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 expenditures once again met our core target of $100 million and we have seen research awards faculty, students (both graduate and undergraduate), and research staff. Our overall research advances made throughout a growing and vibrant Rensselaer research enterprise driven by our.

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.
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.

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. Cognitive computing is fundamental to human health, and a vital role in maintaining blood glucose levels. 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 vital role in maintaining blood glucose levels. Glucose metabolism is fundamental to human health, and a vital role in maintaining blood glucose levels.
Research

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.

EXPLORING PHOSPHORENE
Two-dimensional phosphorene, 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.
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 desiccants, 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.

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 absorbance 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 absorbance of 99.84 to 99.86 percent).

The end result of Lin’s work was a material with a total reflectance of 0.03 percent (or absorbance 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 absorbance 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.
Exposomics is the comprehensive study of environmental exposures in humans, from conception through development. 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 method-ology 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, is also a Tetherless World Research Constellation Professor, and co-principal investigator Kristin Bennett, professor of mathematics, will lead the ontology and epigenomics. The Rensselaer team’s principal investigator, Deborah McGuinness, 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.”
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.”

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.
Rensselaer is part of the three new Manufacturing USA Institutes announced by President Barack Obama. Rensselaer has taken a lead role in the new Clean Energy Smart Manufacturing Innovation Institute (CESMII), in partnership with the Department of Energy. The Smart Manufacturing Leadership Coalition will lead the new 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.

**$80M** will be provided by the Department of Defense to launch the ARM (Advanced Robotics Manufacturing) Institute, of which Rensselaer is a founding member.

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.
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 Impact” with Kamalini Luku 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. Panels 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 Jeannine 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.”

President Jackson also led a panel on “The Future of Work.” The digital revolution is blurring the lines between work and leisure and expanding the boundaries of the workplace 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 Jeannine Hennis-Plasschaert, Minister of Defense, Netherlands.

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Global Challenges: infrastructure, sustainability, resilience

Methods of systems of modifying air flow at building structures (Patent in South Africa)

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

Rajendra Dahal
Kuan-Chih Huang ‘14Ph.D.
James J. G. Lu
Yaron Daron ‘00G, ‘93Ph.D.
Ishware Bhat ‘81G, ‘85Ph.D.
Neuro-Neurotrophic-Neurodegeneration and Methods of Fabrication (Patent in the United States)

Jonathan Dordick
Prashanth Asuri ‘07Ph.D.
Ravindra Kane
Sandip Roy Kogany ‘06Ph.D.
Enhanced Stability of Proteins Immobilized on Nanoparticles (Patent in the United States)

Partha Dutta
Paswanth Ansal ‘07Ph.D.
Vidhish Mistry
Sahand F. Movaghar ‘16M.S.
Improved Selective Catalytic Reduction of Nitrogen Oxides (Patent in the United States)

James C. Pabla, ‘92Ph.D.
Jonathan Dordick
Patrick Gaffney
Stuart Ezell
John T. Hanlon
Dorcus H. Kontoleon
Congjun Wang ‘10Ph.D.
Improved Insecticide Formulations (Patent in the United States)

Jonathan Dordick
Li Jia ‘14Ph.D.
Behind the Scenes of Nanoformulation (Patent in the United States)

Henry A. Scarton
Andrew Gavens
Full-duplex ultrasonic through-wall communication and power delivery system with frequency tracking (Patent in the United States)

Gary J. Saulnier ‘80, ‘85Ph.D.
Kyle R. Witt ‘06, ‘12Ph.D.
Tristan J. Lawey ‘07, ‘09G, ‘11Ph.D.
Gary J. Saulnier ‘80, ‘85Ph.D.
Wen-Li Huang ‘09Ph.D.
Yimin Gu ‘03G
Yiling Zhu ‘06G, ‘10Ph.D.
Scattered photon extraction based light fixtures (Patent in Japan and China)

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