RENSSELAER RESEARCH REPORT 2018

FOCUS ON HEALTH

From Bench to Bedside

Research at Rensselaer is transforming health-care delivery and patient outcomes

Our endeavors in the field of human health are a prime example of "The New Polytechnic"—a vision for the future of Rensselaer Polytechnic Institute in which the Institute serves as a great crossroads for collaborations animated by new technologies and tools, and extending across disciplines, sectors, and global regions, in order to address complex global challenges.

By bringing together engineers and researchers in the life, physical, and computational sciences with physicians, we have the opportunity to understand health and disease from bench to bedside, from the nanoscale on up—from the level of the molecule, to the cell, to the tissue, to the organ, to the patients, in all their remarkable complexity.

The work of our faculty has helped us to attract distinguished partners in both research and education to amplify our efforts. We have partnered with IBM to create our new Center for Health Empowerment by Analytics, Learning, and Semantics, or HEALS, which is taking a radically new approach to managing chronic medical conditions such as heart disease and diabetes. HEALS is bringing together faculty from across the campus who are applying advanced cognitive computing capabilities to enable individuals better to understand and to improve their own health.

Our partnership with the Icahn School of Medicine at Mount Sinai involves research, education, and technology transfer. This is a tribute to our strengths in biotechnology, computation, data science, immersive technologies, materials science, and the entire range of engineering disciplines—and to the increasing awareness that these disciplines are required, if we are to make progress in improving human health and mitigating disease.

Rensselaer has also taken a leadership role as a Tier One university partner in the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL), a national consortium, established by the U.S. Department of Commerce, that seeks to accelerate biopharmaceutical manufacturing innovation while enabling more efficient and rapid manufacturing capabilities. And, by ensuring U.S. biomanufacturing competitiveness, better, safer, and cheaper pharmaceuticals will be available to all Americans.

Our Center for Biotechnology and Interdisciplinary Studies (CBIS) was made possible through such partnerships. Just over a decade ago, Rensselaer and New York state worked together to build this center. That investment helped Rensselaer to become a leader in biotechnology by fostering industry collaborations, significantly increasing the attraction of federal funding from the National Science Foundation and National Institutes of Health, generating intellectual property and patents, and producing graduates who have gone on to become leaders in the biotech sector in such companies as Regeneron Pharmaceuticals, AMRI, GE, Taconic Biosciences, and many more.

In fact, scientists and engineers at CBIS are developing a blood test to detect autism; using stem cell bio-engineering to tackle Alzheimer's, osteoporosis, and osteoarthritis; creating a contamination-free form of the blood thinner heparin; and developing a new diagnostic test to predict comorbidities, such as fractures, that are associated with diabetes.

In our Center for Lighting Enabled Systems & Applications and the Lighting Research Center, Rensselaer and its partners are exploring ways to use light to reduce stress and improve health and well-being.

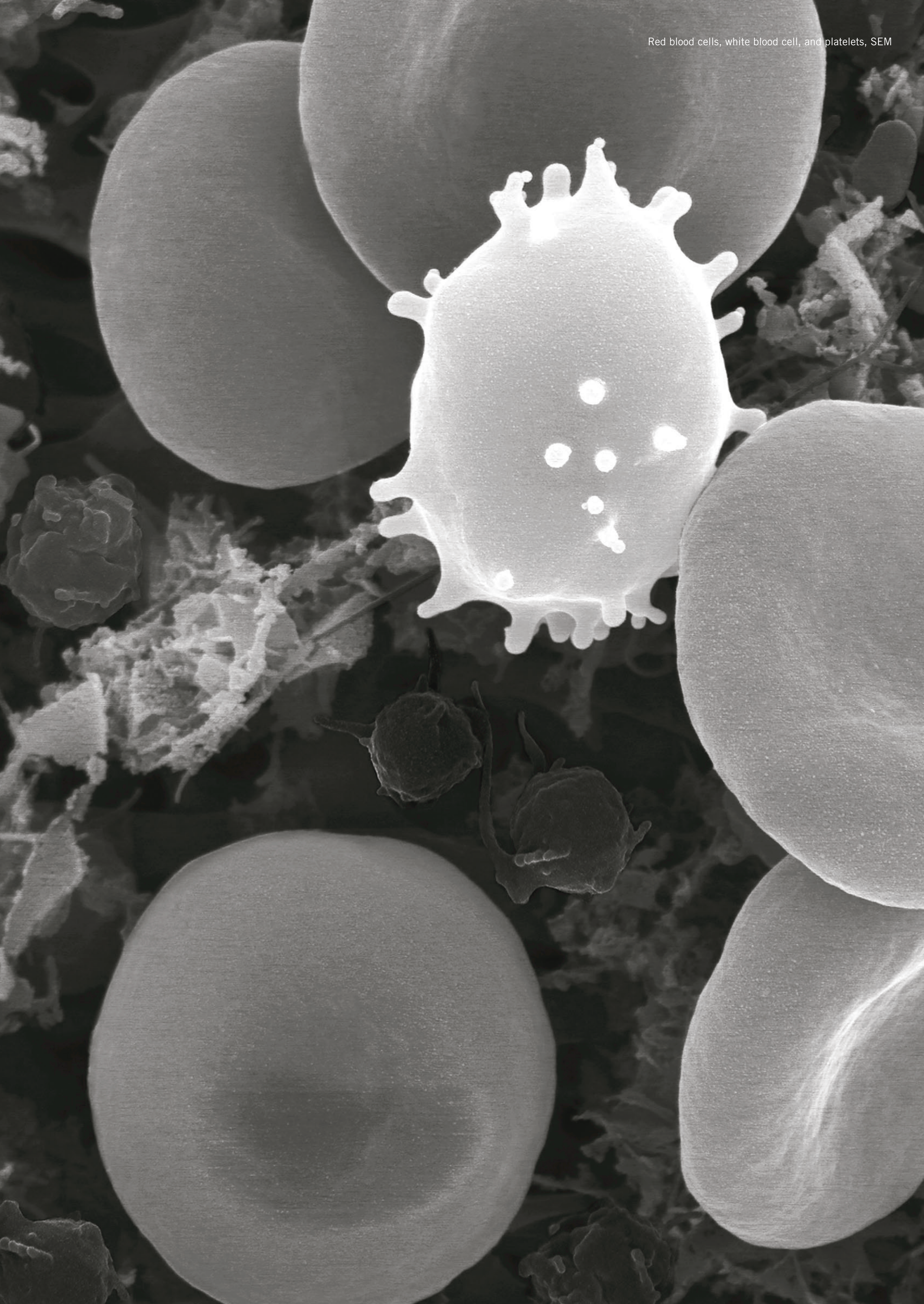
Our Center for Modeling, Simulation and Imaging in Medicine seeks to develop advanced modeling, simulation, and imaging technology for health care, and transition those technologies to clinical practice.

With our campuswide interdisciplinary focus on translational medicine, we hope to realize the promise of regenerative medicine, to design new classes of therapeutics based on an understanding of disease that begins at the molecular level, to develop more advanced medical devices, and, ultimately, to find better means of preventing and treating disease across the board.

Shirley Ann Jackson, Ph.D.

PRESIDENT, RENSSELAER POLYTECHNIC INSTITUTE

We have the opportunity to understand health and disease from the nanoscale on up—from the level of the molecule, to the cell, to the tissue, to the organ, to the patients, in all their remarkable complexity.



Red blood cells, white blood cell, and platelets, SEM

AUTISM

A BLOOD TEST FOR AUTISM

Most children are not diagnosed with ASD until after 4 years of age. Earlier diagnosis is generally acknowledged to lead to better outcomes as children engage in early intervention services. Now, an algorithm based on levels of metabolites found in a blood sample can accurately predict whether a child is on the autism spectrum of disorder (ASD), based upon a recent study. The algorithm, developed by researchers at Rensselaer, is the first physiological test for autism and opens the door to earlier diagnosis and potential future development of therapeutics.

"Instead of looking at individual metabolites, we investigated patterns of several metabolites and found significant differences between metabolites of children with ASD and those that are neurotypical. These differences allow us to categorize whether an individual is on the autism spectrum," said systems biologist Juergen Hahn, professor and head of the Department of Biomedical Engineering. "By measuring 24 metabolites from a blood sample, this algorithm can tell whether or not an individual is on the autism spectrum, and even to some degree where on the spectrum they land."

Autism spectrum disorder is estimated to affect approximately 1.5 percent of individuals and is characterized as "a developmental disability caused by differences in the brain," according to the Centers for Disease Control and Prevention. The physiological basis for ASD is not known, and genetic and environmental factors are both believed to play a role. According to the CDC, the total economic costs per year for children with ASD in the United States are estimated between $11.5 billion and $60.9 billion. Research shows that early intervention can improve development, but diagnosis currently depends on clinical observation of behavior, an obstacle to early diagnosis and treatment. "This is the first physiological diagnostic and it's highly accurate and specific," said Hahn.

Researchers have looked at individual metabolites produced by the methionine cycle and the transsulfuration pathways and found possible links with ASD, but the correlation has been inconclusive. Hahn said the more sophisticated techniques he applied revealed patterns that would not have been apparent with earlier efforts.

"A lot of studies have looked at one biomarker, one metabolite, one gene, and have found some differences, but most of the time those differences weren't statistically significant or the results could not be reliably replicated," Hahn said. "Our contribution is using big data techniques that are able to look at a suite of metabolites that have been correlated with ASD and make statistically a much stronger case."

A follow-up study has confirmed the exceptional success of the blood test in assessing whether a child is on the autism spectrum.

DIET AND BACK PAIN: WHAT'S THE LINK?

Can a diet high in processed fat and sugar and Type 2 diabetes cause degeneration of intervertebral discs in the spine? If so, what is happening, and can it be prevented? As part of an ongoing collaboration between Rensselaer and the Icahn School of Medicine at Mount Sinai—a partnership that draws upon the expertise of both schools to address significant health problems—researchers hope to answer those questions by investigating the link between diet, obesity-linked Type 2 diabetes, and intervertebral disc degeneration.

Researchers on the project suspect the diet associated with Type 2 diabetes—one high in processed fats and sugars—causes inflammation and modification of disc tissue, triggering a chain of responses, which leads to degeneration. To test this hypothesis, the researchers have set three goals: to establish whether mice fed a diet associated with Type 2 diabetes will develop intervertebral disc degeneration, isolate the effect of diet causing changes in the tissue, and evaluate how the diet modifies proteins within the disc.

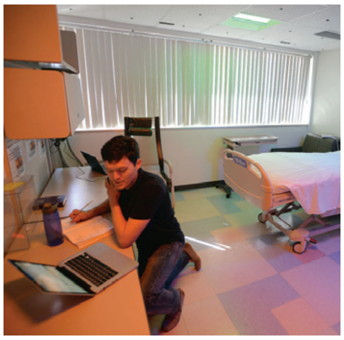
Deepak Vashishth, a professor of biomedical engineering and the Rensselaer lead on the project, said the partnership makes it possible to tackle a project of this complexity.

"We're trying to establish the mechanism whereby this diet, and Type 2 diabetes, leads to disc degeneration, and that's not an easy thing to do because, within the body, various processes are linked and feedback loops are difficult to unravel," said Vashishth, who is also the director of the Center for Biotechnology and Interdisciplinary Studies. "To investigate this question, you need the mix of experts from different disciplines with different skill sets that the partnership allows."

At the core of the research project are the effects of advanced glycation endproducts (AGE)—proteins or lipids that have become coated in sugars, which damage their function. Research suggests that a diet high in heat-processed foods, including fried foods, plays a role in AGE formation.

At Rensselaer, researchers will analyze various mouse and human tissue samples, helping to determine how healthy disc tissue in humans and mice differs from the tissue of patients and mice that have developed disc degeneration, as well as mice that have been treated with a drug intended to block the effects of a diet high in AGEs on the spine.

Research indicates the accumulation of AGEs causes structural deterioration, increases inflammation that could lead to disc degeneration, and contributes to a host of degenerative diseases such as diabetes, atherosclerosis, and Alzheimer's. The project is supported by a $3.3 million grant from the National Institutes of Health.



Transforming Patient Health Care and Well-Being Through Lighting

The world of health care is changing rapidly and there is increased interest in the role that light and lighting can play in improving health outcomes for patients and providing healthy work environments for staff, according to many researchers. Recently, the Center for Lighting Enabled Systems & Applications at Rensselaer, together with the Illuminating Engineering Society, sponsored a workshop to explore pathways to define and promote the adoption of lighting systems specifically for health-care environments.

The workshop brought together lighting and human health researchers, healthy-lighting design experts, senior representatives from health-care standards organizations, and health-care providers. The aim of the workshop was to initiate an important discussion among diverse stakeholders on the changes in modern health-care interior lighting applications. The result is the release of a white paper detailing the outcomes and contributions of the participants.

The white paper can be found online at https://lesa.rpi.edu/wp-content/uploads/2018/02/IES_RPI_LESA_FinalWkshpRpt_20180213.pdf.

NEURODEGENERATIVE DISEASE

RENSSELAER ENGINEERS TAKE TO FLIGHT

Amir Hirsa, professor of mechanical, aerospace, and nuclear engineering, and a group of undergraduate and graduate students spent time last fall at Sanford International Airport in Florida—completing an experiment in zero gravity.

The trip featured the second parabolic flight campaign (the first was in February 2016) for the Rensselaer team, and was in support of an experiment created by the team that will be flown aboard the International Space Station (ISS) in 2019. The purpose of the ISS experiment (the hardware for which is called “Ring-Sheared Drop,” or RSD) is to study the process of proteins aggregating into amyloid fibrils, the same material that forms the waxy substance surrounding and eventually killing the neurons of those afflicted by Alzheimer’s disease. The RSD gives a unique opportunity to study amyloidogenesis at fluid interfaces, mimicking certain aspects of the physiological scenario.

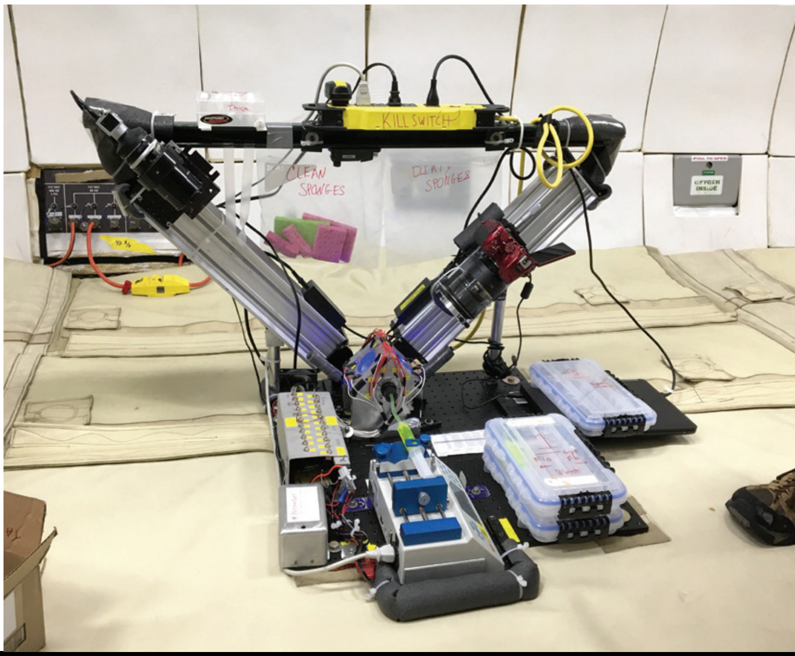
Amyloid fibril formation in proteins is widely studied because of its role in diseases such as Alzheimer’s and Parkinson’s, as well as its promise for advanced materials. In addition to the intrinsically devastating effects of neurodegenerative diseases, these diseases also represent a huge monetary cost in the United States. In 2010, it was estimated that more than 14 percent of the elderly population suffers from dementia and that the cost of care was between $150 and $200 billion annually. The cost is projected to reach $400 billion by 2040.

Zero Gravity Corporation (ZERO-G), the parabolic flight provider for the November 2017 Research Campaign, uses *G-FORCE ONE*®, a specially modified Boeing 727 airplane. To create weightless environments, the ZERO-G pilots fly the plane in the trajectory of parabolas where in the top part of each arc scientists experience 25 to 30 seconds of weightlessness during which they perform their experiments.

The RSD project is in its fifth year; so far, the Rensselaer team has received commitments from NASA totaling nearly $1.5 million and the project has been approved for additional funding until September 2020. The hardware is expected to be on the ISS in early 2019.

In addition to Hirsa, the Rensselaer team included James Young ’12 (M.S., chemical engineering), ’13 (Ph.D., mechanical engineering), lecturer in mechanical, aerospace, and nuclear engineering; aerospace engineering juniors Sean Hurst, Leo Gallo, and Patrick McMackin; and doctoral candidate Adi Raghunandan.

(l-r) Amir Hirsa, Jim Young, Sean Hurst, Leo Gallo, Adi Raghunandan, and Patrick McMackin.



ALZHEIMER'S DISEASE IS CURRENTLY RANKED AS THE MOST COMMON CAUSE OF DEMENTIA AND IS THE SIXTH LEADING CAUSE OF DEATH IN THE UNITED STATES, AMONG OLDER ADULTS.

PERSONALIZED MEDICINE

HACKING HEALTH CARE AND HELPING CANCER PATIENTS

Four years ago, Rensselaer and the Icahn School of Medicine at Mount Sinai entered into a relationship to promote personalized medicine and medical care through collaborations in education, research, and development of new diagnostic tools and treatments. Several innovative projects on Alzheimer's disease, cancer, diabetes, and osteoporosis have already emerged from this partnership.

As part of the relationship, the Icahn School recently hosted a health hackathon, supported in part by the Center for Biotechnology and Interdisciplinary Studies at Rensselaer, to explore transformative ideas in several areas of health-care delivery. The event included Rensselaer students, as well as students from Mount Sinai Medical Center, Columbia University, and CUNY, and hospital staff. Rensselaer students were part of all three finalist teams.

Computer science doctoral candidate Angela Su was one of a dozen undergraduate and graduate students who entered the Mount Sinai Health Hackathon. Her team, which also included biomedical engineering student Alagu Chidambaram, was one of three finalists. Finalists were awarded $2,500, and participated in an innovation "Shark Tank-type" showcase in February 2018, during which the finalists presented a five-minute pitch to a panel of entrepreneurs.

Su and her six-member team designed "On track," a web-based school and socializing tool for pediatric cancer patients. The tool makes it possible for parents and teachers to keep kids connected with their classroom and peers as they undergo treatment.

"My team ended up being super diverse, everyone came from different backgrounds—biomedical, education, computer science," Su said. "Everyone had a different role, and we worked really well together. We did a lot of background research to see what kinds of problems pediatric students might be going through, what resources are available, and how our potential solution would be helpful. During the event, they had mentors circulating among the teams and they gave us great advice on how to shape our idea."

Two Rensselaer students were on each of the two remaining finalist teams. Lydia Krauss, a biomedical engineering undergraduate, worked on "Helping Stand," a portable device to help fatigued patients get out of a car. And Michael Bramson, a graduate student in biomedical engineering, worked on "StreamLine," an AI-based tool for streamlining the clinical trial protocol development process.

The multidisciplinary competition focused on creating novel technology solutions for assessing, monitoring, managing, and treating problems in health care, with a focus on cancer.

STUDYING SPINAL CORDS

Two doctoral students in biomedical engineering who are working to help victims of spinal cord injuries, Anthony D'Amato and Christopher Johnson, have been awarded New York State Department of Health Spinal Cord Injury Research Board Predoctoral Fellowships.

The Spinal Cord Injury Research Board (SCIRB) awards predoctoral and postdoctoral fellowships to stimulate spinal cord injury research, to accelerate the pace with which basic findings are translated into clinical benefits for spinal cord-injured per sons, and to fill fundamental gaps in knowledge that are barriers to scientific advances in spinal cord injury research.

Both D'Amato and Johnson are graduate researchers in the lab of Ryan Gilbert, professor of biomedical engineering at Rensselaer. The Gilbert Lab focuses on the development of biomaterials for use in spinal cord injury repair. These materials are designed to serve as growth conduits, drug delivery vehicles, support scaffolds for regeneration, and culture models for preliminary in vitro testing.

"These fellowships will allow Anthony and Christopher to pursue high-impact research over a three-year span, and will provide funds to further their research and education activities," said Gilbert. "We are very thankful that the state has these opportunities, and that our students are competitive for such awards."

Each year, approximately 1,000 New York residents suffer traumatic spinal cord injuries, joining the nearly 282,000 people living in the United States with paralysis. The New York State Spinal Cord Injury Research Board was created in 1998 to support neurological spinal cord injury scientific research projects from leading researchers within New York state to find a cure for spinal cord injuries.

JENNIFER HURLEY

BY DISRUPTING OUR CLOCKS, WE MAY BE ALTERING OUR METABOLIC OUTPUT AND CHRONICALLY INFLAMING OUR BODIES.

In Jennifer Hurley's lab, researchers study how circadian rhythms allow us to keep track of time. These circadian rhythms allow us to anticipate 24-hour oscillations in our environment, such as changes from light (daytime) to dark (nighttime), and are essential to our fitness.

CIRCADIAN RHYTHMS

TRACKING THE CIRCADIAN CLOCK

Biology dictates that DNA creates proteins that create—among other things—metabolites, the outputs of metabolism. In organisms from fungi to humans, the relationship between these players is heavily influenced by our internal circadian clock, and responds to environmental influences (such as a prolonged day) with implications for industry as well as human health.

"Many disorders associated with disrupting our circadian clocks have links to inflammation, which is an immune system response," said Jennifer Hurley, assistant professor of biological sciences. "I think that by disrupting our clocks, we may be altering our metabolic output and chronically inflaming our bodies."

But the system, which is enormously complex, is poorly understood.

To better understand this system, researchers at Rensselaer, Dartmouth, and the Pacific Northwest National Laboratory are collaborating on a project that uses data—tracking levels of RNA and protein in a cell as they fluctuate with the day/night cycle—to create a computer model depicting how the metabolic environment influences cells throughout the circadian day.

"The complexity of this system is phenomenal; the interactions within a single cell could generate millions of data points," said Hurley, Rensselaer lead on the project, which is supported by a $3.1 million grant from the National Institutes of Health.

"The intricacy is unfathomable by the human mind alone, but computer modeling combined with experimentation can help us to understand this system."

Hurley, an expert in circadian biology, has built massive data sets that track clock-controlled levels of RNA and protein in *Neurospora,* a fungus which produces cellulases, proteins useful to the biofuels industry because they break down cellulose in plants.

While the more profound impacts of the research may relate to human biology, the project also may make it possible to boost *Neurospora's* production of cellulase, a benefit to the biofuels industry.

Understanding Heart Disease

In the lab of Douglas Swank, professor of biological sciences, researchers are using *Drosophila (*commonly known as the fruit fly) as a model organism to unravel some of the biggest mysteries of the human heart. Swank has received funding from the National Institutes of Health to seek the molecular causes of hypertrophic cardiomyopathy, or enlarged heart disease. Using *Drosophila* enables Swank and his team to study aspects of the disease that cannot be studied in humans, other model organisms, or cell culture. “Our goal is to try to understand the molecular mechanism behind this disease so that we can help develop better treatments,” Swank said.

The program will fund eight students per year in exploring the interdisciplinary, clinical, and translational nature of research on Alzheimer's disease and related dementias.

ALZHEIMER'S DISEASE

CONFRONTING DEMENTIA FROM LAB TO BEDSIDE

We know Alzheimer's as a brutal disease that dismantles our loved ones, but there is hope. Science and engineering researchers are looking inside the disease to identify early warning signs and develop the imaging techniques to see them, to unravel the bio-chemical puzzle that creates a toxic clump of misfolded proteins, and to develop and test new drugs and therapies that chip away at cognitive decline. The insights that emerge from such research are the seeds for medicine in the form of diagnostic tools, treatments, and hopefully, a cure.

To bolster the connections between the lab and bedside, the National Institutes of Health's National Institute on Aging has awarded Rensselaer a five-year $1.5 million training grant to support a new Alzheimer's Disease Clinical and Translational Research Training Program. The program positions Rensselaer students to contribute to Alzheimer's research by exposing them to a range of biotechnology and lighting research on neurodegenerative diseases, including a summer clinical rotation in medical research at the Icahn School of Medicine at Mount Sinai, with whom Rensselaer has an existing partnership.

"We want our students to understand this disease in a holistic sense and carry that knowledge through their education and their career," said Mariana Figueiro, principal investigator on the grant, and director of Rensselaer's Lighting Research Center. "The perspective they gain, built upon the strengths of research at Rensselaer, will improve their ability to develop more effective diagnoses, treatments, and cures."

Advancing Personalized Anti-Cancer Drugs

Researchers at Rensselaer and Albany Medical Center are working together to develop three-dimensional bioprinting and imaging techniques that will generate and analyze tumor models in the laboratory, with the goal of accelerating the development and optimization of personalized anti-cancer drugs. The joint research, supported by a $3.7 million grant from the National Cancer Institute, will help address fundamental issues in cancer research and treatment."If successful, our study will help researchers to develop personalized anti-cancer treatments," said David Corr, one of the study's principal investigators and Rensselaer associate professor of biomedical engineering. "Ultimately, this research could help clinicians identify whether a particular drug, or drug combination, is effectively reaching the cancer cells in that type of tumor, in that specific person—to inform a patient-specific treatment strategy prior to undergoing chemotherapy."

“ECONOMICS IS A SOCIAL SCIENCE THAT HAS ALWAYS PLAYED AN INTEGRAL PART IN SHAPING POLICY.”

UNDERSTANDING HEALTH CARE THROUGH AN ECONOMICS LENS

Rensselaer’s economics department is introducing upper-level electives in health economics, behavioral economics, and the economics of government regulations, among other areas. Several economists who recently joined the faculty are teaching a cluster of new courses that reflect the Institute’s emerging focus on health care and big-data analytics. The new professors have diverse research interests, but they share expertise in various aspects of heath care. Their work ranges from research that looks broadly at health-care systems, to work that centers on patients, to innovation and economic policy.

“Economics is a social science that has always played an integral part in shaping policy,” says Chad Stecher, one of the new professors. “We are following in the footsteps of generations of economists who use mathematical and statistical tools to study topical issues.” Stecher looks closely at what makes people decide to take or not to take medicine that is known to save lives.

Vivek Ghosal, the Virginia and Lloyd W. Rittenhouse ’35 Professor of Humanities and Social Sciences who heads the economics department, studies aspects of health care and innovation related to the markets for pharmaceuticals and medical devices, among other fields.

Jianjing Lin specializes in health-care economics and industrial organization. For her dissertation, she looked at the slow shift many hospitals are making from paper to digital record keeping—a perfect application for Rensselaer students to explore. Among other things, she identified a steep learning curve for older doctors who become less efficient when they are not given proper training in the technology.

Jason Huh studies Medicaid expansion, examining whether the sweeping reform has influenced the location of new medical practices. Huh’s research, which was accepted for publication by the *Journal of Health Economics,* found that the number of dentists in poor counties rose 12 percent from 2006 to 2013—that’s three more for every 100,000 individuals. The shift, he noted, came mainly from recent dental school graduates, signaling, perhaps, an emerging pattern of care for underrepresented Americans.

HUMAN HEALTH

FIGHTING CHRONIC DISEASES WITH COGNITIVE COMPUTING

IBM and Rensselaer have announced the creation of the new Center for Health Empowerment by Analytics, Learning, and Semantics (HEALS). Located on the Rensselaer campus, the HEALS center is a five-year collaborative research effort aimed at researching how the application of advanced cognitive computing capabilities can help people to understand and improve their own health conditions.

"This collaboration between Rensselaer and IBM, which combines our significant research strengths in cognitive computing, could generate insights which will aid clinicians with more effective treatments for individual patients and overall efficiencies in the health care system," said President Shirley Ann Jackson. "In this expansion of our long-standing research partnership with IBM, I am pleased that HEALS will advance preventive health care."

"Cognitive computing is poised to transform every profession, industry, and economy, and IBM is committed to helping to solve the world's biggest health challenges," said John Kelly III '78, senior vice president, cognitive solutions and research at IBM. "We are excited to collaborate with Rensselaer on the development of the HEALS research center to advance precision medicine with the help of Watson technologies and to help improve the quality of care clinicians can deliver to individuals."

The new center's vision is to advance the understanding of chronic disease prevention through data-driven discovery and analysis of factors that can help predict the propensity to develop chronic conditions, and provide personalized health recommendations and lifestyle guidance for clinicians to deliver to their patients.

Specifically, the center plans to develop cognitive tools for health empowerment that use analytics, knowledge-driven learning, and semantics-based interrogation to address data-to-knowledge gaps to enable clinicians and patients to help manage and prevent chronic diseases and conditions.

VIRTUAL SURGERY

SIMULATOR-TRAINED MED STUDENTS FASTER THAN PEERS

While simulation platforms have been used to train surgeons before they enter an actual operating room (OR), few studies have evaluated how well trainees transfer those skills from the simulator to the OR. Now, a study led by Rensselaer that used noninvasive brain imaging to evaluate brain activity has found that simulator-trained medical students successfully transferred those skills to operating on cadavers and were faster than peers who had no simulator training.

Arun Nemani, who earned his doctorate in the Department of Biomedical Engineering, is the first author on the study, along with Suvranu De, the J. Erik Jonsson '22 Distinguished Professor of Engineering and head of the Department of Mechanical, Aerospace, and Nuclear Engineering; and Xavier Intes, professor in the Department of Biomedical Engineering. They evaluated the surgical proficiency of 19 medical students, six of whom practiced cutting tasks on a physical simulator, eight of whom practiced on a virtual simulator, and five of whom had no practice. Study results were presented at the American College of Surgeons Clinical Congress 2017.

"We plan on using these study findings to create robust machine learning-based models that can accurately classify trainees into successfully and unsuccessfully trained candidates using functional brain activation," said Nemani.

The medical students who practiced on the physical simulator completed the task in an average of 7.9 minutes with a deviation of 3.3 minutes. Those who used the virtual simulator did the task in 13.05 minutes vs. an average of 15.5 minutes for the group that had no practice.

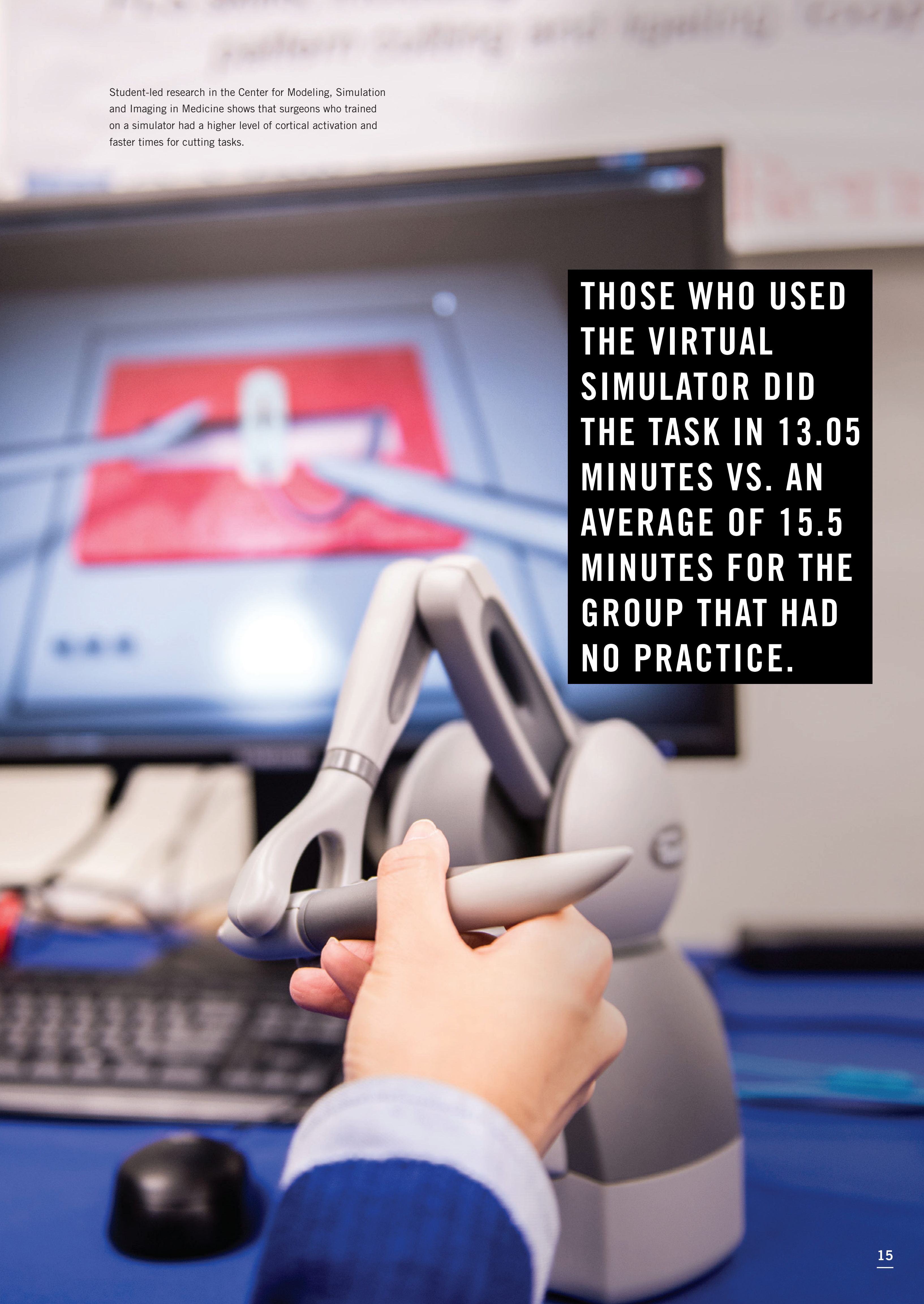
Brain imaging measured activity in the primary motor cortex, located in the frontal lobe. The researchers found that the simulator groups had significantly higher cortical activity than the group that had no training.

"This is a significant leap in the use of noninvasive brain imaging technology to quantify human motor skills and represents a paradigm shift in which surgeons and other medical professionals may be certified and credentialed one day," said Suvranu De.

Gut Check

Probiotic yogurts and pills promise better health, but the bacteria we ingest find a complex and challenging environment when they enter our gut. Food sources shift with every meal we eat, and the threat of pathogens is ever-present. In this competitive landscape, there's a clear winner already on the field: The genus *Bacteroides* makes up 30 percent of the bacteria in the human gut, the single most abundant genus.

Bacteroides are a successful bacterium in our gut microbiome. By offering metabolic capabilities that humans don't have, it helps us to obtain important nutrients. So why are *Bacteroides* so resilient? If we can understand their success, it will ultimately allow us to design probiotic formulations for human health and aid patients with an imbalance of gut bacteria," said Blanca Barquera, professor of biological sciences and lead researcher on a new project investigating *Bacteroides*, supported by the National Institutes of Health.



Student-led research in the Center for Modeling, Simulation and Imaging in Medicine shows that surgeons who trained on a simulator had a higher level of cortical activation and faster times for cutting tasks.

THOSE WHO USED THE VIRTUAL SIMULATOR DID THE TASK IN 13.05 MINUTES VS. AN AVERAGE OF 15.5 MINUTES FOR THE GROUP THAT HAD NO PRACTICE.

REGENERATIVE MEDICINE

3D PRINTING OF SKIN WILL HELP END ANIMAL RESEARCH IN TOXICOLOGY

Carolina Motter Catarino, a graduate student in chemical and biological engineering at Rensselaer, has been awarded £10,000 from the Lush Prize, which is a collaboration between cosmetics company Lush and research organization Ethical Consumer. As the largest prize fund for the complete replacement of animal experiments, it funds projects working to end animal research in toxicology (chemical testing).

The Lush Prize is awarded in several key areas: science, training, public awareness, lobbying, and young researchers. Catarino is among 13 young scientists—from Brazil, the United States, China, Japan, Singapore, Australia, Germany, Luxembourg, and the UK—to be recognized.

Catarino's research, titled "Animal-free approaches for engineering physiologically relevant humanized skin models using 3D bioprinting technology," focuses on tissue engineering.

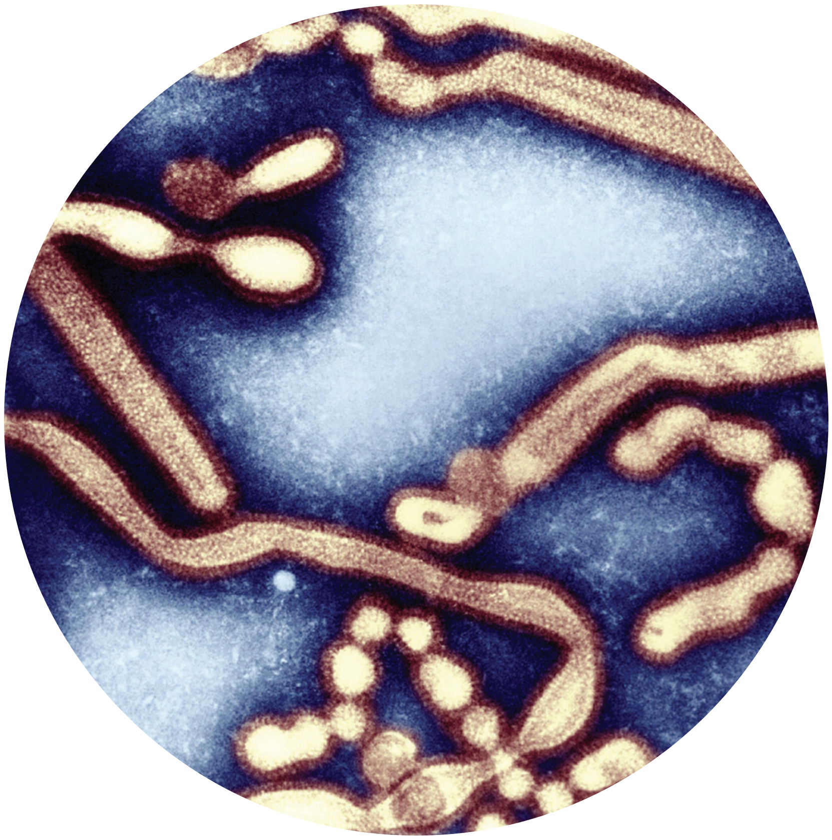
From the earliest successes in culturing live cells in a laboratory to the latest advances toward the development of complex tissues and organs, tissue engineering is impacting people's lives. The first human tissue to be successfully engineered in the lab was skin. Typically, skin models employ scaffold materials that are derived from animals, along with human skin cells. A key limitation of these models is that they still fail in recapitulating the complexity of the human skin. For example, these models do not contain all cells present in the skin nor do they contain adnexal structures, such as hair follicles and sweat glands.

Catarino's research has been focusing on enhancing the complexity of reconstructed skin models through substitution and diversification of non-animal-derived scaffold materials, inclusion of additional cells compared to traditional models, and generation of follicular structures, all using 3D bioprinting. This technology allows the precise placement of the bioinks containing scaffold components and cells at appropriate locations within the 3D skin tissue. This project can help in the development of the next generation of skin models for screening of chemical compounds as well as clinically superior skin grafts.

"Carolina is an exceptionally motivated and talented young scientist," said Pankaj Karande, associate professor of chemical and biological engineering and Catarino's adviser. "She combines her passion for research with diligence to find impactful solutions for human health. Her doctoral thesis on 3D printing of human skin has the potential to develop human-relevant models for efficacy testing while reducing the dependence on animals in research. Furthermore, her work can provide novel avenues for engineering human tissues in the lab for regenerative medicine and therapies."

Winners were honored at the Lush Prize Awards Ceremony in London in November. They also had the opportunity to participate in a networking event that brought together scientists and campaigners from around the world to discuss potential collaborative projects.

Carolina Motter Catarino (left) won the Lush Prize for her research on 3D printing of human skin.



BIOTECHNOLOGY

NANO-DECOY LURES HUMAN INFLUENZA VIRUS TO ITS DOOM

To infect its victims, influenza A heads for the lungs, where it latches onto sialic acid on the surface of cells. Now, Rensselaer researchers have created the perfect decoy: a carefully constructed spherical nanoparticle coated in sialic acid that lures the influenza A virus to its doom. When misted into the lungs, the nanoparticle traps influenza A, holding it until the virus self-destructs.

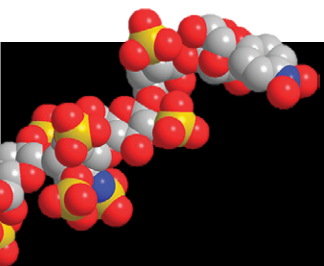
In a study on immune-compromised mice, the treatment reduced influenza A mortality from 100 percent to 25 percent over 14 days. The novel approach, which is radically different from existing influenza A vaccines, and treatments based on neuraminidase inhibitors, could be extended to a host of viruses that use a similar approach to infecting humans, such as Zika, HIV, and malaria.

"Instead of blocking the virus, we mimicked its target—it's a completely novel approach," said Robert Linhardt, a glycoprotein expert and Rensselaer professor who led the research. "It is effective with influenza and we have reason to believe it will function with many other viruses. This could be a therapeutic in cases where vaccine is not an option, such as exposure to an unanticipated strain, or with immune-compromised patients."

The project is a collaboration between researchers within the Center for Biotechnology and Interdisciplinary Studies at Rensselaer and several institutions in South Korea including Kyungpook National University.

The new solution targets an aspect of infection that does not change: All hemagglutinin varieties of influenza A must bind to human sialic acid. To trap the virus, the team designed a dendrimer, a spherical nanoparticle with treelike branches emanating from its core. On the outermost branches, they attached molecules, or "ligands," of sialic acid.

"The major accomplishment was in designing an architecture that is optimized to bind so tightly to the hemagglutinin, the neuraminidase can't squeeze in and free the virus," said Linhardt. "It's trapped."



Poised for Clinical Trials

Heparin, which has been in use since the late 1930s, is an anticoagulant. A synthetic version of low molecular weight heparin is poised for clinical trials and development as a drug for patients with clotting disorders, and those undergoing procedures such as kidney dialysis, heart bypass surgery, stent implantation, and knee and hip replacement. "This is at the cusp of clinical trials and commercial use. There is no question about the science; we have proven that this is a safer, more effective alternative to its natural counterpart, and what now determines its success or failure is the marketplace," said Robert Linhardt, the Broadbent Senior Constellation Professor of Biocatalysis and Metabolic Engineering and one of the inventors of the new drug.

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.

Technology Commercialization
Recent Breakthroughs

X-Genetics Neurological Therapy Approach and Tools

Using visible light to stimulate neurons, optogenetic technologies have the potential to address some of the greatest neurological disorders people face today, including depression, Alzheimer's, and Parkinson's diseases. Another important use is the development of optogenetic tools to study brain circuits and functions. A drawback of optogenetics as a potential treatment and tool is that light cannot penetrate deeply into tissue, like bone, in a non-invasive manner, thereby obstructing access to areas of the brain. Rensselaer's Clark and Crossan Endowed Chair Professor Ge Wang and his group have created an "X-Genetics" method and system to overcome the limitations of optogenetics by controlling the behavior of a neuron through the stimulation of X-ray sensitive biomolecules, causing a change in the membrane potential of a neuron. Wang's X-ray stimulation technique penetrates both bone and soft tissue with very little attenuation, allowing access to tissues visible light cannot probe. Further, a deep learning algorithm can be combined with the method to build reconstructed images from raw data obtained via medical imaging providing a roadmap for the brain.

Saltwater Battery Backup Power System

Battery backup systems provide popular alternatives to generators because they avoid fuel management and the negative environmental impacts of fossil fuels. The systems typically incorporate lithium-ion batteries that are designed to operate as frequently as daily. Yet, the materials are expensive and lithium battery construction, supply chain, and mining have undesirable environmental and social consequences. External factors affecting the power distribution reliability of lithium power systems include weather patterns, age, and solar activity. Attempting to outrival some lithium system shortcomings, Rensselaer graduate Patrick Calhoun has invented a low-cost, non-toxic, galvanic cell backup power system utilizing cells suspended over a saltwater electrolyte by an electromagnet. During power interruption, the grid-connected system's galvanic cell tubes drop into an electrolyte mixture, causing a reaction that forms electrical power. The innovative system permits a dependable, inexpensive, non-hazardous solution for intermittent power restoration.

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

Patents and Inventors

Yimin Gu
Nadarajah Narendran
High-Power White Emitting Diodes and Manufacturing Methods Thereof (Patent in Europe)

Michael Amitay
Edward DeMauro
Anna Helen Dyson
David Menicovich
Ajith Rao
Peter Stark
Jason Oliver Vollen
Methods and Systems of Modifying Air Flow at Building Structures (Patent in Japan)

Michael Amitay
Daniele Gallardo
David Menicovich
Active Modular Aerodynamic Drag Reduction System (Patent in Japan)

Jean Paul Freyssinier
Yimin Gu
Nadarajah Narendran
Yiting Zhu
Scattered-Photon Extraction-Based Light Fixture (Patent in Japan)

Mark P. Wentland
Carboxamide Bioisosteres of Opiates (Patent in Canada)

Jonathan Seth Dordick
Robert John Linhardt
Zhenyu Wang
KS Heparosan Fermentation and Purification (Patent in Malaysia)

James V. Crivello
Vinyl Ether Functional Oligomers and Methods for Making and Using Same (Patent in the United States)

Edward Harris
Robert John Linhardt
Jian Liu
Yongmei Xu
Reversible Heparin Molecules and Methods of Making and Using the Same (Patent in the United States)

Rahul Mukherjee
Trevor Simmons
High-Performance Cathode Materials for Lithium Sulfur Batteries from Lignosulfonate (Patent in the United States)

Mark P. Wentland
8-carboxamido-2, 6-methano-3-benzazocines (Patent in the United States)

Brian C. Benicewicz
Henrik Hillborg
Linda S. Schadler Feist
Su Zhao
Use of layered core/shell nanoparticles to improve the properties of machine insulation materials (Patent in Europe)

Charles Sanford Goodwin
Robert F. Karlicek Jr.
Jian-Qiang "James" Lu
Anton Tkachenko
Light Emitting Diodes and a Method of Packaging the Same (Patent in Japan)

Partha S. Dutta
Therapeutic Environmental Lighting and Imaging Systems (Patent in the United States)

Jian Sun
Multi-Terminal DC Power Systems Employing Autonomous Local Control Methods (Patent in Europe)

Brian C. Benicewicz
Robert F. Karlicek Jr.
Ying Li
Linda S. Schadler Feist
Richard W. Siegel
Peng Tao
Lei Wang
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Joe H. Chow
Scott Gordon Ghiocel
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Wenxiang Cong
Ge Wang
Yan Xi
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Anqing Liu
Michael Shur
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Ishwara B. Bhat
Tat-Sing Paul Chow
Rajendra P. Dahal
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Kim Boyer
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Xinchi Zhang
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Ishwara B. Bhat
Rajendra P. Dahal
Yaron Danon
Jian-Qiang "James" Lu
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Travis B. Bashaw
John Blackburn
Paul Darois
Steve Galonska
Burt L. Swersey
Training Device for Extinguishing Fires, Method and System of Use Thread (Patent in France, Netherlands, and Great Britain)

Brian C. Benicewicz
Henrik Hillborg
Linda S. Schadler Feist
Su Zhao
Use of layered core/shell nanoparticles to improve the properties of machine insulation materials (Patent in France, Germany, Great Britain, Europe, and Italy)

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