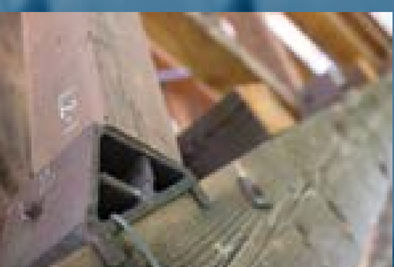
CASE SCHOOL OF ENGINEERING

Annual Report 2012-2013

MAKE IT QUICKER
MAKE IT EFFICIENT
MAKE IT EFFECTIVE
MAKE IT COMPATIBLE



MAKE IT SUSTAINABLE
MAKE IT HAPPEN
MAKE IT ACADEMIC
MAKE IT COMMERCIAL
MAKE IT DYNAMIC
MAKE IT STRATEGIC
MAKE IT BETTER

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY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Dear Colleagues and Friends:

At the Case School of Engineering, we make makers.

Bright young students who develop into the solvers of tomorrow's problems.

Faculty members who grow research portfolios that make meaningful contributions to society's most pressing concerns.

We do this, because we must. It is a national imperative.

A special report by the National Science Foundation stated that science and technology are, and will continue to be, "engines of U.S. economic growth and national security." According to the Bureau of Labor Statistics, in the year 2020, there will be 9.2 million jobs in STEM fields. To prepare for this future, research and academic institutions like Case Western Reserve University must take the lead and continue to grow our faculty, staff and students to rise to the challenges approaching us.

We teach our students the foundations of engineering at a depth that allows them to be leaders in their fields. But we go beyond rigorous academic principles. We give them ample opportunities to become excellent communicators. We get them designing and building in their first semester. We teach them how to work in interdisciplinary groups. And we model this behavior by leading multidisciplinary research projects across our departments, across our campus and across our community.

Because we are a culture of makers, and our "open source" spirit means we don't hold back. We think. We collaborate. We discover. And we make. We are makers; we help make makers and together, we make the world better.

Warmest Regards,

Jeffrey L. Duerk
Dean, Case School of Engineering
Leonard Case Jr. Professor of Engineering

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Annual Report 2012-2013

MAKE IT **QUICKER**.
MAKE IT **EFFICIENT**.
MAKE IT **EFFECTIVE**.
MAKE IT **COMPATIBLE**.
MAKE IT **SUSTAINABLE**.

Make it bigger. Or smaller. Slower. Or faster. Make it harder. Easier.

Make it more functional. More beautiful.

Have a better idea from the start. Find new ways to explore its growth.

Ponder it from all angles. Engage everyone possible along the way.

Research it. Teach it. Touch it. Understand it.

Make it better.

Celebrate each step along the way. Be inspired by it. Inspire others.

Make it do more. With less. Make it dynamic. Make it meaningful.

At the Case School of Engineering, we make it all this, and more.

WE MAKE IT **HAPPEN**.

MAKE IT **QUICKER**
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MAKE IT **SUSTAINABLE**
MAKE IT **HAPPEN**

PRINTING IN 3

CASE WESTERN RESERVE HELPS LEAD $70M INITIATIVE TO REVITALIZE U.S. MANUFACTURING, WINS FIRST-ROUND FUNDING

The National Additive Manufacturing Innovation Institute (NAMII) opened its doors in September 2012 in the Midwest's "Techbelt" corridor through Northeastern Ohio, West Virginia and Pennsylvania.

The first major investment for this **national research center for high-tech manufacturing came from a $30-million federal grant** to establish NAMII, with an **additional $40 million coming from the more than five dozen research universities, community colleges, companies and nonprofits involved**. Academic institutions Case Western Reserve, Carnegie Mellon, Youngstown State, Penn State and the University of Akron provide leadership for the endeavor. Coordinating the efforts in manufacturing innovation for Case Western Reserve is James McGuffin-Cawley, chair of the Department of Materials Science and Engineering.

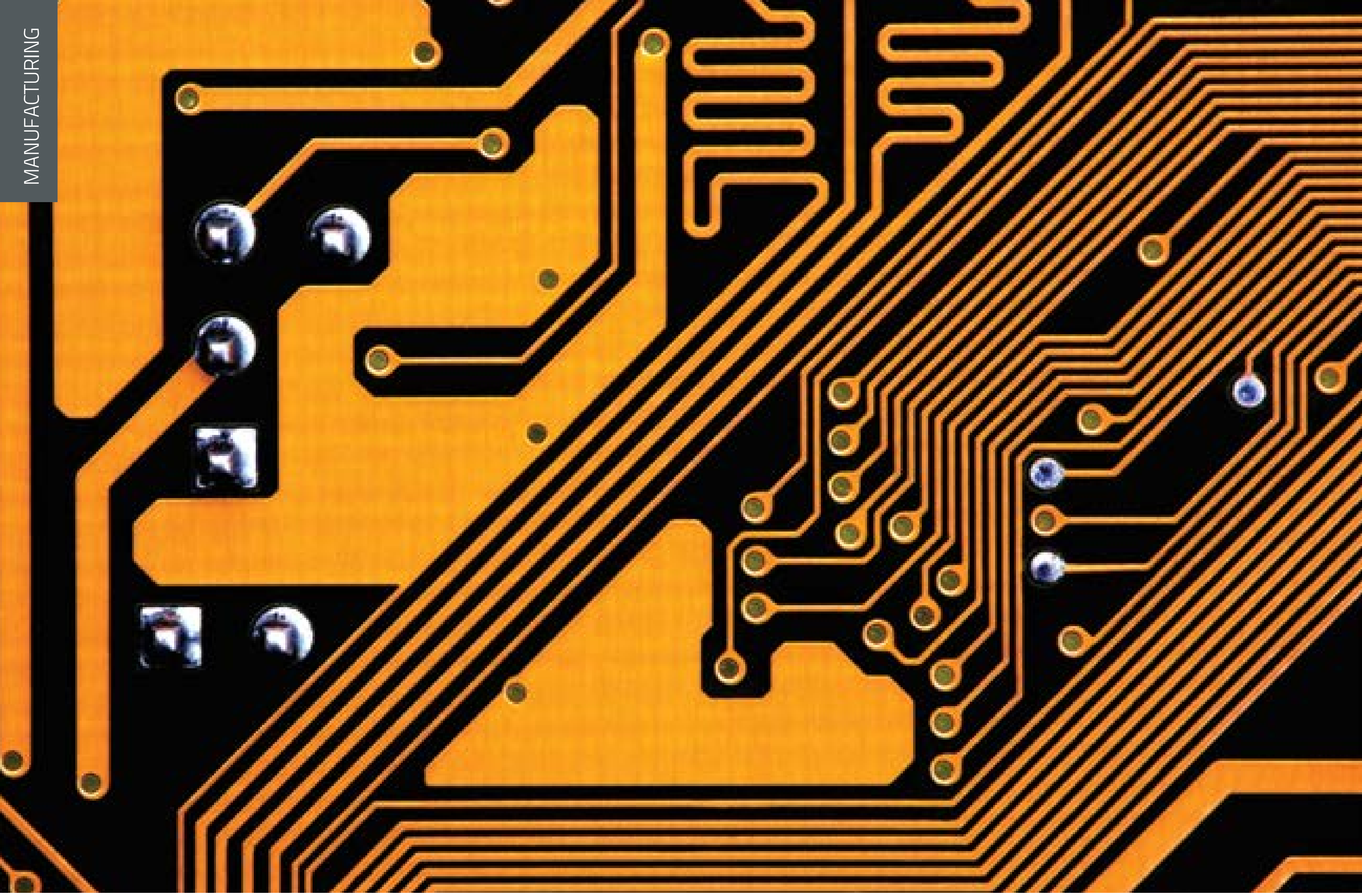
NAMII is focused on innovations in additive manufacturing—a 3-D printing approach to making products by layering materials. Among its potential advantages are timeliness, design flexibility and reduced capital costs by requiring fewer specialized pieces of equipment.

In its first round of funding, NAMII supported seven projects—two of which are led by Case Western Reserve. One grant will fund a project to develop methods for extending the life of molds and dies used in metal casting via techniques like 3-D printing to refurbish existing tooling rather than spending millions of dollars to fabricate entirely new pieces. The second award supports a joint effort between Case Western Reserve and Carnegie Mellon to study the microstructure and mechanical properties of two key additive manufacturing processes—EOS laser sintering and Arcam electron beam melting. This project aims to develop fundamental characterization methods and data to increase the reliability of parts produced by additive techniques.

Learn more at engineering.case.edu/additive-manufacturing.

James McGuffin-Cawley

DIMENSIONS



CASE WESTERN RESERVE PARTNERS WITH ATOTECH TO HELP BUILD THE WORLD'S SMALLEST SEMICONDUCTORS

Pushing the limits of miniaturizing semiconductors is crucial to the fabrication of more powerful and more capable computers, phones and other electronics. The smallest semiconductors on the market today measure about 22 nanometers, and current production methods don't seem up to the task of shrinking them any further.

To address this need, **Case Western Reserve University signed a major research contract with the world's leading manufacturer of chemicals for the metal finishing and electroplating industry—Atotech**—aimed at developing novel chemistries and processes that will enable the manufacturing of the world's smallest semiconductors—less than half the size of today's tiniest devices.

Atotech Deutschland GmbH, headquartered in Berlin, has been collaborating with researchers at Case Western Reserve for the past six years on developing improved chemistries and characterization techniques for advanced metallization of semiconductor devices by electroplating.

This new agreement will build on that work and **explore the application of a metallization technology, called electroless deposition**, which uses a chemical reaction instead of an electric current to create the copper-wire network that distributes the current within the semiconductor device.

The research program will involve faculty members from the chemical engineering, materials science and engineering, and macromolecular science and engineering departments, and scientists from Atotech who will be on-site in Cleveland.

Learn more at engineering.case.edu/Atotech-agreement.

RESEARCHERS WIN $1.2M NSF GRANT TO REFINE MANUFACTURING METHODS TO MASS-PRODUCE NANOSCALE ELECTRONICS

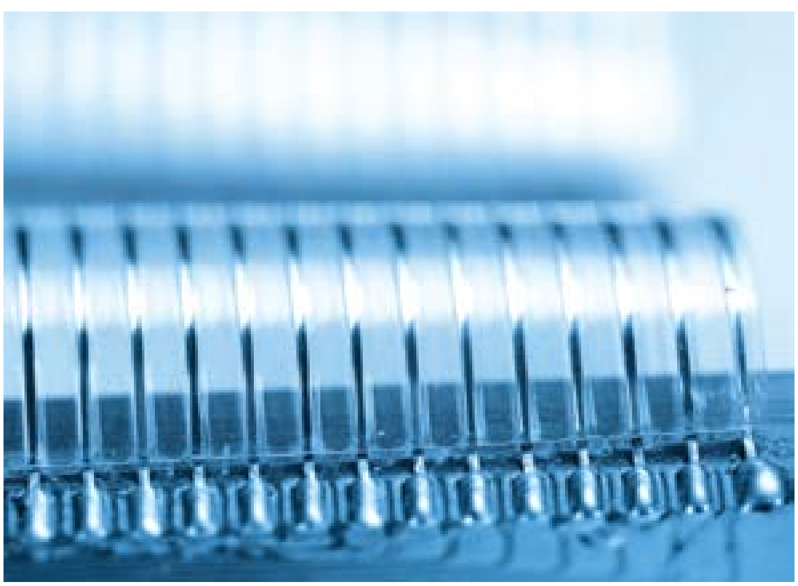
A team of engineers from Case Western Reserve University has won a $1.2-million National Science Foundation grant to revolutionize the production of flexible nanoscale electronics.

Ultimately, scientists and engineers aim to build **ultra-tiny, highly flexible devices for a variety of applications**, from non-invasive biosensors for personalized medicine to integrated circuits for flexible displays, electronic paper, smart textiles and other consumer products.

The industry standard production method for nano-sized electrical components is expensive and time-consuming, and the polymer materials currently being used are insufficient for long-term use.

The four-year grant will help lead researcher Christian Zorman, associate professor of electrical engineering and computer science and his team **refine an alternative technique that uses microplasmas to build metal lines and other electronic structures less than 100 nanometers in width on polymer substrates** with unprecedented moisture-barrier properties.

Learn more at engineering.case.edu/flexible-nanoscale-electronics.



CASE WESTERN RESERVE JOINS EFFORT TO ADVISE LOCAL MANUFACTURERS

Small- and mid-sized manufacturing firms often fail to make the next big leap because they don't have access to the latest technology, marketing and innovative research.

Through a new collaboration, Case Western Reserve is offering up university expertise and resources to provide area companies with everything they need to advance their businesses, which, in turn, can help advance the region as a leading manufacturing center.

Case Western Reserve—with Cleveland State University, Lorain County Community College and the University of Akron—will work with and advise regional small- to mid-sized local manufacturers through a program coordinated by the Manufacturing Advocacy & Growth Network (MAGNET).

MAGNET is a Cleveland-based nonprofit manufacturing consulting service. It estimates that Northeast Ohio is home to about 10,000 small- to mid-sized manufacturers—many of which are successful, but lack the technical services, marketing capabilities and connections to grow.

The agreements commit the institutions to further regional economic development by helping manufacturers pursue innovative growth strategies and, thereby, create jobs. The collaboration essentially provides a tool chest for local industry to tap into.

Learn more at engineering.case.edu/MAGNET.

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BIG MEDICINE +

NEW CODE FOR GENETIC DATABASES EXPEDITES SEARCHES

Zehra Meral Özsoyoğlu

As medical science dives deeper into our genes, unlocking the secrets of our genetic code, genealogical information plays an increasingly important role in our health. Databases of all kinds and sizes exist to help patients, clinicians and geneticists sort through terabytes of information—from web-based tools that record individual family health histories to massive population-based collections that store millions of records.

Pedigree graphs—diagrams that trace hereditary data through generations—are one way this information can be organized. **But sifting through the data and putting it to work can be cumbersome and time-consuming**, even for the fastest computers.

A new method of encoding pedigree data developed by computer scientists at Case Western Reserve University, led by Distinguished Research Professor Zehra Meral Özsoyoğlu, the Andrew R. Jennings Professor of Computing, **offers a more efficient way to sort through big data on these graphs for answering path-based queries**, such as whether ancestors, descendants or second-degree relatives have specific conditions.

Standard techniques store parent/child information together with the data for each node, which means each pedigree query requires a separate step to navigate the graph. An alternative is to use labels for each node in the graph representing paths from the node's ancestors. This method is more efficient, but since multiple labels are used for each node, with a separate label representing each path to every node, it is not scalable for very large graphs. Özsoyoğlu and her team's unique method uses compact encodings that use only one label for each node representing all the paths to the nodes in a compressed format that expedites the search—saving time and space.

The technique could be used to help inform genetic counseling by evaluating family health histories and calculating genealogical measurements that trace hereditary illnesses and identify the genetic risk of some cancers.

BIG DATA

MAPPING THE BRAIN

Case Western Reserve University researchers **launched a clinical trial to study brain-mapping technology and its potential to help restore movement to paralyzed limbs.**

In this early-stage human trial, researchers will **test a system called BrainGate2—a brain-computer interface consisting of a baby-aspirin-sized sensor loaded with more than 90 electrodes—using it to record the brain activity of paralyzed patients as they imagine using their arms and hands**, while also assessing the device's safety and feasibility.

Studies have shown that the brain continues to send signals to paralyzed muscles, even if the neurological connection between them has been severed. Scientists hope to eventually harness these electrical impulses—recording them at the source and using them to drive assistive devices.

The BrainGate technology was developed at Brown University, and the trial includes researchers from Brown, Massachusetts General Hospital, Providence VA Medical Center and Harvard Medical School. Robert Kirsch, chair of Case Western Reserve's biomedical engineering department, is leading the university's efforts on the trial, along with colleagues at the Case Western Reserve School of Medicine.

UNIVERSITY LAUNCHES COMPUTER SCIENCE THINK TANK IN SILICON VALLEY

Once little more than a quick way to crunch numbers, computers are now an essential component to nearly everything we do. They're in our homes, offices, cars—even in our hands. And **Case Western Reserve University's Case School of Engineering created a think tank of industry experts to make sure it stays ahead of the constantly evolving curve of education and research in the computational sciences**.

The Silicon Valley Computing Think Tank met for the first time in December 2012, and then again in April 2013, bringing together 15 of the university's industry-leading alumni—academic leaders, software pioneers, computer engineers and others—to share their ideas on where computing is headed and what the university can do to make sure it secures the cutting edge.

The group **identified a number of priority areas for the university to focus its research and academic efforts, including cloud computing, big data, human-computer interfaces and a number of fields in medicine, from deployment of electronic medical records to brain mapping.**

The group plans to meet twice a year to share insights and recommendations with university leadership.

Anant Madabhushi

NEW CENTER MAKES DIAGNOSES MORE PERSONAL

Aggressive treatment may seem like a logical next step following a cancer diagnosis. But many patients undergo unnecessary surgery or other harsh therapies because science often can't distinguish between slow-growing and aggressive forms of the disease.

A new center established at Case Western Reserve University is using big data to identify different forms of diseases, including cancer, and inform more tailored treatment options.

Associate professor of biomedical engineering **Anant Madabhushi established the Center for Computational Imaging and Personalized Diagnostics** at Case Western Reserve in the fall of 2012, when he was recruited from Rutgers University.

In 2013, Madabhushi and his research team won a $1.2-million grant from the Department of Defense to conduct an image-based analysis of diseased tissue from prostate cancer patients. They will evaluate tumors for characteristics that signal aggression to identify cancers considered very low-risk, which could help guide patients to the most effective treatment. The team has also received:

- $540,000 from the National Institutes of Health to study the use of MRI to guide laser interstitial thermal therapy*
- $100,000 from the Ohio Third Frontier to develop image-analysis-based technologies to predict the aggressiveness of estrogen-receptor-based breast cancers; and
- $125,000 from the Department of Defense to use MRI to study the effects of early treatment changes due to radiation therapy for prostate cancer—a project led by one of the center's post-doctoral fellows, Mirabela Rusu.

In total, Madabhushi and his research teams are working on more than 30 projects, seeking new ways to use informatics to quantitatively describe disease morphology and build new predictors for distinguishing aggression in diseases, including tumors of the prostate, breast, pharynx and brain; lung inflammation; carotid plaque; and epilepsy.

*Funding provided by NIH grant No. R21CA167811

NEW INTEGRATED SYSTEM BRINGS FEELING TO PROSTHETIC LIMBS

Dustin Tyler

A prosthetic hand that allows the user to feel. That's the goal of research being conducted by associate professor of biomedical engineering Dustin Tyler in conjunction with the Louis Stokes Cleveland VA Medical Center, thanks to funding from the VA and DARPA's Reliable Neural-Interface Technology (RE-NET) program.

Tyler's vision is to **create a direct connection between the brain and external devices**, such as prostheses. The project is two-fold: to **create a system that stimulates the brain to "feel" natural sensation from the prosthesis and to record the nerve signals from the brain when thinking about hand movements in order to control the prosthesis**.

Already, the research team has developed the flat interface nerve electrode (FINE) system that **provides enough sensation to 20 contact points on the hand to allow subjects to feel what they touch**. Using a system that connects to the nerves of the forearm above the location of amputation, the system delivers direct sensory feedback to the brain. A person feels touch on the prosthesis just like touching his or her actual hand.

Current functional prosthetic hands require the individual to use visual cues: staring at a coffee mug in order to pick it up, for instance. They also do not allow the individual to determine the amount of pressure required to grab or carry an item, making nuanced movement impossible. These are two of the main reasons nearly 50 percent of all individuals with functional hand prosthetics abandon their devices.

Incorporating the abilities to feel and touch has not only made the prosthetics more useful, but has also created some surprising side benefits, such as the lessening of phantom pain and a more accurate sense of the individual's hand in space.

INTRODUCING

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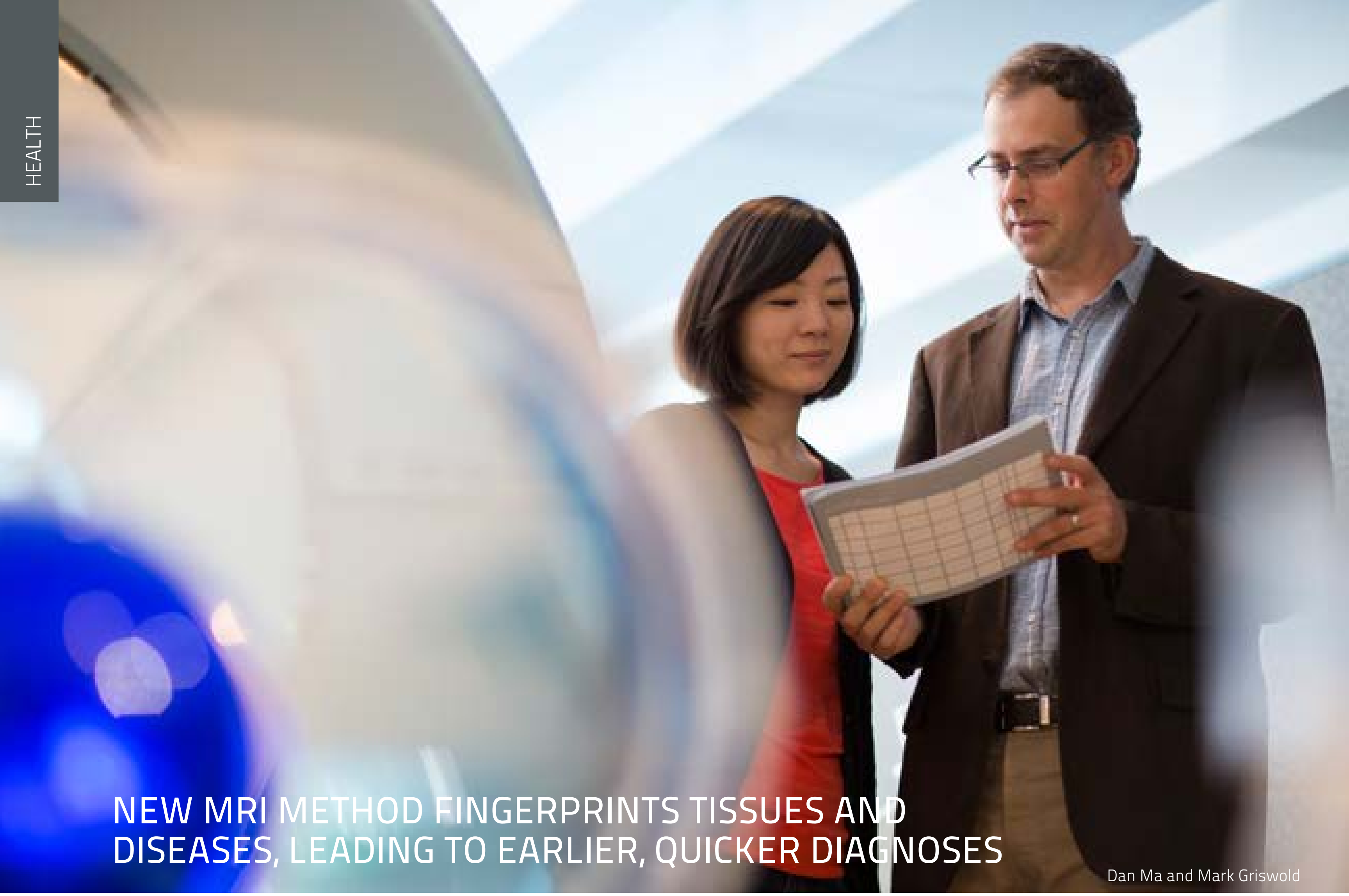
TOUCH



Dan Ma and Mark Griswold

NEW MRI METHOD FINGERPRINTS TISSUES AND DISEASES, LEADING TO EARLIER, QUICKER DIAGNOSES

Each body tissue and disease has a unique fingerprint. And a new MRI method developed by researchers at Case Western Reserve University and University Hospitals Case Medical Center utilizes that signature to provide early identification of specific cancers, multiple sclerosis, heart disease and other maladies.

By using **new MRI technologies to scan simultaneously for various physical properties**, the research team was able to differentiate white matter from gray matter from cerebrospinal fluid in the brain in about 12 seconds, and believes it can achieve the same results even faster in the near future.

The technology has the **potential to make an MRI scan standard procedure in annual check-ups**, which would provide more information and ease interpretation of data.

Research lead Mark Griswold, professor of radiology and biomedical engineering, collaborated on the project with assistant professors Vikas Gulani and Nicole Seiberlich, professor Jeffrey L. Sunshine, Siemens Medical Solutions collaborations manager Kecheng Liu, engineering school dean Jeffrey L. Duerk and biomedical engineering graduate student Dan Ma—who served as first author on the paper, which was published in *Nature*.

Magnetic resonance fingerprinting (MRF) can obtain much more information with each measurement than a traditional MRI, including severity and cause of disease. In MRF, the fingerprint of each tissue, disease and material is recorded individually by simultaneously varying different parts of the input electromagnetic fields that probe the tissues. These variations make the received signal sensitive to four physical properties that vary from tissue to tissue.

The team believes it will be able to interrogate a total of eight or nine physical properties, which will allow elicitation of the signatures from a vast array of tissues, diseases and materials.

Learn more at engineering.case.edu/MRF.

VISUALIZING THE STRESSES ON AN EMBRYONIC HEART IN 3-D

For the first time, researchers have captured a three-dimensional map of the stresses that pumping blood induces in embryonic hearts.

The visualization, created at Case Western Reserve University, is a **key to understanding triggers of heart defects** and brings scientists one step closer to preventing and treating heart defects before birth.

The research group, led by professor of biomedical engineering Andrew Rollins, has **begun testing the new technology to uncover how alcohol, drugs and other factors set off events that result in defects** found in newborn humans.

Passing blood cells drag on the endothelial cells that line the growing heart, a phenomenon called shear stress, which has been linked to changes in gene expression that result in defects, most often in the valves. But precisely how they're connected is unclear.

To look at the structure of the developing heart and blood flow, the researchers **utilized a technology called Doppler optical coherence tomography (OCT), which shines an infrared laser on the heart.**

The reflections measured at various depths are used to create a three-dimensional image. The researchers then add the dimension of time, creating movies of blood flow through the structures—needed to map shear stress.

This technology is being used to study how problems with heart function very early in development can lead to serious heart defects later.

Learn more at engineering.case.edu/3D-stress-map.

NANOPARTICLES HELP DOUBLE INTERNAL INJURY SURVIVAL RATE

In the vital first hour after a traumatic injury, **nanoparticles tailored to interact with platelets can rapidly create healthy blood clots to nearly double survival rate** in cases with significant internal bleeding.

Erin Lavik, the Elmer Lincoln Lindseth associate professor of biomedical engineering, is leading a team that is **developing synthetic platelets that first responders and battlefield medics could carry with them** to stabilize car crash or roadside bomb victims. An injection could slow or halt internal bleeding until the victim reaches a hospital and receives blood transfusions and surgery.

The research team previously knew the nanoparticles stop bleeding faster, but now have confirmed that they can stop bleeding in time to increase survival rate following trauma.

Such a product could be beneficial for the military, which does not currently have blood products to augment hemostasis in the field. It could also have widespread civilian applications: **Traumatic injury is the leading cause of death for people ages 4 to 44**.

Learn more at engineering.case.edu/nanoparticle-platelets.

CONTROLLING siRNA TO AID REGENERATIVE MEDICINE AND CANCER THERAPY

The genetic material small interfering RNA (siRNA) can be packaged and unleashed as a precise and persistent technology to guide cell behavior. A new biomaterial system, developed by associate professor of biomedical engineering Eben Alsberg, can control the location, duration and profile of siRNA release to potentially **inhibit tumor growth or even assist in tissue engineering**.

Alsberg's research group is utilizing this approach to **catalyze stem cells to grow into, for example, bone cells,** instead of fat, cartilage, smooth muscle and other cell types. The technology also has potential to **starve a tumor** by blocking growth of blood vessels that carry nutrition to a malignancy, or bring on cancer cell death by interfering with other cellular processes.

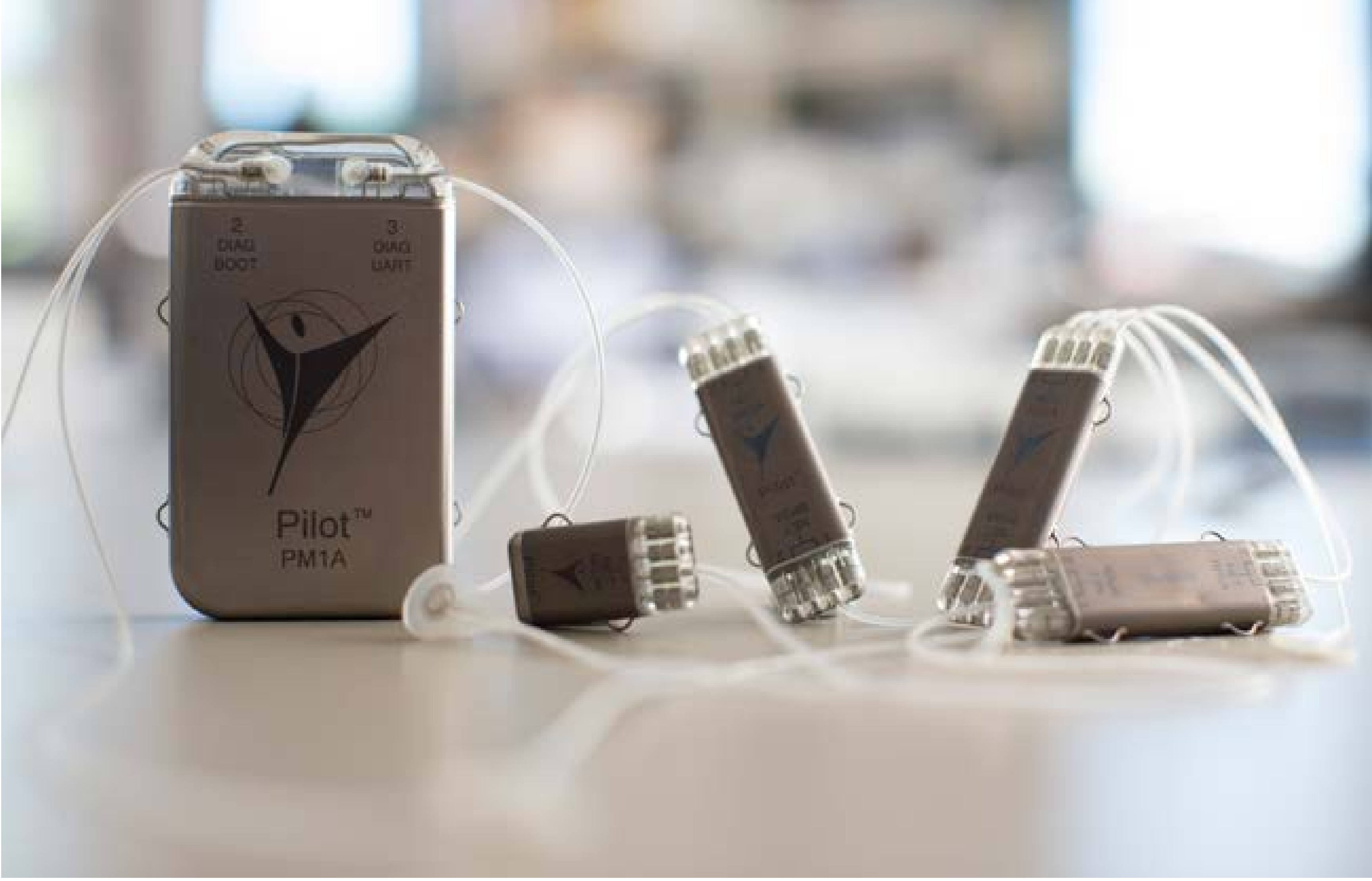
Because siRNA rapidly disperses when injected in the bloodstream or directly into target tissues, the research team **packaged siRNA in a mix of polymeric materials that, under UV light, is induced to form hydrogels** connected by a network of polymer threads. As the threads of hydrogels break down, the siRNA molecules are cut loose to redirect the fate of the targeted cells. Ultimately, this system can be injected into a target tissue and application of light from outside the body or inside the body with a fiber optic cable will induce hydrogel formation.

Learn more at engineering.case.edu/siRNA.

GRAPHENE-POLYMER NANOCOMPOSITE KILLS SURFACE BACTERIA

Macromolecular science and engineering professor Rigoberto Advincula teamed up with researchers from the University of Houston to develop a graphene-polymer nanocomposite that can kill surface bacteria and prevent its growth.

The antimicrobial and biocompatible material is a potential candidate for coatings for surgical equipment and other industrial applications.



CASE WESTERN RESERVE WINS $3M THIRD FRONTIER GRANT TO TEST IMPLANTABLE COMPUTER NETWORK

Could the human body house a computer network? P. Hunter Peckham, the Donnell Institute Professor of Biomedical Engineering and Distinguished University Professor, thinks so. He's leading an effort to **test and introduce to market a fully implantable computer network, including multiple neural stimulation and sensing interfaces**. The system would **enable a quadriplegic to move arms and legs, regulate breathing, control bladder, activate cough** and more.

The Ohio Third Frontier awarded $3 million to move the project forward, and the university and Cleveland-based industrial partners will match the funding.

Peckham hopes to move beyond the current state-of-the-art in neural prostheses, which are limited to only one body function. Peckham's team at the Functional Electrical Stimulation Center has spent the past 10 years developing computer-based implants with network connections powered by batteries that provide all the interfaces needed to record nerve activity and stimulate nerves and their connected muscles.

The team is **building the implanted network to be modular and scalable so it can be tailored to each patient's needs**. The only hardware that will be outside the body is the wireless battery charger patients would use once or twice a week, usually while they sleep.

The network is aimed at those who suffer spinal cord injuries, stroke or multiple sclerosis, as well as to ease chronic pain, or regain control lost to Parkinson's disease or other maladies.

University researchers are pursuing FDA approval to begin their first human study of the system by the spring of 2014.

Learn more at engineering.case.edu/Ohio-Third-Frontier-Grants.

SQUID-BEAK-INSPIRED BIOMATERIAL COULD MOVE RESEARCHERS CLOSER TO BETTER MEDICAL IMPLANTS

From insulin pump needles to stents to prosthetic limbs, many medical implants and devices require hard materials to connect or pass through soft body tissues. The material mismatch can lead to discomfort, infection, poor performance and even outright failure.

But researchers at Case Western Reserve University developed **a new biomaterial inspired by an unlikely model—the squid—that could lead to a new generation of safer, more biocompatible implants.**

Scientists developed the material **based on the mechanical gradient found in the squid beak, which provides a natural buffer between the beak's super-sharp, tough tip and its more malleable body**. In nature, the gradient acts as a shock absorber, allowing the animal to bite down with bone-crunching force without damaging the delicate tissues of its mouth.

The research team included Stuart J. Rowan, the Kent Hale Smith Professor of Engineering in macromolecular science and engineering, Jeffrey R. Capadona, assistant professor of biomedical engineering, and Paul D. Marasco, a researcher at the Louis Stokes Cleveland Department of Veterans Affairs Medical Center.

They created the material using a network of cellulose nanocrystals, whose stiffness can be varied depending on how long they're exposed to ultraviolet light—the longer the exposure, the harder the material. And just like its natural counterpart, the material's gradient was steeper when wet, which means **the body's watery environment will enhance the gradient as well, showing promise for improved medical implants for people.**

Learn more at engineering.case.edu/squid-beak.

Stuart J. Rowan

Jeffrey R. Capadona

EASING THE

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TRANSITION

CIVIL ENGINEERING RESEARCHERS REBUILD HISTORIC BRIDGE TRUSSES TO STUDY REHABILITATION BEST PRACTICES

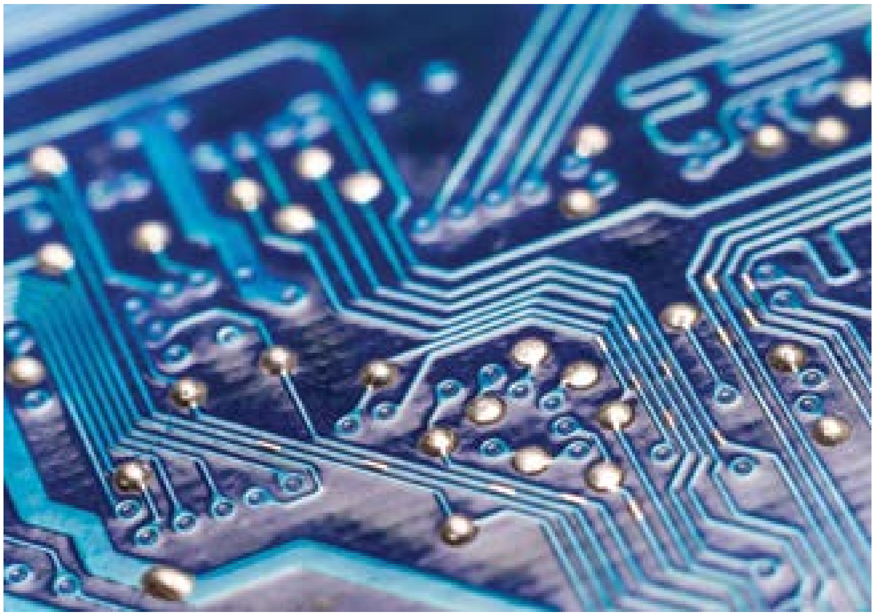
Two 13,000-pound wooden bridge trusses have been constructed outside the Vanderhoof Infrastructure Research and Education Facility at Case Western Reserve University to determine the best approaches to rehabilitate these historic structures.

Standing 11 feet high and 48 feet long, the trusses replicate the design developed by William Howe in 1840. They were part of a New Hampshire bridge built 86 years ago, but were recently burned by arson. Using timbers from Oregon, the trusses were rebuilt in New Hampshire, disassembled and shipped to Case Western Reserve for study.

Under the guidance of civil engineering professor Dario Gasparini, the **trusses have been reassembled, post-tensioned and instrumented with 44 sensors for a yearlong research project on the effects of temperature, moisture and wood viscosity on the stress state in the bridge**. The goal is to provide engineers with information they can use when rehabilitating these bridges; more than 140 still exist.

Initial results show that when restoring these bridges, **wood should be dried to below the average moisture content of the local environment in order to minimize shrinkage and loss of prestress. The trusses should also be post-tensioned in the summer when the temperature is highest, ideally with modern high-strength steel.** This can allow the trusses to be permanently post-tensioned so they don't require future adjustments.

In the spring of 2014, the trusses will be disassembled and shipped back to New Hampshire, where they will be installed for public use.



MATERIALS SCIENTISTS STUDY NEW SYSTEMS FOR HIGH-HEAT-TOLERANT ELECTRONICS

Researchers at Case Western Reserve University **won a $2.9-million grant from the Air Force Office of Scientific Research to investigate new material systems for electrical components that can take some serious heat.**

The aerospace, automotive, oil drilling and other industries are clamoring for electronic devices that can not only withstand high heat and radiation, but also thrive in such punishing environments.

The international team of engineers from three universities including Case Western Reserve, Ecole De Mines and the University of Michigan, led by Alp Sehirlioglu, research associate professor of materials science and engineering at Case Western Reserve, will **explore an alternative to silicon-based electronics capable of standing up to temperatures that would fry traditional components.** They will analyze a quasi-two-dimensional-electron gas, or Q-2D-EG, forming at an oxide-heterointerface—the meeting place between a metal oxide film and a substrate. The conductivity of the interface can be tuned, which allows it to be formed into a transistor.

The electron gas is a temperamental substance, requiring exact specifications to form and function properly. But researchers hope the **electron-gas-producing interfaces can be formed into transistors capable of operating at more than 200 degrees Celsius without external cooling.**

STANDING STRONGER

Buildings constructed before the implementation of modern codes are especially vulnerable to earthquakes. Their Achilles' heel is the development of "soft stories" during seismic shaking that may result from windows, wide doors or other openings in places where bracing or a shear wall would likely be required by today's standards. Civil engineering assistant professor Michael Pollino has launched a project to **test how adding stiff rocking cores—which consist of a strong vertical steel truss or reinforced concrete wall hinged at the base—to substandard frames could protect multi-story buildings from collapse during earthquakes.** The cores re-distribute seismic forces along the building height to help control earthquake-induced motion.

EXPLORING EUROPA

A research project launched by aerospace engineers at Case Western Reserve University could **give scientists a better look at what's hiding under the frozen surface of Jupiter's sixth moon, Europa.**

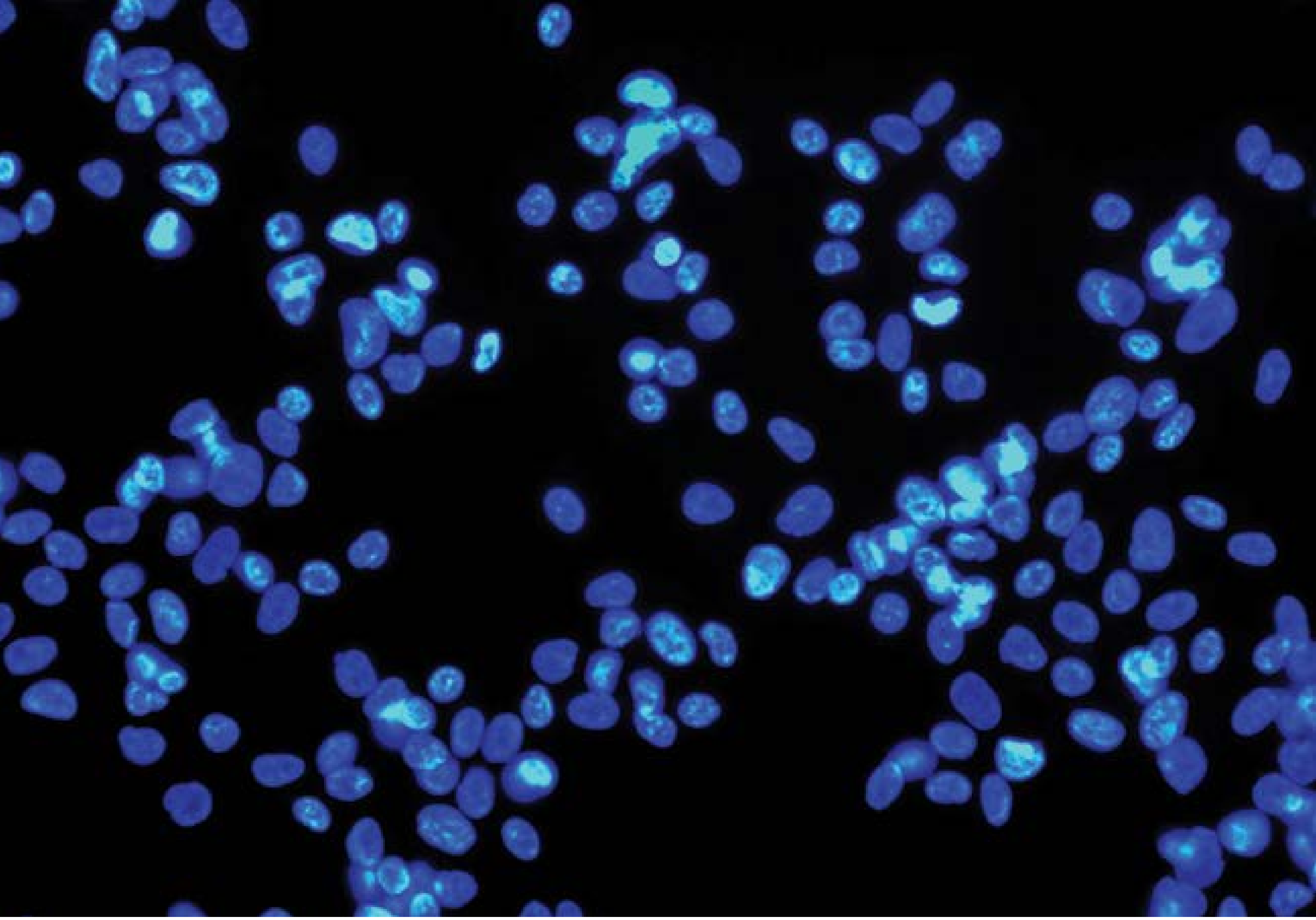
Scientists believe the vast planetary ocean that covers Europa could be one of the most likely spots harboring extraterrestrial life in our solar system. Vikas Prakash, professor of mechanical and aerospace engineering, is leading a NASA-funded effort to **develop an instrumented probe that can penetrate the layer of ice that covers the moon, record data and transmit that information back to an orbiting spacecraft.** The instrument could give scientists an unprecedented look at the composition of the ice layer itself, as well as the opportunity to study the conditions under the ice and evaluate whether the environment could support life.

A MORE NATURAL ARTIFICIAL LENS

Designed to more closely **mimic the workings of the human eye, artificial lenses developed at Case Western Reserve University could improve vision for patients with eye diseases as well as boost the performance of consumer vision products.**

The new technology was developed by Distinguished University Professor Eric Baer, the Herbert Henry Dow Professor of Science and Engineering and the director of the Center for Layered Polymeric Systems—an NSF Science and Technology Center. The lens **refracts light using gradient refractive index optics—or GRIN—the same mode of refraction used by human and fish eyes.**

The team replicated nature's model by stacking thousands of transparent polymer layers, each just nanometers thick. Each polymer has a different refractive index, which means light travels through them at different speeds. The resulting lenses have a wider field of view and the ability to reduce the size and weight of the optic system into which they are placed.



3-D MATERIAL SYSTEM DIRECTS STEM CELL BEHAVIOR

Showing stem cells how and where to grow has been a challenge to creating useful stem cell therapies. But **biomedical engineers at Case Western Reserve University developed a new technique that could give researchers unprecedented control over cell behaviors like proliferation and differentiation.**

Associate professor of biomedical engineering Eben Alsberg and postdoctoral researcher Oju Jeon **encased stem cells in a special hydrogel system.** This network of polymers can be micropatterned in three dimensions to create regions that are crosslinked to one another. Alsberg's system creates an alternating pattern of single- and double-crosslinked areas—like a checkerboard.

Researchers used the micropattern grid and hydrogel system to coax the stem cells to change into new bone or cartilage cells. They found that **cell clusters grew better in the singly crosslinked regions**—possibly because the less restrictive microenvironment allowed for better nutrient transport and provided more space for cellular interactions. The work was published in an online edition of *Advanced Functional Materials*.

The researchers are continuing to use micropatterning to understand the influences of biomaterials on stem cell fate decisions. This approach permits local control over stem cell behaviors, and ultimately, **may allow the engineering of complex tissues for regenerative medicine applications.**

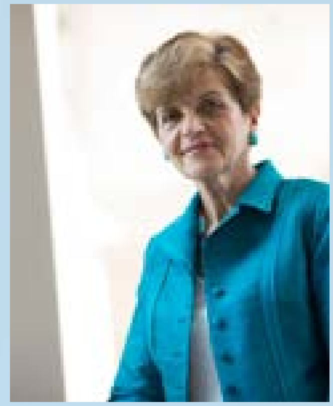
Learn more at engineering.case.edu/stem-cell-system.

MAKE IT **QUICKER**
MAKE IT **EFFICIENT**
MAKE IT **EFFECTIVE**
MAKE IT **COMPATIBLE**
MAKE IT **SUSTAINABLE**
MAKE IT **HAPPEN**

GOING GREENER

RESEARCHERS TO WEAN RENEWABLE ENERGY TECHNOLOGY OFF OIL WITH NATURAL MATERIALS

A $3.8-million National Science Foundation (NSF) grant is helping researchers at Case Western Reserve University make sustainable energy technology even greener by incorporating biomaterials into the construction of wind turbine blades and solar panels.



Ica Manas-Zloczower

The NSF Partnership for International Research and Education (PIRE) grant will support research at Case Western Reserve and seven other partner institutions worldwide for the next five years. **Scientists and engineers will first try to improve the quality and performance of existing materials, then will gradually replace unsustainable ingredients with those derived from plants, bacteria and fungi.**

Associate dean Ica Manas-Zloczower, the Thomas W. and Nancy P. Seitz Professor of Advanced Materials and Energy, is leading the efforts at Case Western Reserve. She continues to refine earlier work that built lighter, stronger wind turbine blades using polyurethane reinforced with carbon nanotubes. Her team is now investigating using natural materials like cellulose whiskers instead of carbon nanotubes to reinforce the resins in the blades.

Another team is looking to make solar panels by using organic materials with improved environmental footprints.

While the initial focus is on applying these natural building blocks to energy technology, the researchers say they expect their new materials will also attract attention from automakers and other production industries.

In addition to developing the new materials, the researchers are also creating new curriculum and information-sharing websites to educate the next generation of scientists working in sustainability.

Learn more at engineering.case.edu/PIRE-grant.

METAL-FREE CATALYST OUTPERFORMS PRICIER PLATINUM IN FUEL CELLS

Fuel cells generate power quietly, efficiently and cleanly. But the expensive platinum needed to make catalysts keeps the fuel cell from becoming the gold standard in electricity production.

But researchers at Case Western Reserve University **discovered a metal-free alternative to pricey platinum catalysts that could help the technology burst through the barriers to mass commercialization.**

The team's **new catalyst, made from graphene nanoparticles edged with iodine, performs better than its platinum counterpart** in an oxygen-reduction reaction—generating 33 percent more current in initial tests. And the metal-free version is cheaper and easier to produce.

The technology to make the alternative catalysts builds on previous work by team member Liming Dai, the Kent Hale Smith Professor of macromolecular science and engineering, who, in collaboration with professor Jong-Beom Baek at South Korea's Ulsan National Institute of Science and Technology, developed a cheap industrial process to make graphene sheets from graphite.

Researchers created the graphene nanoparticles by breaking graphite down inside a ball miller, experimenting with adding different gases to produce different catalysts. In testing, they found that iodine-coated nanoparticles out-performed those edged with bromine or chlorine.

The research team is continuing to refine the materials and process, **aiming to optimize an even better, cheaper catalyst that will help make fuel cells a realistic alternative to fossil fuels.**

Learn more at engineering.case.edu/metal-free-catalyst.

CASE WESTERN RESERVE ENGINEERS WIN GRANT TO HELP DESIGN OFFSHORE WIND FARM

The Case School of Engineering partnered with a team that **won a $4-million grant to design a wind farm off the shores of Lake Erie—and the possibility to compete for $46 million more to build it.**

The Icebreaker project developed by LEEDCo, the Lake Erie Energy Development Corp., was one of seven proposals nationwide to win funding to demonstrate the potential of offshore wind power from the U.S. Department of Energy. It calls for six 3-megawatt turbines located seven miles off the coast of Cleveland.

David Matthiesen, associate professor of materials science and engineering, is leading the university's efforts on this collaborative project. Case Western Reserve engineers are **collecting and analyzing data on Lake Erie wind, wave and ice conditions and assessing the geotechnical conditions of the lakebed** to find ideal sites for the turbines. They are also **testing materials designed to keep the blades ice-free** during Cleveland winters.

Ultimately, the team hopes to demonstrate how to build a wind farm that provides power at a comparable cost to traditional electric plants when the cost of construction, maintenance and energy production are averaged over the turbines' 20-year lifespan.

The DOE plans to fund the construction of up to three of the competing proposals.

Learn more at engineering.case.edu/Lake-Erie-windfarm.

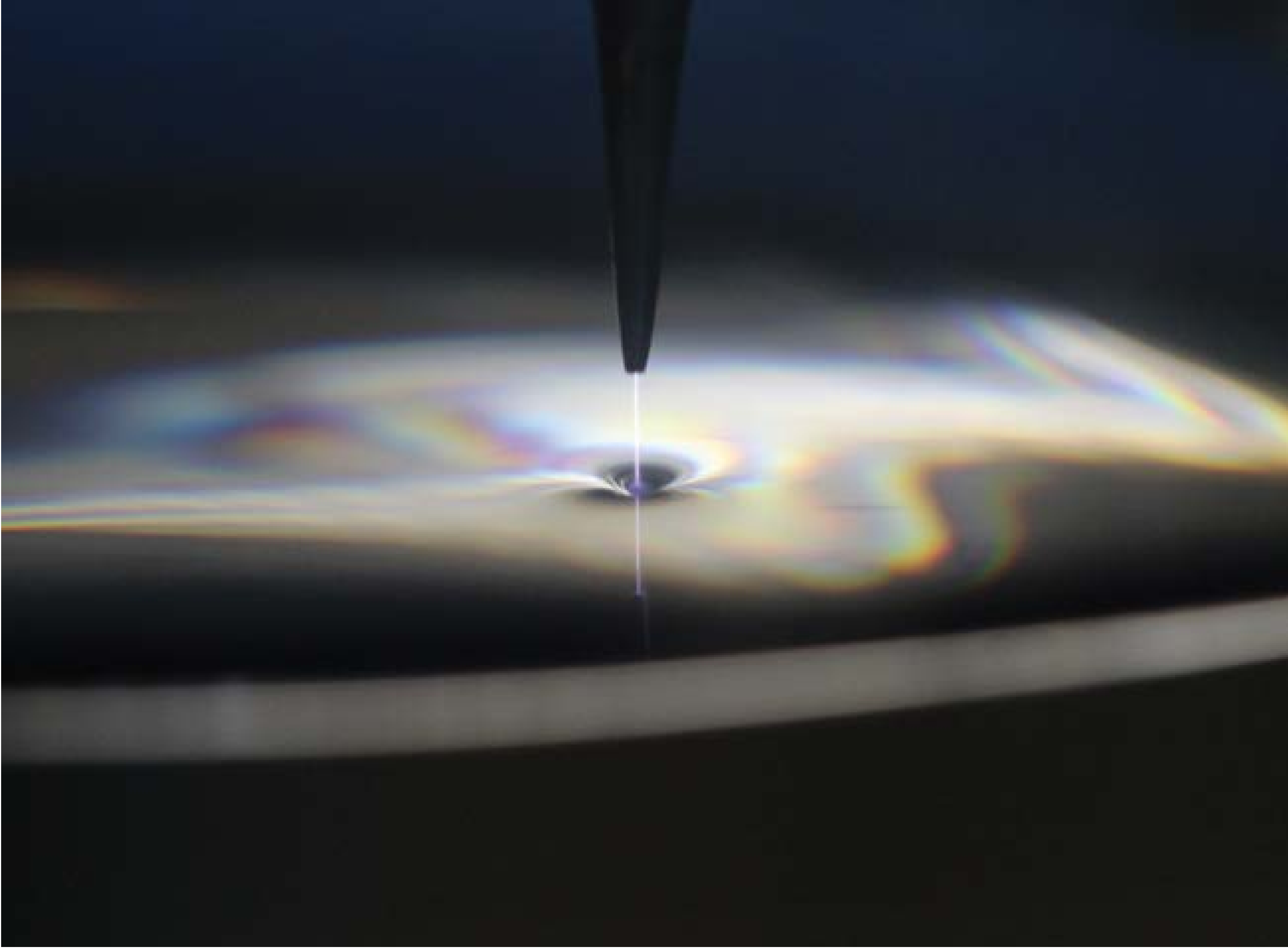
GREAT LAKES ENERGY INSTITUTE APPOINTS ABRAMSON AS FACULTY DIRECTOR

Associate professor of mechanical and aerospace engineering **Alexis Abramson was appointed faculty director of Case Western Reserve University's Great Lakes Energy Institute**. She brings considerable scientific expertise on the characterization of nanostructures and the design and synthesis of nanomaterials for use in alternative energy applications to her new role, as well as proven experience developing strategies to accelerate the commercialization of advanced technologies. She has been a member of the Case School of Engineering faculty since 2003, and served from 2011 to 2013 as chief scientist of the Department of Energy's Building Technologies Office, overseeing the investment of about $90 million per year in the research and development of energy-efficient and cost-effective building technologies.

SMARTER STORAGE

Distinguished University Professor Robert Savinell and chemical engineering research associate professor Jesse Wainright won a grant for more than half a million dollars from the **Department of Energy's Advanced Research Projects Agency – Energy (ARPA-E) to develop an iron-and-water-based flow battery that could accelerate the addition of renewable energy sources to the power grid.**

The researchers have been fine-tuning their "rust-belt" battery for more than a year. The key is a new battery architecture that pumps up the energy storage capacity and improves power density by replacing the conventional solid electrode with a conductive slurry that converts chemical energy to electrical and vice-versa. The slurry can be stored in a separate tank and pumped in as needed, allowing the battery to provide steady power for longer stretches of time.



SCIENTISTS USE MICROPLASMAS TO DRIVE NEW CHEMICAL REACTIONS

Plasmas are commonplace components in many consumer products, from halogen bulbs to high-definition TVs. A team of researchers including chemical engineers from Case Western Reserve University **made a fundamental discovery about how these ionized gases interact with water that could open untapped potential applications for plasmas.**

Chemical engineering associate professor R. Mohan Sankaran has been unlocking the properties of microplasmas for years—finding ways to make them stable enough to study and control. His latest work, a collaboration with University of Notre Dame assistant professor of mechanical and aerospace engineering David Go, **revealed a new trick—the ability to generate hydrogen gas by electrolyzing water, or splitting it into one of its two atomic building blocks.**

Water electrolysis is typically carried out with a metal electrode, such as platinum. Sankaran and his team replaced the metal with a plasma jet and produced the same water-splitting reaction.

The researchers say if plasmas can spur a simple electrochemical reaction like producing hydrogen gas, they have the potential to drive a number of other, more complex electrochemical reactions, from reduction of chemicals with low reduction potentials to nanoparticle synthesis.

MAKE IT **ACADEMIC**
MAKE IT **COMMERCIAL**
MAKE IT **DYNAMIC**
MAKE IT **STRATEGIC**
MAKE IT **BETTER**
MAKE IT **HAPPEN**

SCHOOL LAUNCHES TWO NEW MASTER'S PROGRAMS

The Case School of Engineering **launched two new master's degree programs with tracks of study in fire science and engineering, and translational health technology**.

Both programs are designed to meet the evolving needs of industry by providing highly specialized, in-depth education in specific fields.

The Translational Health Technology program is designed to teach scientists, engineers and health professionals how to commercialize promising ideas for biomedical breakthroughs. While a traditional master's in biomedical engineering focuses on the research itself, this program is designed to hone students' expertise in navigating the tricky waters of moving research into reality. Coursework includes bioengineering, marketing, entrepreneurship, bioregulatory affairs, ethics and experimental design.

The fire science and engineering track drills down into the scientific details of combustion from a mechanical engineering perspective, as well as flammability from the macromolecular engineering angle. The program also incorporates courses from chemical engineering and materials science, giving students a complete understanding of fire events.

School leaders sought the expertise of more than 60 industry partners in developing the new programs, which reflect the overwhelming feedback that companies need employees with more advanced training and access to continuous workforce development.

Both programs feature compact schedules that cater to working engineers and scientists. Full-time students can earn degrees in a year or less, and part-time students in two or three, depending on the program.

Learn more at engineering.case.edu/graduate-programs.

NASA, PTC PARTNERSHIP CREATES HANDS-ON LEARNING OPPORTUNITIES IN AEROSPACE ENGINEERING

Case Western Reserve University announced a **partnership with NASA and Massachusetts-based software manufacturer PTC that will give undergraduate students the chance to work on real-world aerospace projects.**

As a **host of NASA's Strategic Partners for the Advancement of Collaborative Engineering (SPACE) program**, the university initiated a number of projects with the space agency. Students are designing everything from cost-effective human missions to asteroids to tiny satellites to advanced mass transportation systems. Moreover, they're **using the same high-tech tools they would in the industry, thanks to PTC's donation of software to the program.**

The company donated its Windchill® for product lifecycle management requirements and PTC Creo® software for computer-assisted design, as well as hardware servers. These tools allow students to collaborate on the design, testing and simulation of the new products they create.

The first SPACE program was established at the University of Alabama in Huntsville. Case Western Reserve is the second university to join the initiative, and program leaders expect more to follow, which will give students from multiple institutions the ability to work together on NASA projects.

Learn more at engineering.case.edu/NASA-PTC-project.

WIRELESS HEALTH PROGRAM GROWS

Launched in 2010, **Case Western Reserve University's graduate program in wireless health graduated its first master's degree class and its second class of graduate certificate students**. The program's online component, including live online classes, also allowed for the enrollment of its first international long-distance participant—a student from Singapore.

It also opened its own campus at the start of the spring semester of 2013 in its home base in San Diego—a 2,000-square-foot physical home for the program that includes labs, classrooms and study areas.

The program also **finalized a relationship with Scripps Health establishing a rotation course for wireless health master's students at Scripps' San Diego hospitals**. Students are able to shadow working physicians, observe how they currently use wireless technology in their practice and identify problems and solutions for how technology can improve health care delivery.

Wireless health takes advantage of the same high-tech tools that enable people to connect and compute anywhere, but the focus is on developing devices to monitor and improve health by adding sensors and analytics. Employees from national health and technology companies including Qualcomm, Analog Devices and Aetna have enrolled in the program.

Mehran Mehregany, the Goodrich Professor of Engineering Innovation in the Department of Electrical Engineering and Computer Science, launched the program, combining the strengths of his department and the school's expertise in biomedical engineering as natural fits for the burgeoning industry. He serves as the program director. Enrique Saldivar, who holds an MD from Universidad La Salle in Mexico and a PhD in bioengineering from the University of California, San Diego, serves as the program's deputy director and chief medical adviser.

BIOMEDICAL ENGINEERING STUDENTS FIND A COOLER WAY TO TRANSPORT VACCINES

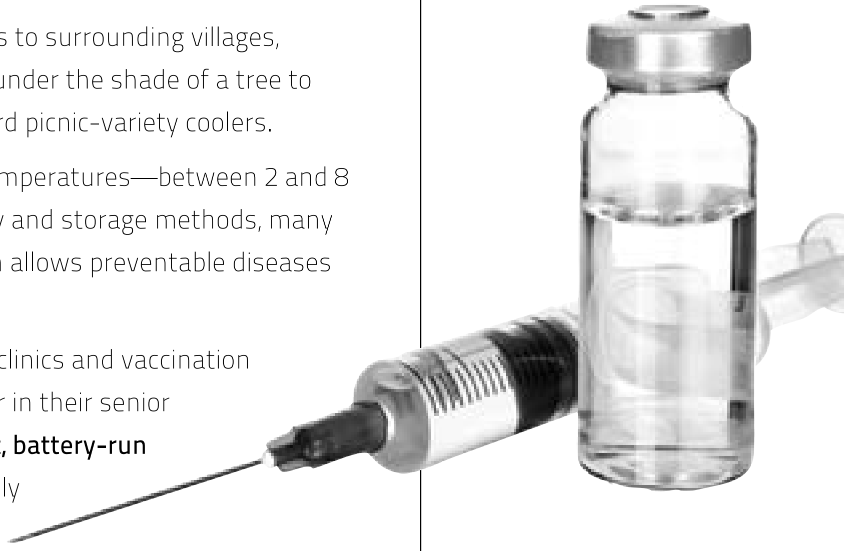
In developing countries with little access to electricity and refrigeration, **keeping vaccines cool** long enough to get them to the people who need them is a serious challenge. A group of **biomedical engineering students along with faculty from the biomedical and chemical engineering departments traveled to Malawi** over their spring break to take a look at the problem firsthand.

Only about 9 percent of the country's population has access to electricity, and nearly 85 percent live in rural areas, according to a World Bank report.

Health workers from nearby clinics ride bikes up to 10 miles to surrounding villages, where they deliver vaccinations in makeshift settings, like under the shade of a tree to keep the shots cool. They transport the vaccines in standard picnic-variety coolers.

Because the medication needs to be stored at such cool temperatures—between 2 and 8 degrees Celsius—and there are such limitations on delivery and storage methods, many children in developing countries don't get vaccinated, which allows preventable diseases to spread further.

The student group and faculty advisers visited health care clinics and vaccination stations in Malawi and then spent the rest of the semester in their senior design class **developing a solution—a portable, lightweight, battery-run refrigeration system** that is easy to transport and effectively cools the vaccines.*



*The project is supported in part by the Team-Based Design in Biomedical Engineering program through the National Institute of Biomedical Imaging and Bioengineering of the National Institutes of Health (R25EB014774) and the National Science Foundation.

SPIN-OFF COMPANY LAUNCHES "EKG VEST" PRODUCT

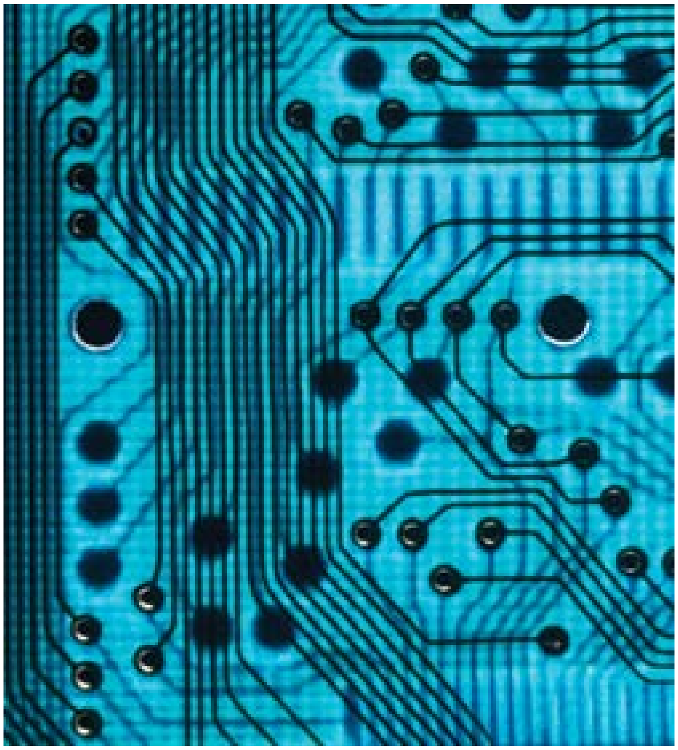
EKGs, or electrocardiograph machines, are the current standard for detecting irregular heartbeats, which can then be corrected with ablation. Yet this external way to monitor the heart can deliver imprecise results up to 40 percent of the time. Doctors must then utilize a catheter inserted into the heart via a blood vessel to locate and ablate the heart tissue responsible for the irregular heart beat. This lengthy process exposes patients to high doses of radiation and still can require several attempts before the procedure is successful. To further complicate the matter, many patients have irregular heartbeats infrequently, so detecting them when they are in for an EKG is not always possible.

Recognizing these many constraints, Case Western Reserve biomedical engineering PhD graduates Charu Ramanathan and Ping Jia set out to find a better diagnostic solution. Using technology they invented with former Case Western Reserve professor Yoram Rudy, they **designed a system to noninvasively generate high-resolution 3-D images of the heart's electrical activity using a single-use, disposable, electrode "vest" worn by the patient**.

The ECVUE system combines electrical information recorded from the body surface of the patient with high-resolution anatomy of the heart from a CAT scan to generate accurate beat-by-beat electrical maps of the heart. The procedure requires just one irregular heartbeat to provide the physician with precise information needed for a successful ablation.

Ramanathan and Jia **formed start-up company CardioInsight Technologies to commercialize the ECVUE system**. To date, the company has conducted more than 700 human clinical cases addressing a variety of rhythm disorders, including atrial fibrillation and cardiac resynchronization therapy for heart failure. The system has been used at hospitals throughout the United States and Europe, including at University Hospitals Case Medical Center, Cleveland Clinic, St. Mary's and Royal Brompton hospitals in London, and the Hôpital Cardiologique Haut-Leveque in Bordeaux, France.

CardioInsight received approval to use the ECVUE in Europe and has begun selling the product there in the last year. It is currently pursuing FDA clearance in the United States.



TECHNOLOGY TRANSFER STATS: 2012-13

In FY2013, Case School of Engineering faculty contributed to:

- **76 invention disclosures**—3.9 times the national per-dollar proficiency average*
- **91 patent filings**—5.4 times the national per-dollar proficiency average*
- **18 deals** (options and non-exclusive and exclusive licenses)—3.62 times the national per-dollar proficiency average*

**AUTM U.S. Licensing Activity Survey for U.S. universities, FY2012 (latest available data).*

CONSERVOCARE GETS LICENSING

Case Western Reserve University **spinoff ConservoCare has obtained licensing options to develop a medical device for bladder control**. Based in Atlanta, ConservoCare is focused on restoring bladder function lost due to injury or illness. Kenneth J. Gustafson, associate professor of biomedical engineering and urology and a research scientist at the Louis Stokes Cleveland VA Medical Center, is working closely with ConservoCare on the feasibility of a nerve-block medical device.

DATA-HEAVY DISCS

How much data can you fit on a disc? A Case Western Reserve University startup is shooting for 1 to 2 terabytes. Using optical technology first developed by the Center for Layered Polymeric Systems at the Case School of Engineering and the university's Department of Physics, **Folio Photonics seeks to make the 1-2 TB optical film with 64 data layers**.

COMMERCIALIZATION HELP NOW OPEN FOR BUSINESS

Blackstone LaunchPad, the university's new commercialization assistance office for student and alumni entrepreneurs, opened its doors on campus in April 2013.

The initiative is the result of a $3.2-million gift from the Blackstone Charitable Foundation and the Burton D. Morgan Foundation.

Case Western Reserve's Blackstone LaunchPad already **assists more than a dozen active student ventures**.

Learn more at case.edu/blackstonelaunchpad.

STUDENT-LED COMPANY GETS ELECTRIC BIKE ROAD-READY

Chemical engineering major Jean Zhao launched EcoSpinners LLC to develop an electric-powered bike that could put a new spin on sustainable transportation.

She and master of engineering and management graduate Justin Einstein designed the **bike, which is powered by a fuel pack consisting of a high-powered lithium ion battery charged by a liquid fuel cell**. The EcoSpinner travels over a range of 100 miles—about four times farther than current electric bikes. It produces **zero emissions, and its electric kick can assist riders** up hills or as they get tired.

Zhao studied dental medicine at Case Western Reserve University before leaving the program to pursue a more tech-focused career at Cleveland-based battery manufacturer Stratum Technologies. She returned to the university last summer, discovered the university's inventor's studio think[box] and used the facility's high-tech tools to hone her idea for a more environmentally friendly vehicle.

EcoSpinners made it to the regional finals of the Clean Energy Challenge in Chicago in April, and Zhao and her partners are continuing to **refine their invention to get it ready to market**.

ENERGY-EFFICIENT APP

Case Western Reserve University **students developed a home-energy-tracking app that won honors at the U.S. Department of Energy's Apps for Energy challenge** and earned the team an invitation to the nation's capital to show off their invention to government, industry and environmental officials.

Computer engineering students Robert Karam and Bryan Marty teamed with Cleveland Institute of Art graduate Patty Ni and created Budget It Yourself, or BIY, which parses energy data provided by power companies and converts it so that anyone with an Android smartphone can budget an electric bill.

As **second-place finishers** in the Apps for Energy challenge, the team traveled to Washington, D.C., in October to demonstrate their product to a number of high-profile officials, including then-Energy Secretary Steven Chu.

AWARD-WINNING STUDENTS

Materials science and engineering 2013 graduate **Alan Filer won a Fulbright scholarship to travel to South Korea**, where he will explore ways to replace costly and toxic rare earth and heavy metals used in solar panels with cleaner, cheaper alternatives like graphene and quantum dots.

Biomedical engineering 2013 graduate **Aaron Mayer won a Fulbright Award** to study immunology and lymphatic approaches to cancer therapy at Ecole Polytechnique Federale De Lausanne in Switzerland.

Chemical engineering PhD student **Mohamed Baqar** won the 2012 Excellence in Thermoset Polymer Research Award from the Thermoset Resin Formulators Association.

Third-year macromolecular science and engineering major **Jack Edelbrock earned honorable mention from the Barry M. Goldwater Scholarship and Excellence in Education Foundation**, which recognizes outstanding potential and commitment to excellence in science, engineering and math.

Senior mechanical engineering major **Matheus Fernandes won the Popular Choice poster award at the COMSOL Multiphysics Conference** for his project titled "Wind Flow Modeling of Area Surrounding the Case Western Reserve University Wind Turbine."

Electrical Engineering and Computer Science PhD student **Tina He won the Best Student Paper competition** at IEEE's eighth International Conference on Nano/Micro Engineered & Molecular Systems for her paper, "Dual-Gate Silicon Carbide Nanoeletromechanical Switches."

STUDENTS COOK UP BIOMATERIALS LESSON WITH JELL-O

A team of Case Western Reserve University students won the Biomaterials Education Challenge at the Society of Biomaterials' national meeting by using Jell-O to teach middle school students about engineering.

The popular snack is also among the nation's best-known biomaterials. Its primary ingredient—gelatin—is derived from the protein collagen, which makes up connective tissues.

Julia Samorezov, Christa Modery-Pawlowski and Amy Wen, all PhD candidates in biomedical engineering, and fourth-year biomedical engineering undergraduate major Sarah Gleeson, designed experiments for eighth-graders to perform on the dessert and tested their lessons with four local school classes. The experiments were designed to teach the younger students about the scientific method, in addition to basic engineering principles.

The team won $2,500 in prize money, which they plan to use to fund the Jell-O-based lessons at more area middle schools and to host a regional conference for the Society of Biomaterials at Case Western Reserve.

VEST DETECTS CANCER EARLY

A diagnostic vest created by a team of graduate students could detect many common cancers before the first sign of symptoms and help doctors catch the disease at its earliest, most treatable stages.

Computer engineering students Abhishek Basak and Vaishnavi Ranganathan and their adviser Swarup Bhunia, the Timothy E. and Allison L. Schroeder associate professor in computer science and engineering, **loaded the vest with ultrasound sensors, signal processing electronics and software to create a portable screening system**. It's designed to detect cancers in organs and tissues close to the skin's surface—the ovaries, breasts, uterus, bladder and prostate—which accounted for nearly half the cancers diagnosed in women and 42 percent of those diagnosed in men last year.

Each battery-powered vest is lined with as many as five strategically located ultrasound transducers and electronic components that create the images. Users would simply slip on the vest and tighten the straps to fit the sensors snugly to the body. Images would be produced in 15 to 30 minutes, and embedded software would automatically detect anomalies and alert the wearer by relaying the information to a smartphone.

The researchers say the vest would be most useful in developing countries as a less expensive, more easily transportable alternative to MRI and CT scanners.

STUDENT STARTUP PUTS RAPID MALARIA TEST ON FAST TRACK TO COMMERCIALIZATION

Two Case Western Reserve University **engineering students developed a hand-held malaria-detecting device and launched their own company to get it to market**.

While it's practically been eliminated in the United States, malaria is the leading cause of death and disease in much of the developing world. The **Rapid Assessment of Malaria device—RAM for short—detects the disease quicker, more accurately and cheaper than current testing methods**, according to its inventors.

Master of engineering and management student John R. Lewandowski and his brother Mark, an undergraduate mechanical engineering major, developed the device based on little more than a refrigerator magnet and laser pointer, in collaboration with assistant professor of international health Brian T. Grimberg. Their product built on previous work done by a team of researchers led by Grimberg, along with a team of physicists led by Distinguished University Professor Robert W. Brown. The Lewandowskis and Grimberg **launched a startup called Disease Diagnostic Group LLC** (DDG) to put their product on the path to commercialization. Funds to support the venture came from various sources, including the Coulter Foundation.

Malaria parasites feed on human red blood cells, but they can't metabolize iron in the blood. The RAM device uses magnets to detect the iron-filled byproducts the parasites leave behind. Current chemical-based tests need to be refrigerated, which confines them to malaria clinics, often located many miles from the villages where patients live. But **with no chemical components to keep cool, the RAM device is easily transportable**, which means clinicians can bring the test directly to the patients who need it.

DDG and its device made headlines in *The New York Times*, *Fortune* and Cleveland's *Plain Dealer*, and **won numerous business plan competitions**. The company took first place in the 2013 LaunchTown Entrepreneurship Business Idea Competition at the University of Akron and finished ninth out of 1,200 competitors at the international Rice Business Plan Competition, taking home more than $66,500 in winnings to hone its invention.

THINK[BOX], THE UNIVERSITY'S INVENTOR'S STUDIO, EXPANDS TO 4,500 SQUARE FEET

Budding entrepreneurs and inventors in the Case Western Reserve University community now have even more room and resources to bring their ideas to life with the expansion of think[box], the university's innovation hub.

The recent renovation adds 1,500 square feet to the invention center, bringing its total space to 4,500 square feet.

The **expansion introduces dedicated creative, collaborative design space** to think[box]. Users will have access to design bays with movable whiteboard walls, as well as multimedia meeting desks where teams can connect multiple personal laptops to an oversized LCD screen.

In May, the university's **Board of Trustees approved the concept for the next iteration of think[box]**, its seven-story, 50,000-square-foot home on campus.

Learn more at engineering.case.edu/thinkbox.

SCHOOL LEADS PROGRAM TO HELP REBUILD IRAQI HIGHER EDUCATION

After decades of underinvestment and isolation, the Iraqi higher education system suffered even further during the Iraq War. In the summer of 2012, **eight Iraqi engineering faculty members came to Case Western Reserve University to learn firsthand how they can reshape their universities and contribute to rebuilding their country**.

The scholars' visit was part of the Fulbright Visiting Scholar Program for Iraq, sponsored by the U.S. Department of State's Bureau of Educational and Cultural Affairs.

After an extensive application process, a panel composed of representatives from the U.S. Department of State and the Council for International Exchange of Scholars selected Case School of Engineering to host the scholars. The purpose of the Iraqis' visit was to observe and engage in both educational and cultural experiences, including learning modern teaching methods, laboratory research projects and exploring area museums, restaurants, music venues and shops.

100

CHEMICAL ENGINEERING DEPARTMENT TURNS 100

The Department of Chemical Engineering headed into its 100th anniversary celebration in 2013. One of the oldest in the nation, the department was founded **in 1913 on the university's strengths in chemistry and engineering—including alumnus Herbert Dow, the founder of the Dow Chemical Company; the Morley Chemistry Laboratory; and alumnus and inaugural chair Albert W. Smith, one of the handful of chemists who pioneered the field of chemical engineering**. Additional internationally renowned alumni include co-founder of Lubrizol, Kent H. Smith, and Charles J. Strosacker, a leader in the development of Dow's chemical product portfolio. Groundbreaking department research includes the kinetic manufacturing of diamonds and the development of respiratory sensors to monitor the breathing of premature infants.

50

MACRO FRONTIERS CELEBRATES 50 YEARS OF POLYMER INNOVATION

To cap off the 2012-13 academic year celebration of the **50th anniversary of the founding of the nation's first stand-alone polymer department**, the Macromolecular Science and Engineering department at Case Western Reserve University hosted the MACRO Frontiers symposium, featuring scholars from more than a dozen academic institutions worldwide.

IEEE ENERGYTECH CONFERENCE HOSTED

Case Western Reserve University hosted the third annual Institute of Electrical and Electronics Engineers (IEEE) EnergyTech Conference in May 2013. The conference offered presentations from members of academia, government and industry on **advances in energy systems concepts and electrical energy technology**, including generation, control, transmission, storage and efficient use.

NAE TOPICAL MEETING ON SHALE AT CWRU

Case Western Reserve University hosted the National Academy of Engineering's topical meeting "Shale Gas: Promises and Challenges" in June 2013. The **two-day event explored the risks and rewards of shale gas**, including its impact on the economy and energy security, and the environmental, health, safety and societal impact of shale gas. Discussions ranged from the link between seismic activity and waste-water injection wells, to the U.S. Environmental Protection Agency's investigation of hydraulic fracturing's impact on drinking water.

STRATEGIC HIRING INITIATIVE BRINGS NEW FACULTY MEMBERS TO CAMPUS

The Case School of Engineering continued its focused faculty expansion project this year, helping to bring six new faculty members to its ranks. The goal of the Strategic Hiring Initiative is to bridge departmental boundaries to bring together research "clusters" to tackle real-world challenges—centered on themes of advanced materials, energy, and human health and technology.

Imaging expert Anant Madabhushi joined the biomedical engineering department as an associate professor and director of the Center for Computational Imaging and Personalized Diagnostics, as well as the biomedical imaging research cluster. Read more about the new center on page 11.

Assistant professor and **structural materials expert Jennifer L.W. Carter** joined the materials science and engineering department and the sustainable manufacturing research cluster. Also joining this research cluster and the **materials department is associate professor Matthew A. Willard**.

Joining the **smart energy/smart grid research cluster is Mingguo Hong**, who sits within the electrical engineering and computer science department as an associate professor.

Biomanufacturing expert Umut Atakan Gurkan joined the mechanical and aerospace engineering department as an assistant professor, as well as the musculoskeletal innovation research cluster.

Also joining the **biomedical engineering department is associate professor Cameron McIntyre**, who resides in the School of Medicine campus and joins the engineering school's health informatics research cluster.

Plans continue to grow the faculty and research clusters at the Case School of Engineering, including active searches in fire science and engineering, biomolecular engineering and informatics.

Learn more at engineering.case.edu/strategichiring.

CASE SCHOOL OF ENGINEERING SETS FUNDRAISING RECORD FOR SECOND CONSECUTIVE YEAR

The Case School of Engineering alumni and friends helped break yet another fundraising record in 2012-2013, raising **$31.7 million in dollars, pledges and commitments**—15 percent more than 2011-2012, the previous record-setting year.

The generous contributions by school supporters also **set another record for cash gifts, with $18.9 million** in new donations provided to the school outright.

This record resulted from **3,250 total gifts from a diverse group of donors, including alumni, friends, corporations and foundations**. Highlights of individual alumni philanthropy included gifts ranging from $3 million to $5 million in support of a number of initiatives across the school—including the university's inventor's studio think[box], the Master of Engineering and Management program, the Dean's Strategic Initiatives Fund, capital improvements like labs and classroom renovations, scholarships, endowed chairs, department support and funding for student projects and competitions.

The scholarship program was bolstered by several donations from alumni to their already-established scholarship endowments, as well as **hundreds of gifts in support of current scholarships, which are key to attracting and retaining the world's best and brightest students**.

The **annual fund received approximately 2,900 donations** of various sizes, including leadership gifts of $1,000 or more from younger alumni. These contributions provide important resources to the dean to make investments in new programs, infrastructure and student support.

The generous support of these and other donors has helped the Case School of Engineering **raise $142 million of its $170-million-minimum capital campaign goal**.

A NEW WELCOME FOR THE WHITE BUILDING

When **Robert Smialek** (CIT '65, GRS '67, GRS '70) first walked through the entrance to the White Metallurgy Building more than 50 years ago, he marveled at the then-new building's modern look and feel. At a time when plastics and "space-age materials" influenced both science and design, the White Building was the perfect architectural space for the emerging home of Case Western Reserve's Department of Materials Science and Engineering.

Smialek, now an independent consultant and member of the department's visiting committee, wants today's students to have that same strong first impression. But as materials and technology have progressed from the 1960s, so has the curriculum and ways that students and faculty interact. Inspired by this new vision, Smialek made a lead gift for the renovation of the White Building.

Similarly motivated, university trustee **Jennie Hwang** (GRS '76), Ohio's only woman elected to the National Academy of Engineering, made a matching lead gift in hopes that this space will inspire tomorrow's students to engage and innovate.

The $1-million-plus proposed renovation would employ the latest materials and focus on a new dynamic entryway featuring an adjoining open-air terrace. An electronic display wall would highlight student projects and research; new windows into a multi-purpose laboratory would give those passing by a look into the exciting work going on inside. The project's next steps are to have additional donor and university commitments in place in the near future.

NEW CENTER ENCOURAGES YOUTH STEM EDUCATION

As a child, **Mark Gelfand** received a shortwave radio kit from his uncle, Leonard Gelfand (CIT '50), and he spent a month fiddling with the vacuum tubes to get it to work. To help encourage that same type of hands-on learning in science, technology, engineering and math for children today, Mark founded the **Gelfand Family Charitable Trust**, which supports STEM education initiatives in several U.S. cities, Israel and east Africa.

In 2012, the trust committed $2 million to create the Leonard Gelfand STEM Center at the university, which seeks to foster collaboration in creating STEM learning opportunities for pre-college youth.

UL HELPS FUND MASTER'S TRACK IN FIRE SCIENCE

With the generous support of **UL (Underwriters Laboratories)**, Case Western Reserve has rolled out a master's degree track in fire science and engineering. The degree curriculum focuses on the scientific disciplines of combustion, found in mechanical engineering, and flammability, found in macromolecular science and engineering.

"The program reflects the growing need for fire engineers and scientists who can research and improve products, building materials, structures and more in the ever-changing environment," says August Schaefer, senior vice president and public safety officer at UL.

Learn more about the new degree track on page 30.

HONORS & AWARDS

Clare Rimnac, associate dean of research and the Wilbert J. Austin Professor of Engineering, won the **Orthopaedic Research Society's 2013 Women's Leadership Award**. Bestowed annually, the award recognizes a woman biologist, clinician or engineer who has made significant scientific contributions to the understanding of the musculoskeletal system, and who has also demonstrated outstanding leadership through **professional services and mentorship**.

Distinguished University Professor **James M. Anderson was elected to the National Academy of Engineering**. Renowned for his research on the safety of medical implants and celebrated for his contributions as an educator, Anderson is also a member of the Institute of Medicine, the Association of American Physicians and the American Academy for the Advancement of Science.

Case School of Engineering Dean **Jeffrey L. Duerk was elected into the inaugural class of Distinguished Investigators of the Academy of Radiology Research**. The alliance of 27 professional imaging societies from around the world established the award in 2012 to recognize researchers for their achievements in the field of biomedical imaging, and Duerk joins an elite group of just 70 initial inductees.

Distinguished University Professor **Robert F. Savinell**, the George S. Dively Professor of Engineering, was appointed editor of the Electrochemical Society (ECS) Electrochemical Science and Technology journals, including ECS flagship publication the *Journal of the Electrochemical Society*. He was also named a fellow of the International Society of Electrochemistry.

Distinguished University Professor and Herbert Henry Dow Professor of Science and Engineering **Eric Baer** received an honorary professorship from Beijing University for Chemical Technology.

Professor of biomedical engineering **Xin Yu** was elected into the American Institute for Medical and Biological Engineering College of Fellows.

Rigoberto Advincula, professor of macromolecular science and engineering, won the 2013 Herman F. Mark Scholar Award from the Division of Polymer Chemistry of the American Chemical Society.

Distinguished University Professor **Chung-Chiun "C.C." Liu**, the Wallace R. Persons Professor of Sensor Technology and Control and professor of chemical engineering, was awarded an honorary professorship by National Cheng Kung University in Tainan, Taiwan.

Wen H. Ko, professor in the Department of Electrical Engineering and Computer Science, won the IEEE Sensors Council's 2012 Technical Achievement Award.

Professor of mechanical and aerospace engineering **Maurice Adams** received the Vibration Institute's Jack Frarey Memorial Award in recognition of his contributions to the field of rotor dynamics.

ADMINISTRATION

Case Western Reserve University

Barbara R. Snyder
President

William A. "Bud" Baeslack III
Provost and Executive Vice President
Professor of Materials Science and Engineering

Case School of Engineering

Jeffrey L. Duerk
Dean and Leonard Case Jr. Professor of Engineering

Gary E. Wnek
Associate Dean, Academics
Joseph F. Toot Jr. Professor of Engineering

Clare M. Rimnac
Associate Dean, Research
Wilbert J. Austin Professor of Engineering

Ica Manas-Zloczower
Associate Dean, Faculty Development
Thomas W. and Nancy P. Seitz Professor of Advanced Materials and Energy

Laura Bulgarelli
Associate Dean, Finance and Administration

Daniel Ducoff
Associate Dean, Development and Global Relations

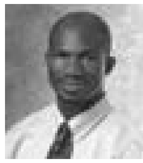
Lisa Camp
Associate Dean, Strategic Initiatives

Deborah J. Fatica
Assistant Dean, Engineering Student Programs

FACULTY as of September 1, 2013

Biomedical Engineering


Robert F. Kirsch
Chair
and Professor


Abidemi Bolu Ajiboye
Assistant Professor


Eben Alsberg
Associate Professor


James Basilion
*Associate Professor**

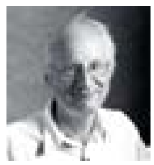

Jeffrey R. Capadona
Assistant Professor


Patrick E. Crago
Professor


Jeffrey L. Duerk
Dean and Leonard Case Jr. Professor of Engineering


Dominique Durand
Elmer Lincoln Lindseth Professor of Biomedical Engineering


Steven J. Eppell
Associate Professor


Miklos Gratzl
Associate Professor


Kenneth J. Gustafson
Associate Professor


Efstathios "Stathis" Karathanasis
*Assistant Professor**


Erin B. Lavik
Elmer Lincoln Lindseth Associate Professor of Biomedical Engineering


Zheng-Rong Lu
M. Frank and Margaret Domiter Rudy Professor


Anant Madabhushi
Associate Professor


Roger E. Marchant
Professor


Cameron McIntyre
*Associate Professor**


P. Hunter Peckham
Distinguished University Professor and Donnell Institute Professor of Engineering


Andrew M. Rollins
Professor


Gerald M. Saidel
Professor


Nicole Seiberlich
Assistant Professor


Anirban Sen Gupta
Assistant Professor


Nicole Steinmetz
*Assistant Professor**


Dustin J. Tyler
Associate Professor


Horst von Recum
Associate Professor

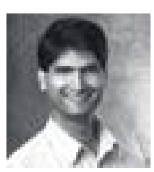

David L. Wilson
Robert J. Herbold Professor


Xin Yu
Professor

Chemical Engineering


Uziel Landau
Chair and Professor


Rohan Akolkar
Associate Professor


Harihara Baskaran
Associate Professor


Donald L. Feke
Vice Provost and Professor


Daniel J. Lacks
C. Benson Branch Professor of Chemical Engineering


Chung-Chiun "C.C." Liu
Distinguished University Professor and Wallace R. Persons Professor of Sensor Technology and Control

*Case Western Reserve University School of Medicine campus

Chemical Engineering, continued


Heidi B. Martin
Associate Professor


Syed Qutubuddin
Professor

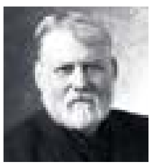

R. Mohan Sankaran
Associate Professor


Robert Savinell
Distinguished University Professor
George S. Dively Professor of Engineering

Civil Engineering


Xiangwu "David" Zeng
Chair and Frank H. Neff Professor

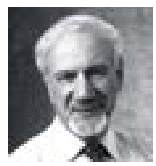

Dario A. Gasparini
Professor


Aaron A. Jennings
Professor


Brian Metrovich
Associate Professor


Michael Pollino
Assistant Professor


Kurt R. Rhoads
Assistant Professor


Adel S. Saada
Professor


Xiong "Bill" Yu
Associate Professor

Electrical Engineering and Computer Science


Kenneth A. Loparo
Chair and Nord Professor of Engineering


Swarup Bhunia
Timothy E. and Allison L. Schroeder Associate Professor in Computer Science and Engineering


Marcus R. Buchner
Associate Professor


M. Cenk Cavusoglu
Professor


Vira Chankong
Associate Professor


Harold Connamacher
Assistant Professor


Evren Gurkan-Cavusoglu
Assistant Professor


Philip X.L. Feng
Assistant Professor


Chris Fietkiewicz
Assistant Professor


Mario Garcia-Sanz
Milton and Tamar Maltz Professor in Energy Innovation


Steven L. Garverick
Professor


Mingguo Hong
Associate Professor


Mehmet Koyuturk
Associate Professor


Michael Lewicki
Associate Professor

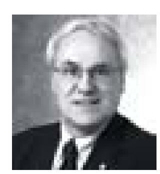

Jing Li
Associate Professor


Vincenzo Liberatore
Associate Professor


Wei Lin
Professor


Behnam Malakooti
Professor


Mehran Mehregany
Goodrich Professor for Engineering Innovation


Francis L. Merat
Associate Professor


Pedram Mohseni
Associate Professor


Wyatt S. Newman
Professor


Gultekin Özsoyoğlu
Professor


Zehra Meral Özsoyoğlu
Distinguished Research Professor and Andrew R. Jennings Professor of Computing Sciences


Christos A. Papachristou
Professor

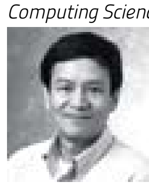

H. Andy Podgurski
Professor


Michael Rabinovich
Professor


Soumya Ray
Assistant Professor


Daniel G. Saab
Associate Professor


Narasingarao Sreenath
Professor


Guo-Qiang "G.Q." Zhang
Professor


Xiang Zhang
Theodore L. and Dana J. Schroeder Assistant Professor in Computer Science and Engineering


Hongping Zhao
Assistant Professor


Christian A. Zorman
Associate Professor

Macromolecular Science and Engineering


David Schiraldi
Chair and Peter A. Asseff, PhD, Professor of Organic Chemistry


Rigoberto C. Advincula
Professor


Eric Baer
Distinguished University Professor and Herbert Henry Dow Professor of Science and Engineering


Liming Dai
Kent Hale Smith Professor


Hatsuo "Ken" Ishida
Distinguished Research Professor


Alexander M. Jamieson
Professor


LaShanda T.J. Korley
Climo Assistant Professor


João Maia
Associate Professor


Ica Manas-Zloczower
Associate Dean of Faculty Development and Thomas W. and Nancy P. Seitz Professor of Advanced Materials and Energy


Jon Pokorski
Assistant Professor


Stuart J. Rowan
Kent Hale Smith Professor


Gary E. Wnek
Associate Dean of Academics and Joseph F. Toot Jr. Professor


Lei Zhu
Associate Professor

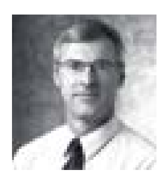
Materials Science and Engineering


James D. McGuffin-Cawley
Chair and Arthur S. Holden Jr. Professor in Engineering


William A. "Bud" Baeslack III
Provost and Executive Vice President and Professor

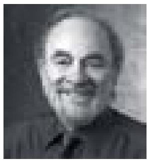

Jennifer L.W. Carter
Associate Professor


Mark R. Deguire
Associate Professor


Frank Ernst
Leonard Case Jr. Professor of Engineering

Materials Science and Engineering, continued


Roger French
F. Alex Nason Professor


Arthur H. Heuer
Distinguished University Professor and Kyocera Professor in Ceramics


Peter D. Lagerlof
Associate Professor


John J. Lewandowski
Arthur P. Armington Professor of Engineering


David H. Matthiesen
Associate Professor


Pirouz Pirouz
Professor


Gerhard E. Welsch
Professor


Matthew Willard
Associate Professor

Mechanical and Aerospace Engineering


Dwight Davy
Interim Chair and Professor Emeritus


Alexis Abramson
Associate Professor


Maurice L. Adams
Professor


Ozan Akkus
Professor


Paul J. Barnhart
Associate Professor


Malcolm N. Cooke
Associate Professor

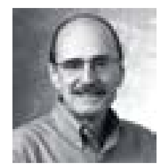

Umut Atakan Gurkan
Assistant Professor


J. R. Kadambi
Professor


Yasuhiro Kamotani
Professor


Kiju Lee
Nord Distinguished Assistant Professor


Bo Li
Assistant Professor


Joseph M. Mansour
Professor


Joseph M. Prahl
Professor


Vikas Prakash
Professor


Roger D. Quinn
Arthur P. Armington Professor of Engineering


Clare M. Rimnac
Associate Dean of Research and Wilbert J. Austin Professor of Engineering


James S. T'ien
Leonard Case Jr. Professor of Engineering

NOT PICTURED

Gregory S. Lee
Assistant Professor, Electrical Engineering and Computer Science

CASE SCHOOL OF ENGINEERING AT A GLANCE

The Case School of Engineering has a proud 125-year history as one of America's top engineering schools. We are innovators and educators—tackling the world's most challenging engineering problems through groundbreaking research while balancing a rigorous academic curriculum with ample hands-on experiential learning opportunities that bring those lessons to life for tomorrow's engineers. More than 100 full-time faculty represent the best minds in their fields, and our students are among the brightest and most ambitious in the nation.

Learn more at engineering.case.edu.

DEPARTMENTS

Biomedical Engineering
Chemical Engineering
Civil Engineering
Electrical Engineering and Computer Science
Macromolecular Science and Engineering
Materials Science and Engineering
Mechanical and Aerospace Engineering

DEGREES AND MAJORS

Bachelor of Science in Engineering (BSE)

Available majors:

Aerospace engineering
Biomedical engineering
Chemical engineering
Civil engineering
Computer engineering
Electrical engineering
Engineering physics
Materials science and engineering
Mechanical engineering
Polymer science and engineering
Systems and control engineering
Bachelor of Science in Engineering without designation

Bachelor of Science in Computer Science (BS)

Master of Science (MS)

Available majors:

Aerospace Engineering
Biomedical Engineering, with optional specialization in Translational Health Technology or Wireless Health
Chemical Engineering
Civil Engineering
Computer Engineering
Computing and Information Science
Electrical Engineering, with optional specialization in Wireless Health
Macromolecular Science and Engineering, with optional specialization in Fire Science and Engineering
Materials Science and Engineering
Mechanical Engineering, with optional specialization in Fire Science and Engineering
Systems and Control Engineering
Undesignated

Master of Engineering (ME)

Master of Engineering and Management (MEM)

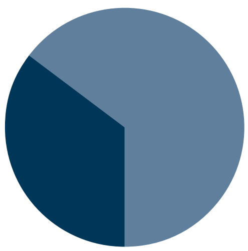
Doctor of Philosophy (PhD)

Available majors:

Aerospace Engineering
Biomedical Engineering
Ceramics and Materials Science
Chemical Engineering
Civil Engineering
Computer Engineering
Computing and Information Sciences
Electrical Engineering
Engineering Mechanics
Fluid and Thermal Engineering Science
Macromolecular Science
Materials Science and Engineering
Mechanical Engineering
Systems and Control Engineering

ENROLLMENT FALL 2013

1,772 Total*



628 Graduate and professional-degree students

1,144 Declared undergraduate engineering students

*In addition, 733 undergraduate students expressed interest in engineering majors but are not expected to declare majors until the end of their sophomore years.

FULL-TIME FACULTY FY 2013

110

TOTAL REVENUE FY 2013

$90.2 million

RESEARCH AND TRAINING REVENUE FY 2013

$47 million

CENTERS AND INSTITUTES

- Advanced Manufacturing and Mechanical Reliability Center (AMMRC)
- Advanced Platform Technology Center
- Case Center for Surface Engineering
- Case Metal Casting Laboratory
- Center for Advanced Polymer Processing
- Center for Advanced Science and Engineering for Carbon
- Center for Biomaterials
- Center for Computational Imaging and Personalized Diagnostics
- Center for Modeling Integrated Metabolic Systems
- Center for the Evaluation of Implant Performance
- Cleveland Functional Electrical Stimulation Center
- Control and Energy Systems Center
- Electronics Design Center
- Great Lakes Energy Institute
- Institute for Advanced Materials
- Materials for Opto/Electronics Research and Education (MORE) Center
- Microfabrication Laboratory
- Neural Engineering Center
- NSF Center for Layered Polymeric Systems (CLiPS)
- Solar-Durability and Lifetime Extension Center
- Swagelok Center for Surface Analysis of Materials
- The Institute for Management and Engineering
- think[box]
- Wind Energy Research and Commercialization Center
- Yeager Center for Electrochemical Sciences

FUNDRAISING FY 2013

Total: $31.7 million

$30.3 million
Case School of Engineering

$1.4 million
Case Alumni Association

In FY2013, the Case Alumni Foundation/Association provided $1.5 million from its endowment to the Case School of Engineering.

U.S. NEWS & WORLD REPORT RANKINGS

51st
for engineering graduate schools

35th
for undergraduate engineering programs

14th
for graduate biomedical engineering programs

11th
for undergraduate biomedical engineering programs

VISITING COMMITTEE

Thomas W. Seitz (CIT '70), chair
Gerald Wasserman (CIT '76), vice-chair
Chi-Foon Chan (GRS '74, '77)
Howard Jay Chizeck (CIT '74, GRS '77)
Archie G. Co (CIT '63)
Walter J. Culver (GRS '62, '64)
John F. X. Daly (CWR '89, GRS '91)
Myra A. Dria (CIT '76)
Robert A. Gingell Jr. (CIT '77)
Jennie S. Hwang (GRS '76)
Joseph P. Keithley
Martin P. Kress
Kenneth R. Lutchen (GRS '80, '83)
Edward P. McHenry (CIT '67, MGT '71), ex-officio
Gerald McNichols (CIT '65)
Somsak Naviroj (GRS '83)
Claiborne R. Rankin
Richard T. Schwarz (MGT '78)
Karl R. Van Horn
Russell J. Warren (CIT '60)
John M. Wiencek (CIT '86, GRS '89)
Simon Yeung (CWR '93)

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engineering.case.edu

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Assistant Director, Marketing & Communications:	Jackie Fitch
Graphic Designer:	Cindy Young
Principal Photography:	Russell Lee (p. 1, 4-5, 9, 11, 12-13, 14, 18, 20, 24-25, 26, 28, 36, 38, 39, 40, 47)
Additional Photography:	Adam Talbot and David Go, University of Notre Dame (p. 29) Andrew Morrell (p. 30) Daniel Lacks (p. 33) Tom Pastoric, Clix (p. 49-52)

Every effort has been made to ensure the accuracy of this report. If you have any questions or concerns, please contact Christine Coolick, director of marketing and communications, Case School of Engineering, Case Western Reserve University, 10900 Euclid Ave., Cleveland, Ohio 44106-7220; 216.368.8694; cmc174@case.edu.


MAKE IT EFFECTIVE
MAKE IT COMPATIBLE
MAKE IT SUSTAINABLE
MAKE IT HAPPEN
MAKE IT ACADEMIC
MAKE IT COMMERCIAL
MAKE IT DYNAMIC
MAKE IT STRATEGIC
MAKE IT BETTER
MAKE IT QUICKER
MAKE IT EFFICIENT
MAKE IT EFFECTIVE
MAKE IT COMPATIBLE
MAKE IT SUSTAINABLE

CASE SCHOOL
OF ENGINEERING
CASE WESTERN RESERVE
UNIVERSITY

10900 Euclid Avenue
Cleveland, OH 44106-7220