Annual Report 2009

engineering unexpected

CASE WESTERN RESERVE UNIVERSITY
CASE SCHOOL OF ENGINEERING

engineering advances by embracing the unexpected

What does a new wind turbine design have in common with tracking the heart's metabolism? How do lab-grown blood vessels relate to new, lightweight foam? These Case School of Engineering research projects found answers in unlikely places. Whether it's breaking a bone to make it stronger or improving health by slowing down the rate of drug delivery, sometimes what works isn't what we expect. At Case Western Reserve University, we open our minds, and those of our students, to discover new points of view—and new solutions.

Dean Norman C. Tien at the new Richard and Opal Vanderhoof Infrastructure Education and Research Facility.

contents

During the past year, the Case School of Engineering faculty have found new ways to harness the power of the wind and to enhance the power of the heart. They have sought strength in buildings and bones. They've outrun speeding bullets and slowed the march of infection. They've also turned Mother Nature on her ear with forms that are simultaneously man-made and natural.

Whether they're in the lab or in the classroom, our faculty and students don't just engineer answers, they discover unexpected points of view for better solutions.

This annual report highlights just a few of their stories and accomplishments, made possible in part by the support of approximately 3,000 alumni and friends who gave more than $8 million in gifts and commitments last year.

Leading their charge is the Case Alumni Association, which represents alumni and provides vital financial support. It was led last year by president Thomas Litzler ('53, G'62), and celebrates its 125th anniversary this spring under new president Kenneth Loparo (G'77). Also assisting us is our Visiting Committee, chaired by Robert Bond ('66), which offers counsel on academic excellence.

I deeply appreciate their support and that of our faculty, staff, alumni and students—who inspire the Case School of Engineering to continue its mission of excellence in education and innovation.

Norman C. Tien
Dean and Nord Professor of Engineering
Ohio Eminent Scholar, Physics

energy

When it comes to the potential of energy, it's all in the design. Imagine 5,000 wind turbines dotting the horizon on Lake Erie. The turbine blades extend longer, thanks to a new bi-plane design that allows for a narrower blade base, reducing their weight by a third. Their shape provides increased aerodynamic efficiency that can collect more energy, and lessens production costs. The blades are equipped with sensors and actuators to assess their mechanical stress loads and make custom adjustments to new hinged flaps quickly and efficiently. Additional sensors detect when ice and snow begin to accumulate on the machine and trigger thermal systems to thaw out the turbines, allowing for their constant use—even during frigid Midwest winters. Built-in storage capabilities take full advantage of windier days while still feeding the electric grid evenly. This is the vision of Mario Garcia-Sanz, the inaugural Milton and Tamar Maltz Professor in Energy Innovation, established after the founding of the Great Lakes Energy Institute. Partnering with The Cleveland Foundation, MT Energy, Parker Hannifin, NASA Glenn, American Electric Power, Kelly Aerospace, Great Lakes Towing Company, Eaton, MegaJoule Storage, JME and Ohio State University, his plans could become a reality. With 68 gigawatts of wind energy potential on the lake, such a farm could provide as many as 10,000 new jobs to the area and would become the first offshore wind farm in the nation. **Because the right energy solutions can power a brighter future.**

When it comes to the potential of energy, it's all in the design. Built to beat nonstop, the heart's energy needs are the greatest of any organ. The physical contraction of the heart is the most energy-demanding part of every beat; therefore, altered energy production can be an early sign of heart disease, which causes the heart muscles to malfunction. Understanding this energy-function relationship can lead to better treatment of heart diseases. Biomedical engineering professor Xin Yu has developed novel imaging and computational methods to assess heart function and energy production in both normal and diseased hearts. The approach combines MR imaging—which evaluates cardiac function—with MR spectroscopy to assess energy conversions in the heart. Collaborating with Case Western Reserve School of Medicine professors, Yu has applied her methods to study various forms of heart diseases, including diabetic cardiomyopathy and heart failure. Using her integrative approach in a study involving genetic modification, Yu has been able to dissect the molecular components responsible for altered energy production in the heart. This innovative technique for assessing energy usage in the heart can help detect cardiac disease earlier and better evaluate treatment. **Because the heart's efficient use of energy makes for a healthy future.**

Everything has a breaking point. Buildings vibrate, shift and even crumble during earthquakes and strong winds. Pipelines crack and burst after repetitive freezing and thawing. To create stronger, more wear-resistant structural connections, foundations and repairs, the work starts in the Bingham Building on the campus of Case Western Reserve University. Isolated in a subchamber, a hydraulic pump whistles away at 100 decibels, pushing 100 gallons of oil per minute through stainless steel pipes, funneling the pressure to five power stations in the new 2,400-square-foot Richard and Opal Vanderhoof Infrastructure Education and Research Facility. There, actuators shepherd that force to load a specimen with up to 50,000 pounds of pressure. Test subjects are bolted to an L-shaped strong wall through 3-inch-wide holes cutting systematically through the 18-inch-thick cell walls. The structure reaches 30 feet high, housing three floors where large-scale horizontal forces of hundreds of thousands of pounds are applied to specimens. A strong floor for vertical loading mirrors the wall's capacity. The new lab will test earthquake resistance, wind force damage and fatigue failure in the likes of alternative energy technologies, high-speed surface transportation components, signage and pipeline systems. **Because to test strength, your test arena needs to be even stronger.**

Everything has a breaking point. Femurs, metatarsals, vertebrae and ribs fracture from impacts and overuse. Even daily wear-and-tear from weight-bearing exercise causes microdamage. Yet your bone's ability to heal itself is unique. While natural microdamage does weaken the bone, it also triggers natural repair systems to rebuild these weakened areas. Osteoclast cells clear away the damage before osteoblast cells lay down new bone, rebuilding the fractured area. But when weight-bearing exercise becomes difficult to do—for the elderly, bed-ridden individuals or even astronauts in space—bone loss becomes problematic. Professor Melissa Knothe Tate, in conjunction with an orthopedic surgeon at Cleveland Clinic and researchers at NASA Glenn Research Center, decided to see if micro-cracks could be created intentionally in a quick and effective way to trigger bone growth. Adapting existing technology used in lithotripsy devices to break up kidney stones with shock waves, Knothe Tate blasted osteopenic bones—weakened by lack of use—in the lab to create microdamage that mimicked naturally occurring, exercise-induced microcracks. Just one lithotripsy treatment created enough microdamage to trick cells to rebuild and strengthen the bone. This new treatment could have life-altering clinical applications for those unable to maintain their bone density. **Because the key to regrowth could be weakening a bone to make it stronger.**

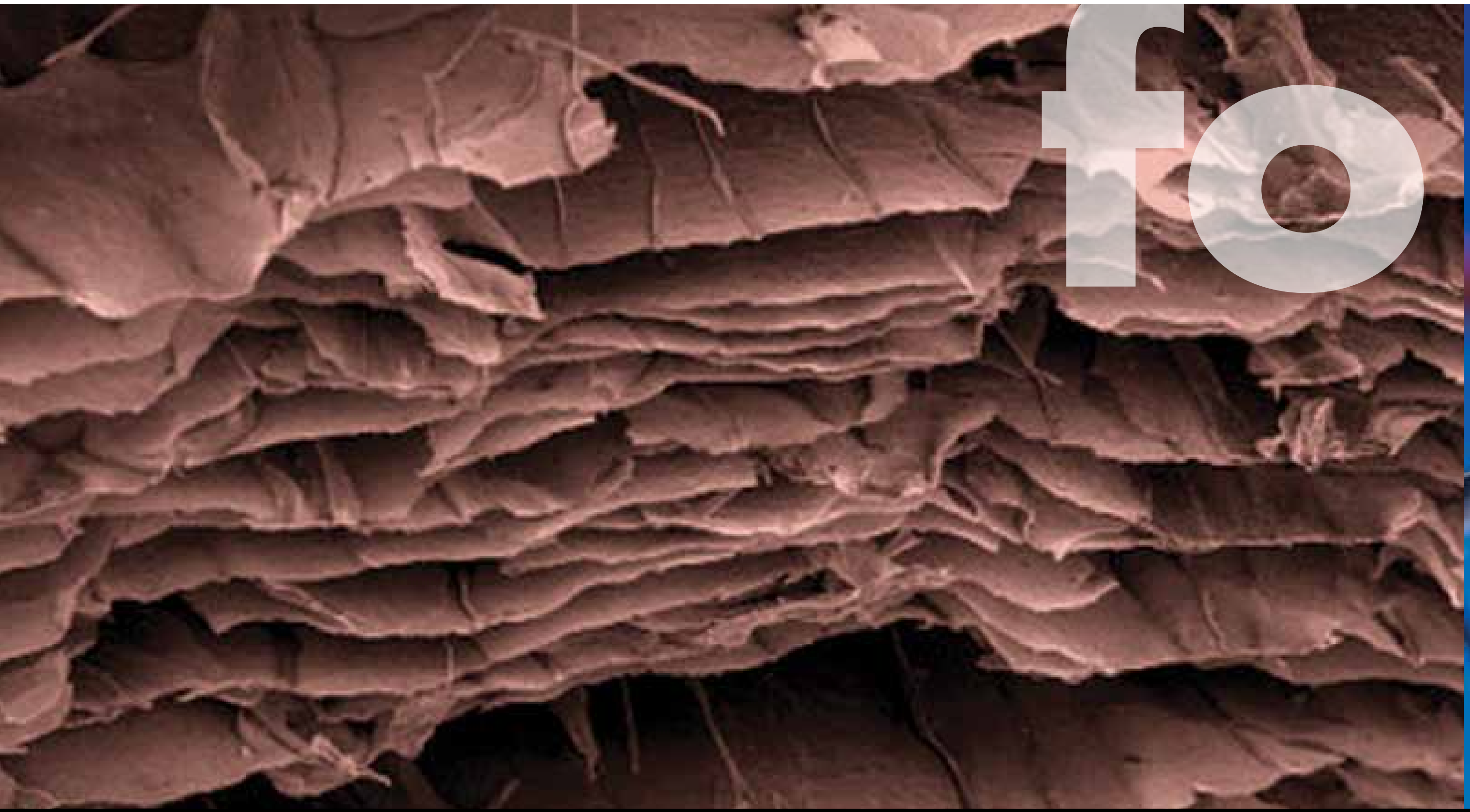
speed

The right speed can mean all the difference in the world. When a bullet strikes the side of a tank, it inflicts minor damage, but what's the damage from a nearby explosion's shock wave? That's the type of question mechanical and aerospace engineering professor Vikas Prakash sets out to answer in his impact mechanics lab: How do materials respond—and fail—under high-speed impacts? The lab uses gas guns to "shock" specimens—propagating waves through the material—at 100 to 1 million strains per second. Prakash's unique setup offers a way to bring more true-to-life dimension to these lab experiments, which traditionally have been able to replicate only head-on collisions. By angling the impacting face of the projectiles and setting test specimens on an incline, he's able to study the effects of multi-axial shock loading, which is how most impacts really occur. To analyze this damage—which can take place in only two microseconds—an ultra-high-speed camera takes images at up to 200 million frames per second while lasers collect data using Doppler shift technology. Prakash collaborates with the U.S. Army and Navy to test coatings for tanks, Humvees and ships; NASA to understand how ice affects a shuttle launch; and even geologists to study how rocks lose strength during an earthquake. **Because the damage done depends on the speed of impact.**

The right speed can mean all the difference in the world. Medical implants can deliver drugs quickly through diffusion, but how do you get them to release in a linear, slow-and-steady fashion? Biomedical engineering professor Horst von Recum has solved this challenge by creating a polymer with chemical "pockets" that have a natural affinity for the drug. Von Recum started with cyclodextrins—a ring of glucose molecules that are naturally hydrophobic—and mixed in antibiotics that also are repelled by water. The drugs' attraction to the cyclodextrin pockets resulted in a much-sought-after coating for device implants that can release antibiotics evenly for more than 30 days (illustrated above on the top orthopedic screw). To use the same delivery system for drugs that aren't hydrophobic, von Recum has attached an innocuous, hydrophobic molecular "arm" to the drug in order to attract it to the pockets. By manipulating how many arms the drug is given, and even by adjusting the size of the pockets, he can precisely manipulate the speed and length of drug delivery. Applications for the medical marvel are extensive, including antibiotic coatings for joint replacement implants and hernia meshes, microbicide rings to prevent HIV, and even chemotherapy seeds that can be used for targeted delivery, eliminating some of the negative systemic side effects of traditional chemotherapy. **Because long-term health can require a slow and steady pace.**

Even 'natural' needs a little engineering. Mother Nature takes the lead to produce the new low-density, foam-like substance AeroClay.® Composed of 98 percent air, with a bit of clay and polymer thrown in, the mixture is processed with water to become a lightweight, multi-talented material. Each batch, created by macromolecular science and engineering professor David Schiraldi, gets its start in a blender where the ingredients are mixed, before being freeze-dried overnight. With the help of molds, the versatile matter can take on any imaginable shape, and turn out tough yet light as air, thanks to the gaps that form between the layers of clay in the freeze-drying process (shown below under a microscope). Unlike other spongy materials, no gas injections or CFC-blowing agents are necessary, making the product environmentally friendly—and potentially biodegradable. Depending on the additives, AeroClay can become a tough ceramic, a bendable rubber, an electrical conductor, a magnet or even an absorbent cat litter—all at a fraction of the weight of their conventional counterparts. When the milk protein casein—a waste product from cheese production—is used, the material becomes an excellent source of insulation that can withstand temperatures up to 300 degrees centigrade. Schiraldi and his team have already developed dozens of AeroClay applications and filed for five patents so far. **Because the best manmade form can be inexpensive, lightweight and safe—and derived from nature.**

Even 'natural' needs a little engineering. Imagine organ transplantation without any concerns over a patient's body rejecting the new organ, or even the need for taxing anti-rejection drugs. That's been the goal of tissue engineering since its inception three decades ago: a fully synthesized organ implant. To date, only small patches of skin have achieved clinical success. The roadblock has been microvascular structures—the intricate web of blood vessels that delivers nutrients to cells. The body has difficulty growing microvascular structures to a bioengineered implant; the process is long and frequently unsuccessful. That's why chemical engineering professor Harihara Baskaran decided to develop an organ implant with built-in microvasculature. Collaborating with biologists, mechanical engineers and even operational research specialists, Baskaran has created a computer program to design tissue-specific microvasculature models, which are then stamped out in a microfabrication lab using "collagen lithography" to create fully functional microvascular systems. Baskaran has been able to add the lining of vital endothelial cells—transporters of nutrients from blood to the body—and *in vivo* studies are planned. If the tissue successfully takes, Baskaran hopes to combine these microvascular systems with cells harvested from the patient to create fully synthesized and personalized tissues and organs. **Because the natural form that suits your body best can be manmade.**



case dean's society

The Case Dean's Society® recognizes individuals who made leadership annual fund gifts of $1,000 or more to the Case Fund® and the Case School of Engineering from July 1, 2008, to June 30, 2009. The Case Alumni Association and the Case School of Engineering wish to thank all members of the Case Dean's Society for their generous support.

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Endowments provide perpetual support for the Case School of Engineering and its faculty, students and programs. The following funds were established from July 1, 2008, through June 30, 2009, by the generosity of our alumni and friends, including those funds created through the Case Alumni Association. The entire Case engineering family is grateful for these lasting contributions.

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The Case School of Engineering wishes to thank the following alumni, corporations, foundations and friends who generously provided gifts and commitments of $10,000 or more from July 1, 2008, to June 30, 2009. Your continued support for the faculty, students and programs of the Case School of Engineering is deeply appreciated.

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administration and faculty

The Case School of Engineering has been renowned for excellence in teaching and research for 130 years. Upholding this tradition are more than 100 dedicated faculty members who pride themselves on their unique student-teacher research collaborations, which are often formed as early as the freshman year. Below is a list of administrators and faculty who foster these relationships.

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Professor of Biomedical Engineering

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Associate Dean of Faculty Development
Professor of Macromolecular Science and Engineering

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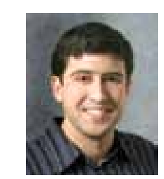
Deborah J. Fatica
Assistant Dean of Engineering Student Programs

Faculty

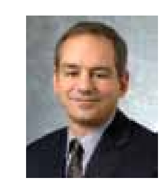
BIOMEDICAL ENGINEERING


Jeffrey L. Duerk
Chair and Allen H. and Constance T. Ford Professor in Biomedical Engineering


Steven J. Eppell
Associate Professor


Eben Alsberg
Assistant Professor


Kenneth J. Gustafson
Assistant Professor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Associate Professor


Miklos Gratzl
Associate Professor


Patrick E. Crago
Associate Dean and Professor


Robert F. Kirsch
Professor


Dominique Durand
Elmer L. Lindseth Professor in Biomedical Engineering


Melissa Knothe Tate
Professor

BIOMEDICAL ENGINEERING, *continued*

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M. Frank and Margaret Domiter Rudy Professor

Roger E. Marchant
Professor

P. Hunter Peckham
Donnell Institute Professor of Engineering

Andrew M. Rollins
Warren E. Rupp Associate Professor of Science and Engineering

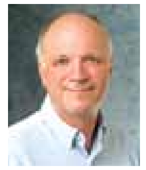
Gerald M. Saidel
Professor

Anirban Sen Gupta
Assistant Professor

Dustin J. Tyler
Associate Professor

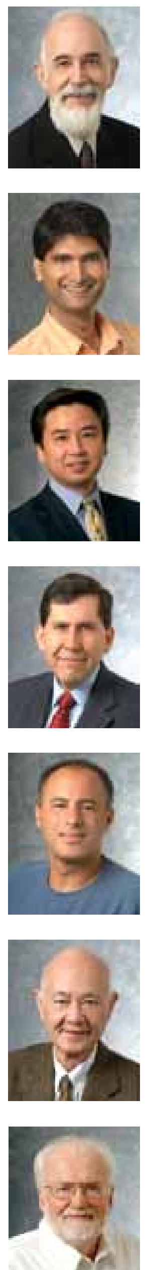
Horst von Recum
Assistant Professor

Xin Yu
Associate Professor



David L. Wilson
Robert J. Herbold Professor

CHEMICAL ENGINEERING



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Associate Professor

Liming Dai
Kent H. Smith Professor

Donald L. Feke
Vice Provost and Professor

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C. Benson Branch Professor of Chemical Engineering

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

J. Adin Mann Jr.
Professor

Heidi B. Martin
Assistant Professor

Syed Qutubuddin
Professor

R. Mohan Sankaran
George B. Mayer Assistant Professor in Urban and Environmental Studies

Robert Savinell
George S. Dively Professor of Engineering

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Chair and Frank H. Neff Professor

Dario A. Gasparini
Professor

Arthur A. Huckelbridge Jr.
Professor

Aaron A. Jennings
Professor

Robert L. Mullen
Professor

Adel S. Saada
Professor

Xiong "Bill" Yu
Assistant Professor

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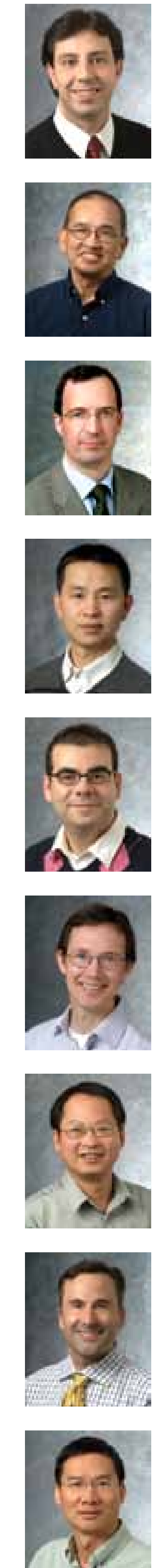
Co-Interim Chair and Professor Emeritus

Steven L. Garverick
Co-Interim Chair and Professor

Swarup Bhunia
Assistant Professor

Michael S. Branicky
Professor

Marcus R. Buchner
Associate Professor



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Vira Chankong
Associate Professor

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Milton and Tamar Maltz Professor in Energy Innovation

Shudong Jin
Assistant Professor

Mehmet Koyuturk
Theodore L. and Dana J. Schroeder Assistant Professor in Computer Science and Engineering

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Jing Li
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Vincenzo Liberatore
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Pedram Mohseni
Assistant Professor

Wyatt S. Newman
Professor

Gultekin Ozsoyoglu
Professor

Z. Meral Ozsoyoglu
Andrew R. Jennings Professor in the Computing Sciences

Christos A. Papachristou
Professor

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Dean and
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Ohio Eminent Scholar, Physics

Jiong Yang
Assistant Professor

Guo-Qiang "G.Q." Zhang
Professor

Xinmiao Zhang
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Christian A. Zorman
Associate Professor

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Leonard Case Jr.
Professor of Engineering

John Blackwell
Leonard Case Jr.
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Climo Associate Professor

P. Anne Hiltner
Herbert Henry Dow Professor
of Science and Engineering

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Professor

Alexander M. Jamieson
Professor

LaShanda T. J. Korley
Nord Distinguished
Assistant Professor

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Associate Professor

Ica Manas-Zloczower
Associate Dean of Faculty
Development and Professor

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Christoph Weder
Alex F. Nason Professor

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Joseph F. Toot Jr. Professor

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Arthur S. Holden Jr.
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Case Western Reserve
University Provost and
Executive Vice President
Professor

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Leonard Case Jr.
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University Professor and
Kyocera Professor in Ceramics

Peter D. Lagerlof
Associate Professor

John J. Lewandowski
Leonard Case Jr.
Professor of Engineering

David H. Matthiesen
Associate Professor

Gary M. Michal
Professor

Pirouz Pirouz
Professor

Gerhard E. Welsch
Professor

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Chair and
Wilbert J. Austin
Professor in Engineering

Alexis Abramson
Associate Professor

Maurice L. Adams
Professor

J. Iwan D. Alexander
Cady Staley Professor

Christopher Herandez
Assistant Professor

J.R. Kadambi
Professor

Yasuhiro Kamotani
Professor

Melissa Knothe Tate
Professor

Kiju Lee
Assistant Professor

Joseph M. Mansour
Professor

Joseph M. Prahl
Professor

Vikas Prakash
Professor

Roger D. Quinn
Arthur P. Armington
Professor of Engineering

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

at a glance

Enrollment
Fall 2009

940 Declared Undergraduate Engineering Students

627 Graduate and Professional-degree Students

1,567 Total*

**In addition, 425 undergraduate students expressed interest in engineering majors, but are not expected to declare their majors until the end of their sophomore years.*

Full-time Faculty
Fall 2009

109

Budget
FY 2009

$80.9 million

Research Revenue
FY 2009

$34.1 million

Fundraising
FY 2009

$5,292,486	Case School of Engineering
$3,510,371	Case Alumni Association
$8,802,857	Total

***U.S. News & World Report* Rankings**

Top 50 for Undergraduate and Graduate Engineering Programs

Top 15 for Graduate Biomedical Engineering Programs

9th for Undergraduate Biomedical Engineering Programs

Departments

Biomedical Engineering

Chemical Engineering

Civil Engineering

Electrical Engineering and Computer Science

Macromolecular Science and Engineering

Materials Science and Engineering

Mechanical and Aerospace Engineering

Research Centers and Institutes

Case Center for Surface Engineering

Center for Applied Polymer Research

Center for Cardiovascular Biomaterials

Center for Computational Genomics and Systems Biology

Center for Layered Polymeric Systems

Center for Mechanical Characterization of Materials

Center for Modeling Integrated Metabolic Systems

Cleveland Functional Electrical Stimulation Center

Electronics Design Center

Great Lakes Energy Institute

National Center for Space Exploration Research

Neural Engineering Center

Science & Technology Application Center

Swagelok Center for Surface Analysis of Materials

The Institute for Management and Engineering (TiME)

Yeager Center for Electrochemical Sciences

Case School of Engineering

Design: Cindy Young, University Marketing and Communications, Case Western Reserve University

Writing and Editing: Christine Coolick, University Marketing and Communications, Case Western Reserve University, and Helen Jones-Toms, Case School of Engineering

Photography: Yasaki Photographic (p. 1, 3, 4, 7, 9), Kelly Aerospace (p. 2), Russell Lee (p. 6), Clixfoto (p.15–19 faculty portraits) and Gwendolyn Morgan, National Science Foundation (p. 17, Michael S. Branicky portrait)

Illustration: Bryan Christie (p. 3)

Every effort has been made to ensure the accuracy of this report. If you have any questions or concerns, please contact Helen Jones-Toms, Director of Marketing and Communications, the Case School of Engineering, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, Ohio 44106-7220; 216.368.8694; hlj2@case.edu.

For more news about the Case School of Engineering, go to **engineering.case.edu**.

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