sun can directly affect cellular communications and navigation systems, such as GPS at the CSTR.

Advanced Energy Systems and Microdevices Laboratory

Eon Soo Lee, Director

The Advanced Energy Systems and Microdevices Laboratory's research is focused on the non-platinum group of metal (non-PGM) catalysts to replace PGM catalysts for electrochemical-energy systems such as fuel cells and batteries, and industrial applications such as filtering systems and petroleum-processing systems. Principal research includes synthesizing and characterizing innovative high-performance new non-PGM catalysts from carbon materials such as graphene, and understanding the fundamental mechanisms of the reaction. The lab's microdevices research concentrates on applying micro- and nano- technology to diagnose complex diseases like ovarian cancer at their early stages using a nano-biochip. The biochip incorporates microchannels with a self-driven flow of biofluid and nano-circuits to sense the existence and severity of the disease with high sensitivity and selectivity. Our research has been supported by the National Science Foundation and NJIT, with many patents issued, and in collaboration with the John Theurer Cancer Center at Hackensack University Medical Center, Brookhaven National Laboratory-Center for Functional Nanomaterials, the Nano and Microfluidics Laboratory at Stevens Institute of Technology, CUNY's Advanced Science Research Center, Rutgers University and Montclair State University.

Analytical Chemistry and Nanotechnology Laboratory

Som Mitra, Director

The Analytical Chemistry and Nanotechnology Laboratory is located in the Department of Chemistry and Environmental Science. Our research focuses on the fields of analytical chemistry, nanotechnology and water treatment. In analytical chemistry, we are geared toward developing instrumentation for online and real-time monitoring analysis, environmental monitoring, field-portable instruments and microfluidic devices. In nanotechnology, we work on nanoparticles, particularly carbon nanotubes, in applications such as batteries and solar cells and chromatography stationary phases. In water treatment our work is related to defluoridation, arsenic removal and desalination.

Atmospheric Chemistry Laboratory
Alexei Khalizov, Director

The Atmospheric Chemistry Lab investigates the origins of atmospheric pollution and evaluates its environmental impacts. Since many pollutants, such as ground-level ozone, are formed directly in the atmosphere through a sequence of complex chemical and physical processes, an understanding of these processes is required to develop appropriate control measures for pollution prevention. The two ongoing research projects in our lab focus on atmospheric aerosols and atmospheric mercury. Atmospheric aerosols originate from direct particle emissions and also from gas-to-particle conversion. We study how atmospheric aerosols form and evolve, and also assess the impacts of aerosols on the climate and human health. We conduct experiments to investigate the atmospheric processing of combustion soot particles and the relationship between particle morphology and optics. Additionally, we develop hyphenated mass-spectrometry instrumentation for chemical analysis of aerosol particles and their gas-phase precursors. The goal of our mercury project is to understand the chemistry and speciation of this persistent, bioaccumulative pollutant emitted to the atmosphere in large quantities by coal-fired power plants. We study gas-phase oxidation of mercury, and its interactions with atmospheric surfaces, and we also develop new detection techniques for atmospheric oxidized mercury based on chemical ionization mass spectrometry.

Controls, Automation, and Robotics Laboratory
Cong Wang, Director; Lu Lu, Co-Director

The Controls, Automation, and Robotics (CAR) Laboratory focuses on the development of control theories and their applications to automation and robotics. With a strong tie to the community of dynamic systems and controls, we continue to push the frontier, especially in the direction of machine learning-based methods and data-oriented and statistical methods. We emphasize the use of computational intelligence and data science. Our work in theory enables us to develop advanced automation and robotics technologies. In particular, we are challenging the limits of high-performance control for advanced manufacturing and automation, as well as developing intelligent and ultra-high-maneuverability motion systems for human-robot interactive and collaborative operations and extreme robotic manipulations. This technology is targeted at sectors ranging from advanced manufacturing, to household automation, to health care.

High Performance Concrete and Structures Laboratory
Methi Wecharatana, Director

High performance concrete has been a topic of global interest for the past 20 years, starting with the production of high-strength concrete, which at 15,000-20,000 psi is five times stronger than normal concrete. Critical innovations in recent years include the development of highly durable concrete, impact-resistant concrete, microdefect-free concrete, fiber-reinforced concrete, fly-ash concrete, high-performance carbon fiber-reinforced concrete and high-strength fiber-reinforced plastics, among others. With funding from the National Science Foundation (NSF), six closed-loop hydraulic MTS and Instron testing machines with capacity ranging from 25,000 to 1 million pounds were installed in our state-of-the-art laboratory and testing facility. Our high-bay structural concrete lab allows us to test full-scale, 12-ft.-long columns with automated closed-loop hydraulic testing machines and our reaction walls enable us to simulate lateral loads from both wind load and earthquakes. The recent addition of two new civil engineers, Matthew Adams and Matthew Bandelt, expert in advanced concrete materials, further expands our programs into research on the fatigue and durability of high-performance, fiber-reinforced concrete and microstructures of high-performance concrete using scanning electron microscopes and transmission electron microscopes. Past and ongoing funding for our research comes from government agencies such as the NSF, the U.S. Department of Energy and the National Oceanic and Atmospheric Administration, as well as from private partners such as Public Service Electric and Gas and SCG of Thailand.

Laboratory for the Mechanics of Advanced Materials
Shawn A. Chester, Director

The primary research goal of the Laboratory for the Mechanics of Advanced Materials is to understand interesting and exciting phenomena in solid mechanics, particularly multiphysics material behavior. Multiphysics behavior occurs when multiple physical phenomena are present in a material's response, beyond deformation. For example, temperature can have a profound impact on the stiffness of materials and some oils degrade the strength of a material over time. Research includes experimental, theoretical and computational solid mechanics. The laboratory works on

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continuum-level descriptions of polymeric behavior of materials, including polymer gels, dielectric elastomers and shape-memory polymers, among others. The lab's general procedure is to conduct experiments to obtain the material's behavior over a wide range of environmental conditions; to develop constitutive models to capture that behavior; to develop and implement numerical procedures for use in finite element simulations; and lastly, to validate the constitutive model and its numerical implementation in exciting representative applications.

Micro and Nano Mechanics Laboratory
Siva Nadimpalli, Director

The Micro and Nano Mechanics Laboratory in the Department of Mechanical and Industrial Engineering aims to provide a fundamental understanding of the mechanics of deformation, fracture, degradation, and the failure of solid materials such as metals, ceramics, polymers and other emerging materials, using a combined experimental and modeling approach. The current focus of this lab is to understand the role of mechanics phenomena in the degradation of lithium-ion batteries to help develop durable and light-weight battery designs for automotive and other future energy-storage needs. The unique facilities of this lab include the experimental apparatus to carry out real-time stress and mechanical property measurements while the battery electrodes are being electrochemically cycled. We also have the ability to make mechanical property measurements in both hot and cold environments. We develop new nano- and micro-scale testing methods to understand the mechanics at nano- and microscale pertaining to the interface fracture, degradation, and failure of solids.

Nanoelectronics and Energy Conversion Laboratory
Dong-Kyun Ko, Director

Research in the Nanoelectronics and Energy Conversion Laboratory focuses on the discovery of new nanomaterials, the design of novel high-performance device structures, and the experimental demonstration of device prototypes. Our particular interest is in colloidal quantum dot-based devices, in which semiconductor nanocrystals with tailored electronic properties are used as fundamental building blocks to construct various electronic and optoelectronic devices from the bottom up. This approach provides an opportunity to exploit unique properties arising from nanoscale components and to explore unconventional device concepts and designs for energy harvesting and optical sensing. One of our recent efforts includes the development of paper-based thermoelectric devices that offer a compelling combination of low-cost, high-throughput fabrication and flexible form. These devices can produce electrical power efficiently from body heat with applications ranging from wearable electronics to sensor-based healthcare monitoring and improvement. Other projects include quantum dot-based sensors and imagers that concentrate on developing new infrared sensing nanomaterials and device structures for high sensitivity photodetection.

Nano-Optoelectronic Materials and Devices Laboratory
Hieu P. Nguyen, Director

The Nano-Optoelectronic Materials and Devices Laboratory develops high-performance nanophotonic and nanoelectronic devices for lighting and energy-storage applications. Such devices are fabricated from gallium nitride (III-nitride)-based semiconductors in the form of nanostructures devised through a state-of-the-art epitaxial growth technique called molecular beam epitaxy. The direct energy bandgap of the III-nitride material system covers a wide energy range from ~ 0.65eV to 6.4eV, which encompasses nearly the entire solar spectrum. It has emerged as a powerful platform to effectively scale down the dimensions of future devices and systems. The group seeks to develop high-power laser diodes, emitting light in the green and ultraviolet spectrum regimes, using these III-nitride nanostructures. In other projects, the group aims to develop superior-quality III-nitride nanostructures wherein we will investigate the epitaxial growth, characterization and applications of III-nitride nanostructures. We believe this will provide an ideal materials system and device structure for applications in biological sensors, solid-state lighting, digital displays, electronic textiles, water-purification systems, solar cells, and hydrogen generation and carbon-dioxide reduction for future clean, storable and renewable source of energy.

Operations Management Laboratory

Wenbo Selina Cai, Director

The Operations Management Laboratory aims to advance the understanding of the impact of key players' decision-making processes on the design, pricing, and management of products and services in supply-chain management. Theories and methodologies in both operations research and microeconomics, such as stochastic processes, optimization, and game theory, are used. Research topics include accelerating the implementation of carbon-capture and storage (CCS) technology through the design of economic incentives and optimal service contracts among participants of CCS networks; improving the performance of primary healthcare services through stochastic scheduling and optimal capacity allocation among reserved and urgent patients; and examining the economic and environmental implications of adopting additive-manufacturing technology in the retail and supply chain.

Resilient and Sustainable Infrastructure Materials and Structures Laboratory

Matthew P. Adams and Matthew J. Bandelt, Co-Directors

The Resilient and Sustainable Infrastructure Materials and Structures Laboratory is a research center focused on improving the knowledge base of materials and structures in the built environment and reengineering them for the future. The laboratory consists of experimental and computational facilities capable of evaluating the performance of existing and emerging construction materials and structures from the nanometer to the meter scale. Recent research has focused on the behavior of sustainable materials, such as recycled concrete aggregates (RCA), and resilient and damage-tolerant materials, such as high-performance fiber-reinforced concrete (HPFRC). Ongoing laboratory upgrades will allow for testing, characterization, and modeling of other sustainable and resilient materials and structures. RCA materials are being used in pavement design, such as for the Illinois Tollway, to increase sustainability and reduce cost; HPFRCs are being deployed in bridge structures, such as the Pulaski Skyway Project, to decrease construction time, and in earthquake-resistant buildings, such as the Lincoln Square Expansion in Bellevue, Washington, to increase ductility and damage tolerance.

Sustainable Environmental Nanotechnology and Nanointerfaces Laboratory

Wen Zhang, Director

This laboratory integrates concepts and principles of nanotechnology and sustainability into the research and education activities of the environmental engineering discipline. Our mission is to apply interdisciplinary knowledge to address the challenges society faces in achieving environmental sustainability. Research is focused on several areas: material characterization at nanoscale using a hybrid atomic force microscope (AFM); the environmental behavior and physicochemical processes of nanomaterials; novel photocatalytic processes for harnessing renewable energy and degrading pollutants; microalgae-harvesting and removal technologies using magnetophoretic-separation and reactive-membrane filtration; chemically-modified polymeric and ceramic-membrane systems for removing emerging contaminants. In the investigations of nanomaterial interfaces, this laboratory specializes in particular in performing in situ measurements of multiple materials' properties using a combination of AFM, Raman, and IR (Hybrid AFM). The properties that could be acquired at a local nanoscale include morphology, surface potential, electronic structures, hydrophobicity, chemical compositions, distribution and quantification. Holistic and accurate measurements of these properties are critical for devising sustainable functional nanomaterials and devices in catalysis, fuel cells, nanomedicine, drug delivery, pollution treatment and remediation.

DATA SCIENCE AND INFORMATION TECHNOLOGY

Center for Big Data

Chase Wu and Yi Chen, Co-Directors

The mission of the Center for Big Data is to synergize the strong expertise in various disciplines across the NJIT campus and build a unified platform that embodies a rich set of big data-enabling technologies and services with optimized performance to facilitate research collaboration and scientific discovery. Current research projects at the Center focus on the development of high-performance networking and computing technologies to support big data applications. We are building fast, reliable data-transfer systems to help users in a wide spectrum of scientific domains move big data over long distances for collaborative data analytics. We are also developing high-performance workflow processes to manage the execution of and optimize the performance of large-scale scientific workflows in various big data computing environments, including Hadoop/MapReduce and Spark. For example, we developed a platform for analyzing user-contributed social-media data to discover adverse drug effects, a leading cause of death. 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. These projects have been supported by the Leir Charitable Foundations, the National Science Foundation and Google.

Center for Computational Heliophysics

Alexander Kosovichev, Director

The primary goal of the Center for Computational Heliophysics is to develop data analysis and modeling tools in the area of heliophysics – the study and prediction of the Sun's magnetic activity – by combining expertise from computer scientists in the Ying Wu College of Computing and from physicists and mathematicians in the College of Science and Liberal Arts. We work in partnership with NASA's Advanced Supercomputing Division at the NASA Ames Research Center. The Center's work is focused on novel, innovative approaches, including the development of intelligent databases, automatic feature identification and classification, realistic numeric simulations based on first-physics principles and observational-data modeling. The Center develops synergies among these approaches to make substantial advances in heliophysics and computer science. Our new methods and tools can be used in broader scientific and engineering applications for developing new approaches to intelligent big data databases as well as for image-recognition and characterization methodologies in collaboration with the Computer Science Department. The computational models have been used for modeling the magnetic activity of other stars in support of NASA's Kepler mission and the effort to search for extraterrestrial life.

Cybersecurity Research Center

Kurt Rohloff and Reza Curtmola, Co-Directors

Cyber technologies are critical in modern society and include communication networks, hand-held computers, cloud-computing environments and embedded computing technologies that are integrated into all modern automobiles, airplanes and military systems. The Cybersecurity Research Center seeks to address ongoing and long-term future cybersecurity needs for protection and further economic development across the State of New Jersey, nationally and internationally. The Center develops new methods for understanding how modern cyber systems can be compromised and fail, how to design cyber systems so they are secure, and how to improve or fix the cyber infrastructure that has already been deployed. Current areas of investigation to address these challenges include developing and applying new approaches to practical encryption, secure cloud-computing services, privacy technologies, improved software-engineering techniques, better data-encoding and communication protocols, and research on human factors. The Center is primarily affiliated with the Ying Wu College of Computing but is intended to be highly collaborative and inclusive, with the goal of including and supporting collaboration with researchers outside of the college and with researchers and practitioners outside of the university. The Center is supported exclusively through external research funds, including from the U.S. Department of Defense and the National Science Foundation. Current collaborators include MIT, Ecole Polytechnique Federale de Lausanne, Raytheon and the U.S. Navy's Space and Naval Warfare Systems Command, among others.

Leir Center for Financial Bubble Research

William Rapp, Director

The Leir Center for Financial Bubble Research seeks to understand through quantitative and qualitative research how a financial bubble can be identified, including its stages of development and what policies can best manage its impacts. The Center examines recent financial crises with the goal of developing a more precise understanding of what constitutes a bubble and what does not. Behavioral characteristics such as over-optimism or pessimism regarding policy, investments and contracts are areas of inquiry. Importantly, the Center's objective is to take an approach to bubble research that focuses on analyzing bubbles in ways that are meant to be useful to practitioners. The proximate "customers" for the research findings are other academics interested in finance and financial institutions generally and in economic instability more particularly. The Center's research on the links between disruptive technologies and bubbles will have relevance for the study of entrepreneurship, which is another area of research focus for the Martin Tuchman School of Management. Outside of academia, we expect significant interest within the financial community and by relevant government regulators.

Structural Analysis of Biomedical Ontologies Center

Yehoshua Perl and James Geller, Co-Directors

The Structural Analysis of Biomedical Ontologies Center (SABOC) is an interdisciplinary research center linking computer science and medicine. It deals with medical terminologies and ontologies, a subject of study that is a sub-field of Medical Informatics. Many biomedical terminologies are measured in the tens of thousands to hundreds of thousands of terms, including drug names and their chemical ingredients, symptoms, diagnoses, body parts, medical procedures, medical devices, infectious agents and accidents, among others. These medical terminologies are hard to understand and contain inconsistencies. Understanding them and finding inconsistencies with textual representations is difficult, and graphical representations are therefore used. In a graphical representation, biomedical terminologies appear as networks in which the terms are symbolized as boxes and the relationships between pairs of terms are symbolized as arrows. Without a sophisticated approach, visualizing these networks on a computer screen can lead to failure. The core research efforts of SABOC are to develop small abstraction networks that summarize large biomedical terminologies; to visualize abstraction networks on a computer screen in a manner that is easier to comprehend than the original terminologies; and to perform quality assurance on the original terminologies by using the abstraction networks to find and remove inconsistencies. As biomedical terminologies are increasingly used in applications such as Electronic Health Records (EHRs), ensuring that terminologies are free of inconsistencies helps ensure the correctness of these applications. SABOC is currently funded by a three-year, $1.75 million grant from the National Institutes of Health.

Advanced Networking Laboratory

Nirwan Ansari, Director

The Advanced Networking Laboratory (ANL) engages in research to improve the performance, dependability and trustworthiness of telecommunications networks. The goals of the ANL are to identify, model, simulate and demonstrate next-generation networking technologies and to add to the knowledge base for next-generation networks, to train tomorrow's network-engineering innovators and to foster industrial collaboration and international partnerships. ANL innovations are disseminated via patent disclosures, journal publications, conference presentations, and presentations to funding sponsors and prospective users. For example, ANL, in collaboration with NEC America, has made advances in passive optical networks. The National Science Foundation (NSF) has supported its investigations into finding a new way to provide services to a growing set of traffic classes in next-generation networks. ANL has led an international collaboration between Japan and the U.S. to identify and to develop advanced security technologies for the next generation of ubiquitous networks under the Strategic International Cooperative Program between Japan's Science and Technology Agency and NSF. Three other recent NSF projects include: FreeNet: Cognitive Wireless Networking Powered by Green Energy to liberate wireless access networks from spectral and energy constraints; GATE (Greening At The Edges) to transform the access portion of communications infrastructure into an energy-efficient version; and REPWiNet (Renewable Energy Powered Wireless Networks) to efficiently power future wireless networks by renewable energy.

Face Recognition and Video Processing Laboratory

Chengjun Liu, Director

The Face Recognition and Video Processing Laboratory develops advanced theoretical methods and applies them to solve problems such as facial recognition, image search, video retrieval, big-data analytics and visualization. These areas have broad applications in Smart City areas such as security and the Internet of Things and in face searches in social media and Web portals such as Facebook and YouTube. Specifically, we focus on pattern-recognition, machine-learning, image-processing and computer-vision research and development with applications in biometrics and security. We have developed advanced pattern-recognition and machine-learning methods, innovative similarity measures and novel color models, local-image descriptors and patented face-detection technology. Our methods have been successfully applied to face recognition, face detection, iris detection and recognition, image-search and image-category classification for homeland security, justice and law enforcement, as well as for business applications.

Intelligent Internet and Information Systems Laboratory

Songhua Xu, Director

Research activities in the Intelligent Internet and Information Systems Lab focus on web intelligence, online content search, understanding, mining, and recommendation, with particular emphasis on information retrieval and knowledge discovery regarding biomedical contents. The lab has conducted extensive studies on automatic document-content understanding, text mining, and text-information fusion from multiple sources. The lab's research portfolio further includes projects on artificial intelligence, computer graphics and visualization techniques, human-computer interaction, digital art and design, and calligraphy. The lab holds 25 approved invention patents and 55 registered software copyright licenses. Recent externally funded projects of the lab include big data computing for cancer informatics. The Internet and online social media have revolutionized the way medical knowledge is disseminated and health information is exchanged and shared among patients, supporters, and health care providers. Online patient communities have grown substantially with millions of active participants from all age groups. Recent studies on researching and analyzing social media content for health-related applications show that these cyber trends provide access to valuable health information, traditionally acquired with scientific methods such as observational epidemiological studies. Our research leverages the power of online content, including user-generated content on social networking sites, to tackle complex migration patterns and their effect on environmental cancer risk.

Social Interaction Laboratory

Donghee Yvette Wohn, Director

The Social Interaction Lab is an interdisciplinary research hub that combines psychology, communication, computing, and design to understand how people interact with technology, a field known as human-computer interaction (HCI). We are particularly interested in studying technologies that are social, such as social media, mobile-health apps, and multiplayer games. Many of our current projects revolve around technology and mental health, including the development of a mobile app to help women in STEM and using bots to facilitate social support in virtual environments.

TRANSDISCIPLINARY AREAS

Center for Applied Mathematics and Statistics
Lou Kondic, Director

The Center for Applied Mathematics and Statistics (CAMS) is an interdisciplinary research center dedicated to supporting research in the mathematical sciences. CAMS brings researchers from academia, industry and government to NJIT by organizing the annual "Frontiers in Applied and Computational Mathematics" meeting and other workshops. CAMS activities include support for the submission of interdisciplinary research proposals and a summer program for graduate students. We are working on modeling and simulations of the systems belonging to a general category of soft matter, including thin liquid films of nanoscale thickness, liquid crystals, granular matter and, more recently, colloids. Research techniques involve developing new models as well as numerical simulations of nonlinear ordinary and partial differential equations. The research approach is interdisciplinary and involves collaborations with colleagues from a variety of disciplines at NJIT, as well as nationally and internationally.

Enterprise Development Center
Jerry Creighton Sr., Director

The Enterprise Development Center (EDC) is a business-development and commercialization center with an ecosystem designed to advance high-tech and life-science entrepreneurial initiatives. The array of service programs available at the EDC combines student, faculty and NJIT resources with a "know-how" network of subject-matter experts, partnerships, interactions among resident companies, and university and business and government collaborations as needed to assist resident companies with R&D tasks, and to provide advice on meeting business-development milestones, scaling their businesses and preparing to obtain access to capital.

Intelligent Transportation Systems Resource Center
Lazar Spasovic, Director

The Intelligent Transportation Systems (ITS) Resource Center was established as a research and technology resource for the New Jersey Department of Transportation's Division of Traffic Operations and Division of Mobility and Systems Engineering. ITS utilizes roadside sensing, information and communication technologies and integrates them into traffic-engineering and management practices with the goals of reducing congestion and improving the mobility, safety, and efficiency of the transportation system in support of sustainable regional growth and economic development. The main purpose of the Center is to conduct research studies of innovative ITS technologies and optimize strategies for their deployment in the regional transportation system. This is accomplished through technology assessment, the evaluation of strategies and deployment scenarios, concept-development studies and technology transfer and training. The Center and its laboratory also serve as a test bed for innovative and promising new ITS technologies. They include vehicle sensing and traffic-flow monitoring, automated traffic-incident detection and emergency response, active traffic management using traffic sensors and wireless communication, traffic and transportation data analytics, ITS system integration, and the introduction of connected and autonomous (driverless) vehicle technologies on our roadways. From a teaching and learning standpoint, the Center builds on and further strengthens NJIT's competencies and national stature in the research areas of information and communication technology and sustainable systems and infrastructure. The Center also serves as the nexus among federal and state transportation agencies, the regional academic research community and the private sector engaged in the development and implementation of innovative transportation-intelligence technology and services.

New Jersey Innovation Institute
Donald Sebastian, President

The New Jersey Innovation Institute (NJII) is an NJIT corporation focused on helping private enterprise meet the grand challenges shared across an entire sector while also helping individual companies innovate new product or market opportunities and develop new strategic business partnerships that embrace emerging technology. It is unique in its formation and role as a not-for-profit corporation in pursuit of economic development and in its agility in transforming intellectual capital into commercial success. More broadly, NJII is driving economic-cluster development, entrepreneurship and enterprise expansion. NJII has strategically organized Innovation Labs (iLabs) serving market verticals to follow industry-led agendas. The five initial iLabs serving as the catalyst for collaboration among the academic, private and public sectors are:

- Healthcare Delivery Systems: NJII helps create new models of evidence-based healthcare. Building on the secure exchange of digital information, these new delivery systems improve the quality of care and foster new medical-device technology to lower costs and improve outcomes.

- Biotechnology and Pharmaceutical Production: NJII helps pharmaceutical companies develop and apply innovative, cost-saving manufacturing technologies and works with biotechnology firms to scale innovation from lab to commercial production.

- Civil Infrastructure: Drawing on leading-edge engineering and materials science, NJII works with partners on innovative solutions to upgrade public infrastructures and develop resilient systems to withstand natural disasters. Solutions include advanced materials, new design and construction methods, and smart-building and sensor technologies.

- Defense and Homeland Security: NJII helps address the demands of national security and defense, including port security, biometric and sensor-based detection systems, unmanned systems, weapons, energetics and material logistics, as well as communications projects and security systems for infrastructure defense, command, control and first-responder support.

- Financial Services: NJII partners with financial and information-technology professionals on issues ranging from identifying and mitigating the impact of financial bubbles to developing and implementing new supply chain-management systems, data analytics for applications ranging from computer-based trading to actuarial assessment and application design to facilitate new customer services.

Otto H. York Center for Environmental Engineering and Science
Som Mitra, Director

The Otto H. York Center for Environmental Engineering and Science offers core and shared research laboratory facilities as a resource for many interdisciplinary research programs and initiatives. The Center was the first building in the nation especially constructed for cooperative public and private research in hazardous wwaste management. Today, it has diversified into many other areas with research projects in nanotechnology, drug-delivery systems, particle engineering, microfluidics, membrane science, environmental science and engineering and biomedical engineering. Researchers from a range of disciplines—chemistry, environmental science, chemical engineering, biomedical engineering, mechanical engineering, material science and pharmaceutical engineering—have laboratories in the Center with extensive facilities in microscopy, mass spectrometry and material characterization. York Center research projects are funded with faculty grants from agencies such as the National Science Foundation, the National Institutes of Health, the National Institute of Environmental Health Sciences, the U.S. Department of Defense and from leading industries. The Center also provides Faculty Instrument Usage Seed Grants (FIUSG) for the use of core laboratories. The purpose of these grants is to promote research across campus by providing free instrument time to obtain preliminary results that will lead to the development of new ideas and grant proposals. The FIUSG initiative also aims to support the launch of new initiatives in core and interdisciplinary emerging areas aligned with NJIT's strategic interests.

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