# RESEARCH

RENSSELAER RESEARCH REPORT 2017

## **Mission** : : **Research**

I am pleased to share with you the 2017 Rensselaer Research Report, which highlights the advances made throughout a growing and vibrant Rensselaer research enterprise driven by our faculty, students (both graduate and undergraduate), and research staff. Our overall research expenditures once again met our core target of $100 million and we have seen research awards climb over 10 percent in FY2016 and into the first third of FY2017. This bodes very well for increased research activity across campus over the next several years.

Our sponsored research expenditures fall largely under our five Signature Research Thrusts: Biotechnology and the Life Sciences; Computational Science and Engineering; Media, Arts, Science, and Technology; Energy, Environment, and Smart Systems; and Nanotechnology and Advanced Materials. Emanating from these pillars of the Rensselaer research ecosystem are broad research platforms that have resulted from the nearly $1.25 billion investment by the university since 2001.

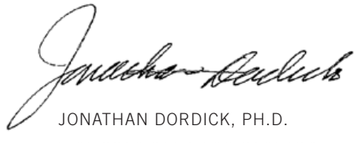
This year we launched our newest institute, the **Cognitive and Immersive Systems Laboratory (CISL) at EMPAC** under the direction of Dr. Hui Su. CISL has begun to link cognitive computing with physically immersive environments that drive multi-individual decision-making in complex situations ranging from a cognitive boardroom to a cognitive classroom. The **Center for Materials, Devices, and Integrated Systems (cMDIS)** under the direction of Dr. Robert Hull has built an extensive faculty membership, currently numbering 90, and this augments an active student and postdoc program. "Research Nucleation Workshops" are defining new areas of research with critical mass at Rensselaer, including workshops being jointly sponsored by major companies. Such interaction with major corporate research institutions will enable preferential access to major equipment not available at Rensselaer. The cMDIS continues the longstanding excellence of nanotechnology at Rensselaer. As part of the inaugural class of NSF-funded Nanoscale Science and Engineering Centers in 2001, Rensselaer has continually advanced both fundamental and applied research in directed assembly of nanoscale materials, which links basic principles of physical, biological, and computation sciences to generate new materials and devices that impact human health, energy efficiency, and manufacturing technologies. Within the cMDIS are three Institute-Wide Centers focused on the built environment (Center for Architecture Science and Ecology), advanced renewable energy (Center for Future Energy Systems), and robotics and advanced manufacturing (Center for Automation, Technology, and Systems).

We live in a data-driven, web-enabled, supercomputer-powered, globally interconnected world. This is a world that Rensselaer has helped to create. It is a world in which Rensselaer is uniquely positioned to help humanity use the remarkable technological tools at its disposal to answer the grand challenges surrounding energy, water, food, and national security, human health, climate change, and the allocation of scarce natural resources. Guiding us through these myriad challenges is the **Rensselaer Institute for Data Exploration and Applications (IDEA)** under the direction of Dr. James Hendler. Research contracts have been established or expanded with a large number of companies, medical centers, and government agencies. Groundbreaking work on health-care data analytics resulted in a joint NIH grant on child health and development with our partners at the **Icahn School of Medicine at Mount Sinai**, as well as potential expansion of multi-hospital predictive data analytics. The **Jefferson Project at Lake George**, led by Dr. Rick Relyea, plays into the heart of IDEA, wherein the first wave of advanced sensors was deployed, enabling data acquisition of the lake's food web, creating physical models, and conducting a wide range of laboratory and outdoor mesocosm experiments that will elucidate the underlying natural and anthropogenic causes of changes in water quality and ecosystem resilience.

The Rensselaer research enterprise is buoyed by an immense computational platform through the **Center for Computational Innovations (CCI)** led by Dr. Christopher Carothers. The CCI is powered by IBM BlueGene/Q supercomputers that now provide over 1.2 petaflops (and growing) of computational power that enables high-end modeling and simulation studies to be performed. This predictive and prescriptive analytics infrastructure is further advanced through access to the IBM Watson cognitive computing engine, both in house at CCI (Rensselaer was the first institution that housed a Watson computing system) and in the cloud.

Within the expansive **Center for Biotechnology and Interdisciplinary Studies (CBIS)** led by Dr. Deepak Vashishth, growth of large-scale translational research has occurred, leading to new tools and knowledge at the biomolecular, cellular, and organismal levels that will ultimately impact the design of new products and processes to benefit society. Indeed, the intersection of life sciences with the physical sciences, computational sciences, and engineering brings together a growing cadre of interdisciplinary biotechnology researchers, supported by the world-class CBIS infrastructure that has led to an increase in federal and industry research funding. From complex biological networks to nanoscale assemblies that mimic biological processes, scientists and engineers in CBIS have elucidated the molecular basis of biological mechanisms and disease, exploited biological systems for the discovery and development of new therapeutics, and developed new cellular niches critical to advance tissue regeneration.

I hope you enjoy the 2017 Rensselaer Research Report, highlighting a number of our exciting discoveries and accomplishments that are helping Rensselaer to change our world for the better.



JONATHAN DORDICK, PH.D.
VICE PRESIDENT FOR RESEARCH
HOWARD P. ISERMANN PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING

Curiosity knows no bounds. We hunger to understand the world around us through patterns, data, explanations, interpretations, relationships, and more. Our most creative thinkers mine knowledge across disciplines for metaphors, connections, contexts, models, and ideas that can be applied fruitfully in new venues. By sharing the perspectives of colleagues with different points of view, researchers hone their questions and improve experiments. In fact, the practice of science is predicated on exposing hypotheses and discoveries to open inquiry, analysis, and criticism. Reaching out broadly and working with people with varied backgrounds is the backbone of effective research. It takes advantage of the differences in ways that reveal the consistency and unity in nature.

**At Rensselaer, we encourage a focus by both our students and our faculty on the great global challenges**—humanity's food, water, and energy supplies; human health and the mitigation of disease; our great need for sustainable infrastructure; national and global security; and the intelligent allocation of valuable natural resources.

Looking past boundaries and working in the spaces between is part of our heritage. In recent years, we facilitated bringing together partners in different fields of inquiry through the establishment of the Center for Biotechnology and Interdisciplinary Studies. And because new combinations of knowledge can occur by serendipity, Rensselaer created the Curtis R. Priem Experimental Media and Performing Arts Center, which draws together under one roof artists, social scientists, engineers, and those who explore the hard sciences.

We continue to pursue collaborations among people whose diverse backgrounds and perspectives promise new ventures that can provide answers to humanity's most important questions. This is why we have embraced the perspective of The New Polytechnic, which recognizes that the divisions between areas of inquiry are artificial, and it is often fruitful to find fresh perspectives and to re-contextualize and reimagine familiar concepts. In this way, we gain the insights needed to innovate and to discover truths that would otherwise be invisible to us.



**"We are bringing together two separate strains of emergent technologies to enhance the power of the other: cognitive computing technologies coupled with intensive visual and auditory immersive environments we are developing at Rensselaer."** PRESIDENT SHIRLEY ANN JACKSON

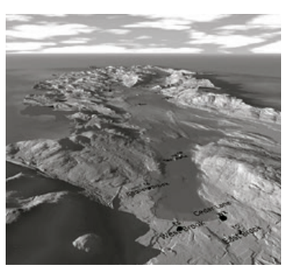
Researchers targeted a group of neurons in the hypothalamus area that plays a vital role in maintaining blood glucose levels. The team used magnetic forces to remotely control the flow of ions into specifically targeted cells in mice.

**34**
research centers

**24**
core lab facilities

### Smart Sensors

With $917,000 in recent support from the NSF, the Jefferson Project at Lake George is poised to complete the most powerful aquatic monitoring sensor network in existence. A collaboration between Rensselaer, IBM Research, and The FUND for Lake George, the multimillion-dollar project aims to develop a new model for technologically enabled environmental monitoring and prediction to better understand and protect the lake's ecosystem.



## ROOMS WITH A VIEW

**Rensselaer and IBM Research have launched a multi-year collaboration to pioneer new frontiers in the scientific field of cognitive and immersive systems.** The research collaboration will be housed in the newly established Cognitive and Immersive Systems Lab (CISL) in the Curtis R. Priem Experimental Media and Performing Arts Center.

CISL's mission is to explore and advance natural, collaborative problem-solving among groups of humans and machines. The lab is built around a futuristic "Situations Room" that can be adapted to industry-specific environments (including cognitive boardrooms, design studios, diagnosis rooms, and immersive classrooms) and is designed to uncover new ways to improve how people work together.

"With the new lab, we are taking an important step toward a future in which smart machines and smart humans potentiate each other, and the end result is better decisions and outcomes," said President Shirley Ann Jackson. "We are bringing together two separate strains of emergent technologies to enhance the power of the other: cognitive computing technologies coupled with intensive visual and auditory immersive environments we are developing at Rensselaer."

"Cognitive computing is poised to transform every profession, industry, and economy, and immersive cognitive systems will play a vital role in shaping the symbiotic work environments of the future in which critical business decisions will be made," said John Kelly III '78, senior vice president, solutions portfolio and research at IBM and a member of the Rensselaer board of trustees. "We are excited to collaborate with Rensselaer on the development of this new frontier as we continue to progress the science that will transform the way professionals around the world work."

Cognitive computing systems are designed to collaborate with human experts in more natural ways, learn through this interaction, and enable individuals and teams to make better decisions by making sense of massive unstructured data. The CISL platform is an immersive, interactive, reconfigurable physical environment that enhances group cognition. It proactively responds to its occupants by "listening" to and "watching" them, engages multiple users working in small groups at the same time on different aspects of a larger activity, and explores interactions and visualizations that would be impossible with a few people looking at limited screens.

HUMAN HEALTH

## ON/OFF SWITCH

**To learn what different cells do, scientists switch them on and off and observe the effects.** There are many methods that do this, but they all have problems: too invasive, too slow, or not precise enough. Now, a new method to control the activity of neurons in mice, devised by scientists at Rensselaer and Rockefeller University, avoids these downfalls by using magnetic forces to remotely control the flow of ions into specifically targeted cells.

Jonathan Dordick, the Isermann Professor of Chemical and Biological Engineering and vice president for research at Rensselaer, and colleagues successfully employed this system to study the role of the central nervous system in glucose metabolism. The findings suggest that a group of neurons in the hypothalamus plays a vital role in maintaining blood glucose levels. Glucose metabolism is fundamental to human health, and a mechanism for controlling metabolism through remote activation of specific regions of the brain may provide new routes to therapies for a range of important diseases.

"These results are exciting because they provide a broader view of how blood glucose is regulated —they emphasize how crucial the brain is in this process," said Jeffrey Friedman '77, Marilyn M. Simpson Professor and head of the Laboratory of Molecular Genetics at Rockefeller.

"We can imagine adapting this method in a number of *in vitro* applications in drug discovery," said Dordick. "Depending on the type of cell type we target, and the gene expression we enhance or decrease within that cell, this approach holds potential in development of therapeutic modalities, for example, in metabolic and neurologic diseases."

Previous work led by Friedman and Dordick tested a similar method to turn on insulin production in diabetic mice. The system couples introduction of a natural iron storage particle, ferritin, and a fluorescent tag to an ion channel called TRPV1.

## HOW REAL IS REALITY TV?

**According to June Deery, professor in the Department of Communication and Media, reality TV has changed television and changed reality, even for those who are not among the millions who watch.** Deery's latest publication, *Reality TV*, is written for a broad audience and it addresses questions such as: How real is reality TV? How do its programs represent gender, sex, class, and race? How does reality TV relate to politics, to consumer society, to surveillance? What kind of ethics are on display?

Drawing on current media research and the author's own analysis, the publication encompasses the history and evolution of reality television, its production of reflexive selves and ordinary celebrity, its advertising and commercialization, and its spearheading of new relations between television and social media.

"To dismiss this programming as trivial is easy," says Deery. "Today, reality television merits serious attention and I believe that the analysis included in this study will interest students in media studies, cultural studies, politics, and sociology—or anyone who is simply curious about this global phenomenon."

Deery's research focuses on media studies and she is particularly interested in contemporary television and its interface with the Internet. She writes on commercialization, politics, gender, and class. For some time, Deery has also been investigating cultural understandings of fact and fiction and is now exploring their status in multiplatform environments.

June Deery's book examines the impact of reality TV shows like *American Idol*.

## EXPLORING PHOSPHORENE

**Two-dimensional phosphane, a material known as phosphorene, has potential application as a material for semiconducting transistors in ever faster and more powerful computers.** But there's a hitch. Many of the useful properties of this material, like its ability to conduct electrons, are anisotropic, meaning they vary depending on the orientation of the crystal. Now, a team including researchers at Rensselaer has developed a new method to quickly and accurately determine that orientation using the interactions between light and electrons within phosphorene and other atoms-thick crystals of black phosphorus.

Phosphorene—a single layer of phosphorous atoms—was isolated for the first time in 2014, allowing physicists to begin exploring its properties experimentally and theoretically. Vincent Meunier, head of the Department of Physics, Applied Physics, and Astronomy and a leader of the team that developed the new method, published his first paper on the material—confirming the structure of phosphorene—that same year.

Meunier says Raman spectroscopy uses lasers to deliver energy toward the phosphorene that causes it to vibrate intrinsically. However, lighting the material from different directions would produce varying results because of the electron and light interaction within the material. With this, the electron-photon interaction, in itself, is anisotropic as well.

Meunier and researchers at Rensselaer contributed to the theoretical modeling and prediction of the properties of phosphorene, drawing on the Rensselaer supercomputer, the Center for Computational Innovations, to perform calculations. Meunier and his team are able to develop the potential of new materials such as phosphorene to serve in future generations of computers and other devices.

### National Competitiveness

Rensselaer, founded in 1824, is America's first technological research university. For nearly 200 years, Rensselaer people have been defining the scientific and technological advances of our world.

Rensselaer faculty (including a Nobel Prize winner in Physics) and alumni represent members of the:

National Academy of Engineering **84**

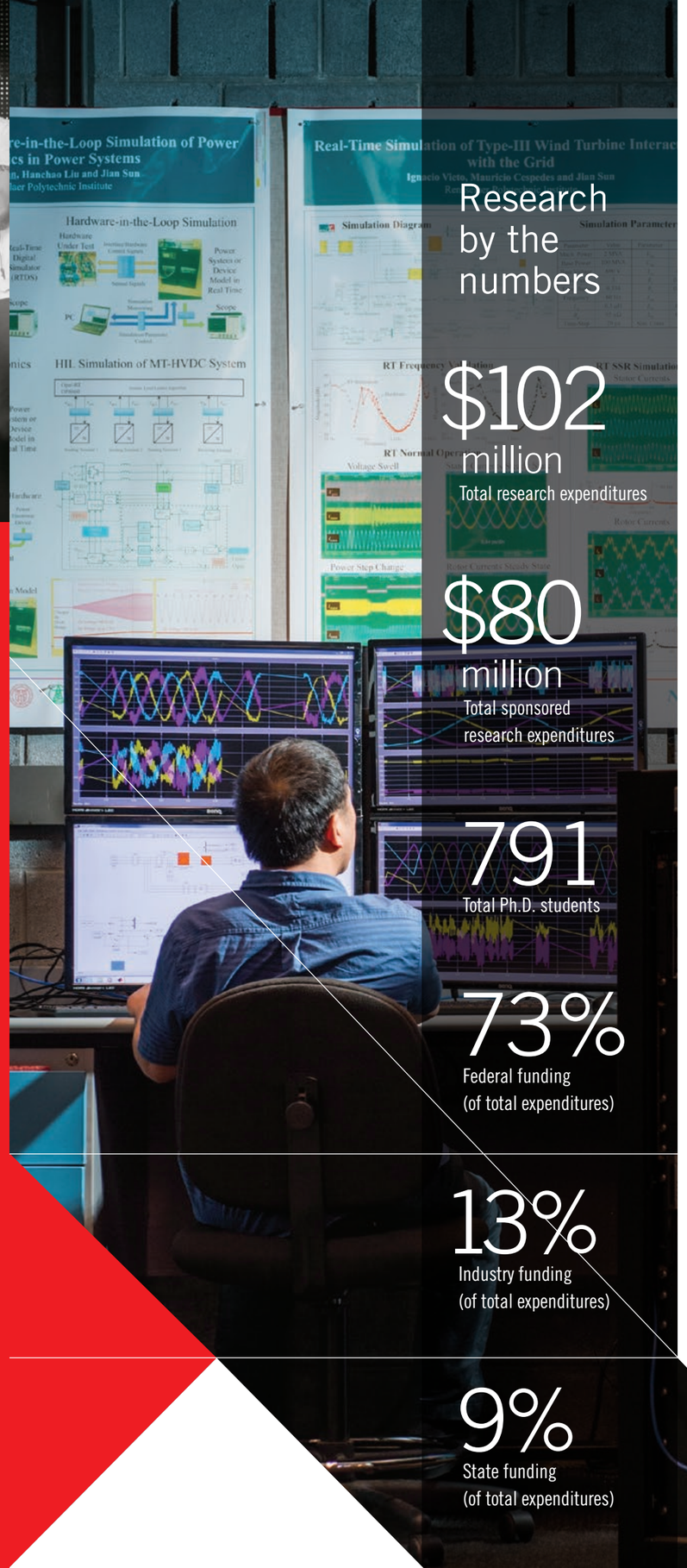
National Academy of Sciences **17**

American Academy of Arts and Sciences **25**

National Academy of Medicine **8**

National Academy of Inventors **7**

National Inventors Hall of Fame **4**




## Research by the numbers

**$102 million**
Total research expenditures

**$80 million**
Total sponsored research expenditures

**791**
Total Ph.D. students

**73%**
Federal funding (of total expenditures)

**13%**
Industry funding (of total expenditures)

**9%**
State funding (of total expenditures)

SUSTAINABILITY

## THE FUTURE OF ENERGY

**Today, the development of clean energy is critical to the economy and the environment of the state and the nation.** Recently, the Rensselaer Center for Future Energy Systems (CFES) was selected to receive a state grant re-designating the center as part of the New York State Center for Advanced Technology (CAT) Program. The 10-year designation amounts to over $9 million in investment into Rensselaer, the Capital Region, and New York state.

CFES is the locus of energy research at Rensselaer, where world-leading science and engineering researchers from all fields gather to collaborate on advancing energy technologies for the benefit and promotion of economic growth in New York. The center's research thrusts range from advanced materials for energy conversion and storage, to energy efficiency, renewable energy, smart grids, and grid resiliency.

"The Center for Future Energy Systems was chosen during a very competitive process to be one of 15 New York State Centers for Advanced Technology, and re-designation will enable the center to expand further its partnership, multiply its economic impacts, and help New York realize its vision for a cleaner, more efficient, and affordable future energy system," said Jian Sun, professor and CFES director.

CFES actively partners with small and mid-sized companies, global corporations, state and federal agencies, and educational institutions to accelerate energy research, move technologies from the laboratory to the marketplace, and ultimately build value and create jobs. Over the last decade, the center has worked with over 70 New York state companies, with a cumulative economic impact of $84 million, leading to the creation of more than 200 jobs.


**How It's Done**
Building panels made of upcycled coconut husks made a statement at the Chalewote Street Art Festival in Accra, Ghana, last summer. The panels were made of pressed coconut husk fibers and soy binders on a backing of recycled burlap bags, which are used in the cocoa export industry. In preparation, architecture students designed and developed a full-scale "Golden Cube" structure in front of the Greene Building on campus.

## TRANSFORMING WASTE INTO SUSTAINABLE BUILDING MATERIALS

**In Ghana, like many tropical countries around the world, people widely use and export coconuts for their fruit, milk, and cooking oil.** The husks are thrown away by the millions, leaving to waste what might instead be transformed into a multifaceted building material.

Building panels made of upcycled coconut husks made a statement at the Chalewote Street Art Festival in Accra, Ghana, last summer. The festival is a forum for showcasing experimental ideas in art and design.

"The coconut is not just any waste product; it has a lot of great properties," said Josh Draper, an architect and clinical professor at the Center for Architecture Science and Ecology (CASE), which hosts Rensselaer's graduate program in Built Ecologies. "The question is 'what if we could take it and make it into something useful and something beautiful for our buildings?'"

For seven years, researchers at CASE in New York City and in the School of Architecture in Troy have been developing building products from coconuts and other agricultural waste as a sustainable, low-energy alternative to plywood and other materials made with synthetic adhesives. They are using coconuts to create non-toxic wall modules and an acoustical panel system that can help cool buildings passively.

Ghana is a target country because construction is booming, building materials are largely imported, and coconuts are commonly used and their by-products are discarded.

The ropelike coir fiber extracted from a coconut husk is very strong. And the coir can be pressed with the coconut's pith, a dust in the husk that acts as a natural binder, to form a biocomposite that is as strong as plywood.

In addition, Draper says, the coir and pith are dessicants, which remove moisture and pollutants from the air. CASE researchers and other Rensselaer collaborators are developing an acoustical panel with these materials, which could save energy and money by reducing loads on air-conditioning.



SUSTAINABILITY

## DARK MATTERS

**Nanophotonics expert and physics professor Shawn-Yu Lin received the 2016 Institute of Electrical and Electronics Engineers (IEEE) Nanotechnology Council Pioneer Award in Nanotechnology "for pioneering contributions to the development of 3-D optical photo crystals and the discovery of the darkest nano-material on Earth."**

The darkest material was discovered by Lin and his team in 2008. The material, a thin coating comprised of low-density arrays of loosely vertically aligned carbon nanotubes, absorbs more than 99.9 percent of light and could one day be used to boost the effectiveness and efficiency of solar energy conversion, infrared sensors, and other devices. The research has been recognized by the *Guinness Book of World Records*.

The total reflectance of conventional black paint, for example, is between 5 and 10 percent (or absorptance of between 95 and 90 percent). The darkest man-made material, prior to the discovery by Lin's group, boasted a total reflectance of 0.16 percent to 0.18 percent (or absorptance of 99.84 to 99.82 percent).

The end result of Lin's work was a material with a total reflectance of 0.03 percent (or absorptance of 99.97 percent)—more than three times darker than the previous record, which used a film deposition of nickel-phosphorous alloy. Lin's darkest material has a higher absorptance than the recently reported value of 99.965 percent by Surrey NanoSystems. The original darkest material from Rensselaer is still the darkest man-made nano-material on Earth.

### Summer Research

Students from a variety of universities spent time on campus last summer engaged in undergraduate research programs. Students from Historically Black Colleges and Universities, the Hispanic Association of Colleges and Universities, and Rensselaer's own Summer Undergraduate Research Program worked with some 30 faculty advisers and graduate student mentors on a variety of research projects.




Shawn-Yu Lin was honored for developing the "darkest nano-material on Earth," which could have applications in photonics, electronic materials, and solar energy capture.

## Recent Research Partnerships

Bill & Melinda Gates Foundation

Boeing Company

Corning

Disney Imagineering

GlobalFoundries

IBM

Icahn School of Medicine at Mount Sinai

Medtronic

Mitre Corporation

Optum Labs

Tokyo Electron America

"Exposomics" is the comprehensive study of environmental exposures in humans, from conception through development. Rensselaer is part of the Children's Health Exposure Analysis Resource, whose goal is to assess the full range of environmental exposures that may affect children's health.





### Global Recognition

Two faculty members have been invited to join the World Economic Forum's Network of Global Future Councils. **Cynthia Collins** (above), associate professor of chemical and biological engineering, has been selected for the Global Future Council on Biotechnologies, and **Heng Ji** (below), the Edward P. Hamilton Development Chair and associate professor of computer science, has been selected for the Global Future Council on the Future of Computing.

HUMAN HEALTH

## IS YOUR CITY HEALTHY?

**Scientific research plays an integral role in how cities are governed, and in the cities' overall environmental health.** But policymakers in such areas as transportation and public health approach science from different perspectives, and, historically, they do not consider how their practices interrelate.

A $300,000 National Science Foundation (NSF) grant awarded to faculty in the School of Humanities, Arts, and Social Sciences will be used to examine how science is applied in six cities, and how it is used to manage air quality. Of significance is the fact that the study of science-based policies in six cities is being conducted through the lens of the humanities.

"This is an attempt to characterize the governance styles of officials, scientists, nonprofit organizations, and concerned citizens," said Kim Fortun, professor of science and technology studies and principal investigator on the project. "There are remarkable differences between, say, Houston and New York, which partly result from the political and cultural history of the places."

In addition to those two cities, the two-year project, "Environmental Health Governance in Six Cities: How Scientific Cultures, Practices and Infrastructure Shape Governance Styles," will study Philadelphia, Pennsylvania; Albany, New York; Bengaluru, India; and Beijing, China.

Teams in each city will examine policy governing the environment, health, transportation, and education. Researchers, coordinated by the core team at Rensselaer, will do extensive interviews with the stakeholders to see how they approach and apply science to address air pollution and other health threats.

"The relationships between the departments of environment, health, and transportation are often very minimal and they can benefit from seeing how they can work together to deal with air pollution," Fortun said. "We will involve these stakeholders in workshops so we all work together to address the health stressors."

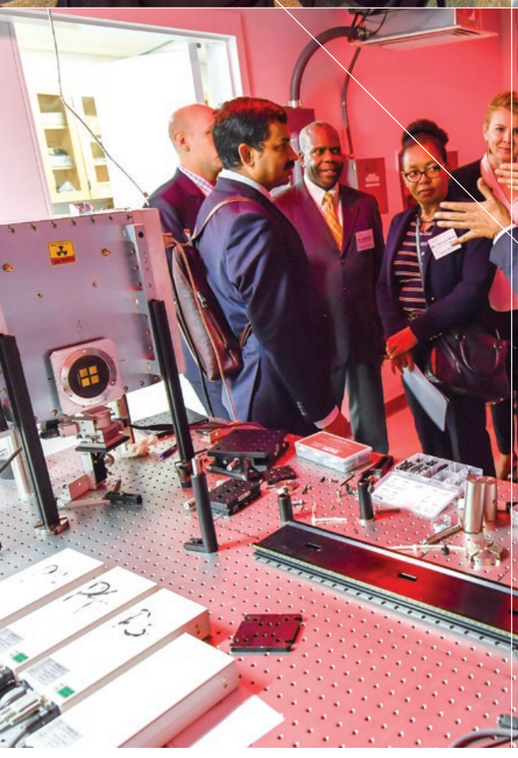
## "EXPOSOMICS"

**To support its groundbreaking work in the emergent field of "exposomics," the National Institutes of Health (NIH) has awarded two grants to research teams from Rensselaer and the Icahn School of Medicine at Mount Sinai.** In addition, the state of New York and Mount Sinai provided $3.2 million to these grants in matching funds through the state's Division of Science, Technology, and Innovation program; these funds were critical in securing the grants.

"Exposomics" is the comprehensive study of environmental exposures in humans, from conception through development. The grants, totaling $20 million over four years, are from the NIH's newly formed Children's Health Exposure Analysis Resource program, or CHEAR.

The first grant—made possible by the Icahn School of Medicine's partnership with Rensselaer—will be for a Data Repository, Analysis, and Science Center. The Data Center will address methodology for combining data from a wide range of environmental health studies, developing precise vocabularies for semantically accelerating the exposomics field, developing statistical approaches for analyzing exposomic/chemical mixtures, and performing big data science, integrating exposomics with genomics and epigenomics. The Rensselaer team's principal investigator, Deborah McGuinness, Tetherless World Research Constellation Professor, and co-principal investigator Kristin Bennett, professor of mathematical sciences, will lead the ontology and data science research for the data center.

Almost all diseases have both environmental and genetic causes. The overarching goal of CHEAR is to bring together environmental exposure measures with genomic measures of health risk.



25

foreign countries represented in "Global NY FDI Road Show"



GLOBAL RECOGNITION

## FOREIGN DIRECT INVESTMENT ROAD SHOW

**Last fall, representatives from 25 foreign countries and territories toured business and academic locations in the Capital Region**—including Rensselaer—as part of an initiative to attract foreign direct investment (FDI) to New York state. The two-day "Global NY FDI Road Show" made stops at three locations in the Capital Region, with 36 consuls general and other foreign representatives who traveled from New York City for the opportunity.

Lieutenant Governor Kathy Hochul, who addressed the leaders from six continents, said, "New York state has the talent and the resources to attract foreign investment in a number of industries. The more we expose the international community to the wealth of opportunities New York state has to offer, the more foreign direct investment we will attract."

At Rensselaer, the group spent a half-day in the Center for Biotechnology and Interdisciplinary Studies (CBIS). Speakers included Steve Rock, senior research scientist, who spoke about the work being done in the Center for Automation Technologies and Systems; Nick Viggiani, assistant vice president for research, who spoke about Rensselaer applied research and industry partnerships; and CBIS Director Deepak Vashishth, who gave an overview of the research at CBIS and who also led a tour of the facility. The session concluded with a working lunch led by Jonathan Dordick, vice president for research, who spoke on "Research That Matters."

NATIONAL COMPETITIVENESS

## JOE CHOW ELECTED TO NATIONAL ACADEMY OF ENGINEERING

**Joe Chow, power grid control expert and professor of electrical, computer, and systems engineering**, has been elected to the National Academy of Engineering (NAE). Chow was elected for his technical contributions to modeling, analysis, and control of large-scale power grids.

Election to the NAE is among the highest professional distinctions accorded to an engineer. Academy membership honors those who have made outstanding contributions to "engineering research, practice, or education, including significant contributions to the engineering literature" and to "the pioneering of new and developing fields of technology," according to the organization.

Over the past three decades, Chow has been at the cutting edge of electric power systems engineering. His work in modeling and control of large-scale power systems has growing applications in development and maintenance of smart grids. For example, his work on synchrophasors, devices that make real-time measurements of electrical quantities, allows new mechanisms to monitor the power grid for boosting the amount of energy that can be reliably transmitted on high-power, high-voltage electric grids.

Chow serves as the campus director of the Center for Ultra-wide-area Resilient Electric Energy Transmission Networks (CURENT), jointly funded by the National Science Foundation and the U.S. Department of Energy. CURENT is dedicated to developing the next generation of electric grids, or "smart grids," that promise higher efficiency, greater reliability, and the smooth integration of renewable energy sources into large power transmission systems.

**$80M**

will be provided by the Department of Defense to launch the ARM (Advanced Robotics Manufacturing) Institute, of which Rensselaer is a founding member.



**$70M**

will be provided by the Commerce Department to establish the National Institute for Innovation in Manufacturing Biopharmaceuticals. Rensselaer is part of this public-private partnership.



NATIONAL COMPETITIVENESS

## MANUFACTURING USA

Manufacturing USA, formerly the National Network for Manufacturing Innovation (NNMI), is a network of U.S. research institutes focused on advancing American manufacturing through public-private partnerships between U.S. industry, universities, and federal government agencies.

Through Manufacturing USA, industry, academia, and government partners are leveraging existing resources, collaborating, and co-investing to nurture manufacturing innovation and accelerate commercialization.

Rensselaer has taken a lead role in three new Manufacturing USA Institutes announced by President Barack Obama focusing on smart manufacturing, biomanufacturing, and robotics.

The Smart Manufacturing Leadership Coalition will lead the new Clean Energy Smart Manufacturing Innovation Institute (CESMII), in partnership with the Department of Energy.

The coalition brings together a consortium of nearly 200 partners from across academia, industry, and nonprofits—to spur advances in smart sensors and digital process controls that can radically improve the efficiency of U.S. advanced manufacturing.

The institute will focus on innovations that can dramatically reduce energy expenses in advanced manufacturing, making our manufacturing sector strong today and positioning the United States to lead the manufacturing of tomorrow, helping sustain the current resurgence of U.S. manufacturing.

CESMII will launch five regional manufacturing centers across the U.S., each focused on local technology transfer and workforce development. Rensselaer will lead the Northeast center for CESMII programs, involving regional partners from industry, academia, and government.

Overall, CESMII partners will bring more than $140 million in public-private investment from leading universities and manufacturers to develop smart technologies and systems for use in advanced manufacturing.

In biomanufacturing, Rensselaer will be a Tier 1 partner in the new $200 million public-private partnership to advance U.S. leadership in biopharmaceuticals. A $70 million award from the U.S. Commerce Department established the new National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL), complementing an initial private investment of at least $129 million from a consortium of more than 150 companies, educational institutions, nonprofits, and state governments.

NIIMBL, led by the University of Delaware, will advance U.S. leadership in the biopharmaceutical industry, foster economic development, improve medical treatments, and ensure a qualified biopharma workforce.

"This is a powerful new partnership that is uniquely positioned to have a profound impact on the state of the art in biomanufacturing of protein biologics, and cell and gene therapeutics," said Jonathan Dordick, vice president for research and the Howard P. Isermann Professor of Chemical and Biological Engineering. "Rensselaer has a long and distinguished history of important contributions to the field of biomanufacturing, and as a key member of NIIMBL, we expect that Rensselaer researchers will play a significant role in many aspects of this institute."

Rensselaer also is a founding member of the Advanced Robotics Manufacturing (ARM) Innovation Institute. The Department of Defense (DoD) will provide $80 million in federal funding to launch the ARM Institute, led by Carnegie Mellon University, to stimulate robotics technology development in manufacturing environments. The investment will be matched by a $173 million contribution pledged by the more than 220 partners that make up the winning coalition.

According to the Department of Defense, robotics is increasingly necessary to achieve the level of precision required for defense and other industrial manufacturing needs.

GLOBAL RECOGNITION

## PRESIDENT JACKSON PARTICIPATES IN WORLD ECONOMIC FORUM 2017

**President Shirley Ann Jackson was once again invited to participate in the World Economic Forum (WEF) Annual Meeting, held in Davos, Switzerland, January 17-20.** The theme for this year's meeting of global decision-makers was "Responsive and Responsible Leadership."

President Jackson has participated in this annual gathering of thought leaders in the Swiss Alps since 2008. A record 3,000 participants took part in over 400 panels, sessions, and conversations.

She led several panel discussions during the meeting, including one on "Leadership in the Age of Political Risk." She also co-led a Humanitarian Hub informal dialogue about "Measuring for Maximum Impact" with Kamalini Lokuge of the Humanitarian Research Program at Australian National University. The two led a conversation about the ways that data science can help us to better understand environmental health threats to children.

President Jackson also led a conversation that explored how museums and universities can (and already do) work with corporate partners to address global challenges. Panelists included Peter Salovey, president, Yale University; Lonnie Bunch, founding director, National Museum of African American History & Culture, Smithsonian Institution; and Franz Paasche, senior vice president, corporate affairs, PayPal.

In addition, she moderated a panel on "The Future of Warfare." The digital revolution is blurring the lines between war and peace and expanding the boundaries of the battlefield to new domains. The panel featured an intense discussion, led by President Jackson, with Jean-Marie Guéhenno, International Crisis Group; Sir Lawrence Freedman, Kings College; Mary Cummings, Duke University; and Jeanine Hennis-Plasschaert, Minister of Defense, Netherlands.

Other panels that President Jackson participated in included "Powering Mobility," which focused on the intersections between technological advances in the transportation sector and in the energy sector; "Cyber War," which examined attacks on critical infrastructure and attempts at sabotage of political processes; and "The Global Security Outlook."

## FIVE-STAR RESEARCH

**The increasing volume of online customer reviews of companies, products, and services requires organizations to carefully examine how they respond.** The complex question of if and how firms should respond to online reviews and the effects of managerial response on future customer attitudes has limited systematic research available.

Professor T. Ravichandran, the Irene and Robert Bozzone '55 Distinguished Professor in the Lally School of Management, presented his research on this current topic at the Copenhagen Business School as part of their "Renowned Scholars Seminar Series."

His talk was based on his research with doctoral student Chaoqun Deng. Their research shows that electronic word of mouth, as signified by customer reviews in online forums, has grown in importance in terms of its influence on customer attitudes and purchase decisions.

The study concludes that managers should interact with consumers carefully in the review community in response to expressed dissatisfaction in order to restore that company's reputation and brand image.

## WEF by the numbers

**3,000**
participants

**1,200**
chief executives

**50+**
world leaders

**20%**
women




GLOBAL RECOGNITION

## DATA PROJECT ADDRESSES CHILDHOOD STUNTING

**Rensselaer has received a grant of nearly $1 million from the Bill & Melinda Gates Foundation** for continuing work on a novel data visualization platform that will harness and accelerate the analysis of vast amounts of data for the foundation's Healthy Birth, Growth, and Development Knowledge Integration initiative.

This grant brings total giving from the foundation to Rensselaer over the course of this project to nearly $1,360,000.

The Healthy Birth, Growth, and Development Knowledge Integration (HBGDki) initiative aims to facilitate collaboration between researchers, quantitative experts, and policy makers in the search to identify the root causes and best solutions for addressing the serious problem of childhood stunting in developing nations.

According to the United Nations Children's Fund, more than a quarter of children under age 5 worldwide are permanently "stunted" due to malnutrition and other factors that are still poorly understood. Impaired growth and development are complex, multidisciplinary problems that involve diverse issues including nutritional deficiencies, environmental exposures, infectious diseases, water, and sanitation conditions.

The goal of the initiative is to enable broader impact of insights, through the integration of multidisciplinary data from past and ongoing studies, to identify the most effective intervention packages for promoting healthy birth, growth, and development in vulnerable populations.

"We welcome this additional support from the Bill & Melinda Gates Foundation to address a pressing worldwide challenge," said President Shirley Ann Jackson. "With the first phase of the project successfully completed, Rensselaer researchers and data scientists will now employ their extensive expertise and innovative technologies to develop a data visualization platform that will greatly enhance the effort to improve child health worldwide."

Anna Dyson, professor of architecture and director of the Center for Architecture Science and Ecology (CASE), is principal investigator on this phase of the project.

**+25%**
of children under age 5 are permanently stunted due to malnutrition and other poorly understood factors

Global Challenges: energy, water, food ✱ infrastructure, sustainability, resilience ■ climate change ● national/global security ✪ disease /disease mitigation ✚

# Signature Research Thrusts

Rensselaer has a broad, collaborative, and vibrant research community that is focused on the growing interface of the basic sciences and engineering. This provides the basis for innovative solutions to today's Global Challenges, including: mitigating disease; providing clean food and water; developing new sources of clean and renewable energy; and establishing a sustainable and resilient national and international infrastructure.

## ENERGY, ENVIRONMENT, AND SMART SYSTEMS

Exploring renewable technologies, energy efficiency, and the understanding of global environmental change to preserve the biodiversity of the planet.

## BIOTECHNOLOGY AND THE LIFE SCIENCES

Creating new routes to drug discovery and development, and understanding the fundamental mechanisms of disease, from Alzheimer's and diabetes to cancer.

## MEDIA, ARTS, SCIENCE, AND TECHNOLOGY

Facilitating new approaches to networking, advanced visualization, sensor design, haptics, and multiscale modeling and simulation, which are supported by the core capabilities of EMPAC.

## COMPUTATIONAL SCIENCE AND ENGINEERING

Focusing on high performance computing, big data, and data analytics, which supports research and innovation across a broad front.

## NANOTECHNOLOGY AND ADVANCED MATERIALS

Developing robust, affordable, and sustainable methods for manufacturing new functional hybrid materials, and the hierarchical systems and products based upon them.



# Patents and Inventors Patents

**Michael Amitay**
**Anna H. Dyson**
**Edward DeMauro '12Ph.D.**
**David Menicovich '13Ph.D.**
**Ajith Rao '11Ph.D.**
**Peter Stark '89**
**Jason O. Vollen**
Methods and systems of modifying air flow at building structures (Patent in South Africa)

**B. Wayne Bequette**
**Bruce Buckingham**
**Kimberly Caswell**
**Eyal Dassau**
**Francis Doyle '77**
**Hyunjin Lee**
Kalman Filter Based On-Off Switch for Insulin Pump (Patent in the United States)

**Rajendra Dahal**
**Kuan-Chih Huang '14Ph.D.**
**James J. Q. Lu**
**Yaron Danon '90G, '93Ph.D.**
**Ishwara Bhat '81G, '85Ph.D.**
Neutron-Detecting Apparatuses and Methods of Fabrication (Patent in the United States)

**Jonathan Dordick**
**Prashanth Asuri '07Ph.D.**
**Ravindra Kane**
**Sandeep Karajanagi '06Ph.D.**
Enhanced Stability of Proteins Immobilized on Nanoparticles (Patent in the United States)

**Partha Dutta**
Passivated Nanoparticles, Method of Fabrication Thereof, and Devices Incorporating Nanoparticles (Patent in Europe)
Room Temperature Growth of High Quality, Stable and Tuned Semiconductor Nanocrystals from Ammonia Containing Aqueous Solutions (Patent in Germany, France, Great Britain, and Netherlands)

**Partha Dutta**
**Sruthi Muralidharan**
Multiplexed Pulse Modulation Using Superposition (Patent in the United States)

**Anna H. Dyson**
**Michael K. Jensen**
**David N. Borton '72**
Concentrating type solar collection and daylighting system within glazed building envelopes (Patent in the United States)

**Robert F. Karlicek Jr.**
**Charles S.S. Goodwin '01, '06G**
**Jian-Qiang "James" Lu**
**Anton Tkachenko '15Ph.D.**
Light Emitting Diodes and a Method of Packaging the Same (Patent in the United States)

**Robert F. Karlicek Jr.**
**Pankil Butala**
**Li Jia '14Ph.D.**
**Thomas Little '83**
**Richard J. Radke**
Sensory Lighting Systems and Method for Characterizing an Illumination Space (Patent in the United States)

**Mei-Li Hsieh** (Rensselaer visitor)
**Yong Sung Kim**
**Shawn-Yu Lin**
Integrated Polarized Light Emitting Diode With a Built-In Rotator (Patent in the United States).

**Nadarajah Narendran**
**Yimin Gu '03G**
Package design for producing white light with short-wavelength LEDs and down-conversion materials (Patent in Japan)

**Nadarajah Narendran**
**J.P. Freyssinier '03G**
**Yimin Gu '03G**
**Yiting Zhu '06G, '10Ph.D.**
Scattered-photon extraction based light fixtures (Patent in Japan and China)

**Tristan J. Lawry '07, '09G, '11Ph.D.**
**Gary J. Saulnier '80, '85Ph.D.**
**Kyle R. Wilt '06, '12Ph.D.**
**Jonathan D. Ashdown '06, '08G, '12Ph.D., '14G**
**Henry A. Scarton**
**Andrew Gavens**
Full-duplex ultrasonic through-wall communication and power delivery system with frequency tracking (Patent in United States)

**Gary J. Saulnier '80, '85Ph.D.**
**Jonathan D. Ashdown '06, '08G, '12Ph.D., '14G**
**Tristan J. Lawry '07, '09G, '11Ph.D.**
**Kyle R. Wilt '06, '12Ph.D.**
**Henry A. Scarton**
Multi-Channel through-wall communication system using crosstalk suppression (Patents in United States and Georgia)

**Mark Wentland**
8-Formamido-2, 6-Methano-3-Benzazocines (Patent in Europe)

Large Substituent, Non-Phenolic Opioids and Method of Use Thereof (Patent in United States)

Quaternary Opioid Carboxamides (Patent in Canada, Belgium, Europe, Ireland, Israel, Japan, and Switzerland)

Morphine Derivatives Containing a Carboxamide Group as Opioid Receptor Ligands (Patent in Belgium, Europe, France, Germany, Great Britain, Ireland, Italy, Netherlands, Spain, and Switzerland)

8-Carboxamido-2, C-Methano-3-Benzazocines and 3-Carboxamido-3-Deoxymorphinans (Patent in Belgium, France, Germany, Ireland, Italy, Netherlands, and Switzerland)

8-Substituted-2, 6-Methano-3-Benzazocines and 3-Substituted Morphinanes as Opioid Receptor Binding Agents (Patents in Great Britain and Spain)

Technology Commercialization
## Recent Breakthroughs

### Multifunctional Protein-Delivery Gold Nanocages

Hollow gold nanocages are powerful vehicles for the transport and administration of therapeutic agents, bioactive compounds, biomolecular reagents, biocatalysts, and other molecular compounds. However, better control of the cages' content is needed. To increase bioavailability of contents, researchers at Rensselaer created a porous, large surface-to-volume ratio nanocube with payload molecules electrostatically adsorbed onto their surfaces. These highly biocompatibile particles can be tailored for controlled duration and bioavailable concentration of payload molecules. The sustained release of proteins and their unique design make them useful for applications like drug delivery and photothermal ablation of tumors. The tenability, strong scattering, and adsorption peaks in the near-infrared region make these gold nanocages useful for biomedical imaging. This research was led by Richard Siegel, the Robert W. Hunt Professor of Materials Engineering, Vice President for Research Jonathan Dordick, the Howard P. Isermann Professor of Chemical and Biological Engineering, and former Rensselaer student Xi Qian.

### In Vitro Isolation of Cancer Cells

Current chemotherapy strategies struggle to deal with the variability of cancer from patient to patient. Individualized treatment could be more successful, yet cancer cells from each patient must be isolated and analyzed. Previous methods lack specificity and typically rely on techniques likely to alter the cancer cells disrupting individualized treatment. A team led by Rensselaer Biomedical Engineering Associate Professor Ryan Gilbert invented an inexpensive device to effectively isolate cancer cells from a tumor sample, advancing further experimentation in cancer cell identity. The device has three main components: a layer of very fine electrospun fibers, a protein coating layer that includes at least two different proteins to promote growth of distinct cell types, and nanospheres containing chemo-attractants for cancer and healthy cells. By allowing the precise isolation of different types of cells and promoting their growth, the system effectively facilitates experimentation in cell profiling, drug discovery and development, and genomic studies.

*To learn more, go to* www.rpitechnology.com *or email* otc@rpi.edu.

# Rensselaer Leadership

**Shirley Ann Jackson**
President

### PRESIDENT'S CABINET

**Craig A. Cook**
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Vice President, Research, and Howard P. Isermann Professor, Chemical and Biological Engineering

**Graig Eastin**
Vice President, Institute Advancement

**Virginia Gregg**
Vice President, Finance, and Chief Financial Officer

**Prabhat Hajela**
Provost

**Richie C. Hunter**
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**John Kolb**
Vice President, Information Services and Technology and Chief Information Officer

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Associate Vice President & Director of Athletics

**Curtis Powell**
Vice President, Human Resources

**Claude Rounds**
Vice President, Administration

**Jonathan D. Wexler**
Vice President, Enrollment Management

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Dean, Lally School of Management

**Curt Breneman**
Dean, School of Science

**Evan Douglis**
Dean, School of Architecture

**Shekhar Garde**
Dean, School of Engineering

**Mary Simoni**
Dean, School of Humanities, Arts, and Social Sciences

### DIRECT REPORTS TO THE PRESIDENT

**Johannes Goebel**
Director, Curtis R. Priem Experimental Media and Performing Arts Center (EMPAC)

**James E. Spencer Jr.**
Executive Director, Rensselaer Technology Park, Real Estate and New Venture Development for Rensselaer Polytechnic Institute

# Rensselaer Research Centers

### INSTITUTE CENTERS

Center for Architecture Science and Ecology
*Anna Dyson*

Center for Automation Technologies and Systems
*Daniel Walczyk*

Center for Biotechnology and Interdisciplinary Studies
*Deepak Vashishth*

Center for Cognition, Communication, and Culture
*Jonas Braasch*

Center for Computational Innovations
*Christopher Carothers*

Center for Future Energy Systems
*Jian Sun*

Center for Materials, Devices, and Integrated Systems
*Robert Hull*

Center for Modeling, Simulation and Imaging in Medicine
*Suvranu De*

Cognitive and Immersive Systems Lab @ EMPAC
*Hui Su*

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Margaret A. and David M. Darrin '40 Fresh Water Institute
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*Bolek Szymanski*

Rensselaer Institute for Data Exploration and Applications
*James Hendler*

Scientific Computation Research Center
*Mark S. Shephard*

### LALLY SCHOOL OF MANAGEMENT

Center for Financial Studies
*Chanaka Edirisinghe*

The Paul J. '69 and Kathleen M. Severino Center for Technological Entrepreneurship
*Jason Kuruzovich*

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Lighting Research Center
*Mark S. Rea*

### SCHOOL OF ENGINEERING

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*Ricardo Dobry*

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*Michael Amitay*

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*Jose Holguin-Veras*

Center for Ultra-wide-area Resilient Electric Energy Transmission Networks
*Joe Chow*

Gaerttner Linear Accelerator Center
*Yaron Danon*

Lighting Enabled Systems & Applications
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Center for Deep Listening
*Tomie Hahn*

### SCHOOL OF SCIENCE

Baruch Center for Biochemical Solar Energy Research
*K.V. Lakshmi, Scientific Leader*

Center for Initiatives in Pre-College Education
*Paul Schoch*

Center for Inverse Problems
*Joyce McLaughlin*

Data Science Research Center
*Bülent Yener*

New York Center for Astrobiology
*Bruce Watson*

New York State Center for Polymer Synthesis
*Chang Y. Ryu*

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