

JOHNS HOPKINS

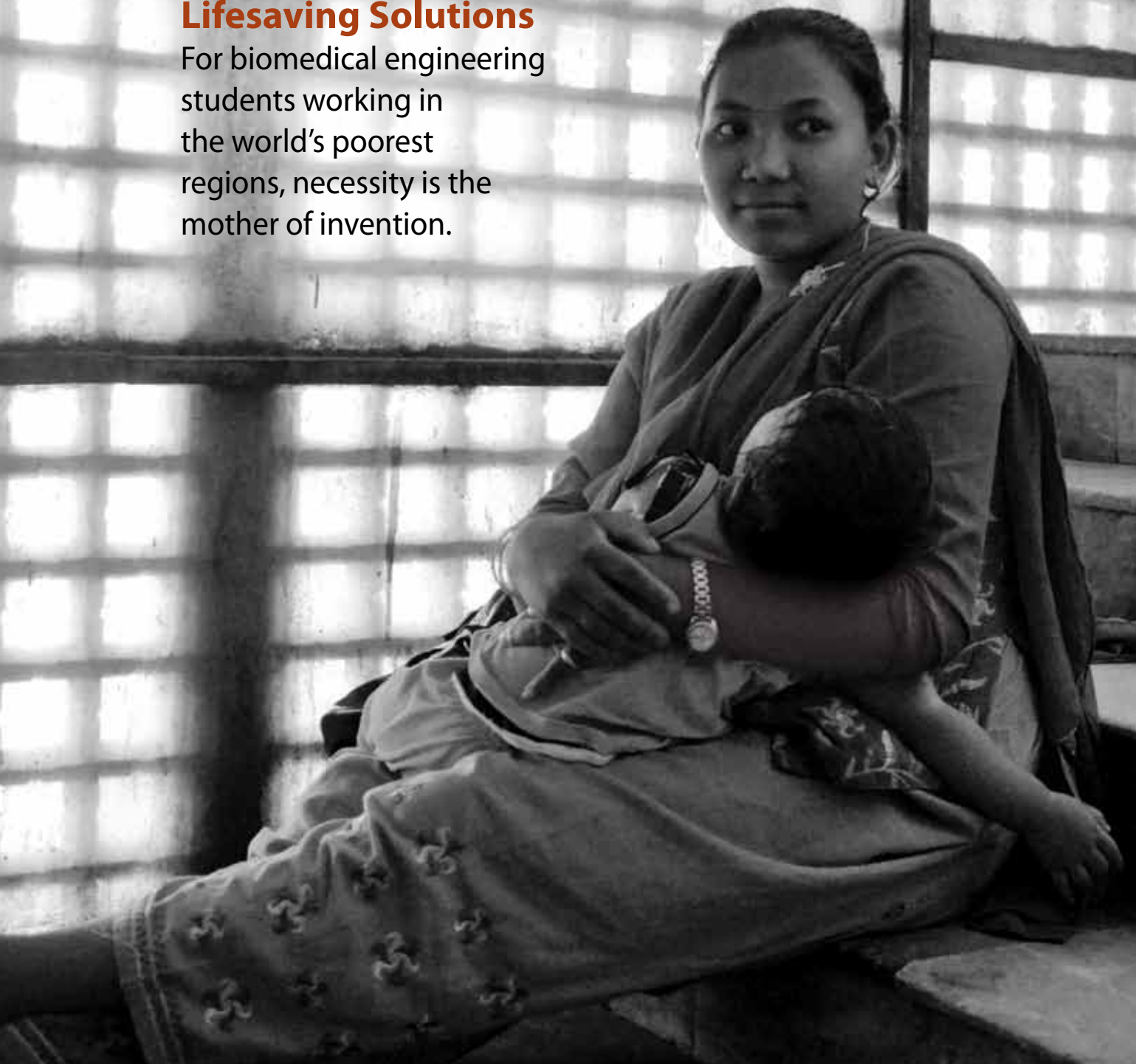
ENGINEERING

THE MAGAZINE OF THE JOHNS HOPKINS WHITING SCHOOL OF ENGINEERING

FALL 2011

Lifesaving Solutions

For biomedical engineering students working in the world's poorest regions, necessity is the mother of invention.



Plus: Mapping the Mind • Data Driven • Big Blue Baby

Mission Monument: Daredevil Engineers

Several weeks after a 5.8 magnitude earthquake shook the East Coast in late August, Katie Francis, BS '06, was called in on a five-member team of engineers to rappel down the marble exterior of the 550-foot Washington Monument to inspect the historic landmark for damage.

A junior structural engineer with WJE Associates Inc., of Northbrook, Illinois, Francis worked for more than a week on the obelisk's north side (facing the White House), examining each marble block. She was looking for cracks, loose stone, wobbly mortar, and other damage. Preliminary reports show moderate damage near the monument tip, where most shaking occurred.

Francis got her start rappelling at Hopkins, where she trained to be a climbing instructor with the Outdoor Pursuits program. This, however, was her most amazing climb to date. "We went out the windows at 500 feet," she says. "And then we ascended to the top... It was quite a view."



Data Driven

10

As computing ability jumps by leaps and bounds, researchers wrestle with making the best use—and reuse—of all that data. [By Mat Edelson](#)

Big Blue Baby

18

Shake, rattle, and roll: We take you up close and personal with the prized progeny of Ben Schafer's Thin-walled Structures Lab. [By Abby Lattes](#)

Lifesaving Solutions

20

For biomedical engineering students working in the world's poorest regions, necessity is the mother of invention. [By Mary Beth Regan](#)

Big Ideas

3

Insights and Discovery

Storm chasers, mapping the mind, energy star, so random, membranes matter, and more

Currents

27

Whiting School News

All systems go at Raytheon, finger lickin' good—across the globe, a dream realized, end of an era, biomedical engineering at 50, and more.

Final Exam

36

Cool ideas abounded at last summer's Climate Showcase, which took students to nonprofits across the city to assess energy efficiency.

“

Today's mobile devices are much more insecure than the PC you have at home....You can't be sure your Angry Birds application isn't changing your vote. ”

— AVI RUBIN, WHITING SCHOOL PROFESSOR OF COMPUTER SCIENCE, IN THE *NEW SCIENTIST*, ON THE POTENTIAL FOR MALWARE EMBEDDED IN MOBILE APPS TO INVADE ELECTRONIC VOTING SOFTWARE.

Dear Whiting School Community,

Every year, I am invigorated by the energy, dedication, and creativity of our engineering undergraduates here on the Homewood campus.

Right now, we have students working on projects that include designing innovative medical devices for use in developing countries, building new yeast genomes that have the potential to boost bread's nutritional value, and planning the construction of a daycare center in Ecuador. All of these projects are fabulous, and all reflect the values of a Johns Hopkins education.

But as the Whiting School leadership team charts its course in a new five-year strategic plan, we have the perfect opportunity to take a step back and determine how these values will be better expressed in the future. How do we educate our undergraduates to meet the challenges of an even more complex world? What will define a Hopkins undergraduate engineering education in the years to come?

Historically, we have done an excellent job of combining a deep technical education with rich offerings in the humanities and social sciences. Our undergraduates work on important research in our laboratories and are mentored by world-renowned faculty. And we support extracurricular initiatives that draw upon students' engineering skills and expand their worldviews and experiences.

While these experiences are valuable, I have to wonder if it is time to reconsider the skills our students need for success in the years ahead. We need to graduate students who can think creatively, holistically, imaginatively—even artistically—if they are to solve a whole new set of complex societal and global problems.

The challenges of the 21st century require expertise and collaboration from across a wide span of disciplines. How do we secure the world's nature resources while balancing the needs of 7 billion people? How do we harness advances of modern medicine to improve the health of people from countries as diverse as Ethiopia and the United States? How do we utilize more effectively the terabytes of raw data generated by supercomputers?

Our Vice Dean of Education Edward R. Scheinerman is working with faculty to determine what it will take to prepare our students to tackle these challenges. And at a recent daylong retreat, our senior leaders and faculty spent hours discussing this topic.

As valued members of our community, your insights are invaluable. Send your ideas or suggestions to engineeringinfo@jhu.edu. Together we can find that balance between technical expertise and creative problem solving that will be critical to educating the next generation of innovators.

Best wishes,



Nicholas P. Jones
Benjamin T. Rome Dean, Whiting School of Engineering



After studying biomedical engineering at University of Virginia and conducting research on access to care as a Fulbright Scholar in Jordan, Omid Akhavan, 26, enrolled in the CBID program at Hopkins to pursue interests in engineering and public health. A novice photographer, he came across the woman on our cover outside a crowded hospital in Kathmandu. "She was just sitting on a step, holding her child, humbly waiting for care," he says.



Associate editor Mary Beth Regan experienced "a sense of hope" while reporting this issue's cover story. "I appreciate the freshness of the students' ideas. They are so committed to a global world view and to empowering women in underserved areas," says Regan, a former contributor to *Business Week*, *The Washington Post*, and *Cox Newspapers*.

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Johns Hopkins Engineering magazine is published twice annually by the Whiting School of Engineering Office of Marketing and Communications. We encourage your comments and feedback. Please contact us at:

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JEFFREY F. BILL

Big Ideas

Insights and Discovery

Storm Chasers

Nearly a week before Hurricane Irene slapped the East Coast in September, leaving as many as 5.5 million people without electricity, Seth Guikema was stockpiling food, water, batteries—and cranking up his laptop to predict how many people would be left without power.

Guikema, an assistant professor in the Department of Geography and Environmental Engineering, has been working for several years on a computer model that predicts power outages in advance of hurricanes. His collaborators include Johns Hopkins doctoral candidate Roshanak Nateghi and Steven Quiring, a geography professor from Texas A&M University.

Irene, the first hurricane to make landfall in the United States since 2008, presented a perfect test storm. The model builds on earlier work with a Gulf Coast utility, in which the team developed a statistical model that lets them predict on a grid of 12,000-foot-by-8,000-foot cells

which areas likely will lose power.

The Gulf Coast model looks at wind speed and duration, and then uses proprietary data about how many electrical poles, electrical lines, and transformers are in each grid cell. It uses records of soil moisture and pre-storm drought conditions as proxies for where trees might topple. “For the Gulf Coast, we are able to predict with good accuracy the fraction of customers that will be out of power,” Guikema says.

With Irene fast approaching, could the team—now including undergrad Lucas Henneman—predict power outages in Maryland, and along the East Coast, using publicly available data such as wind speed, wind duration, and population? The answer: evidently, yes.

Based on the best post-storm track and intensity estimates from the National Oceanic and Atmospheric Administration, for example, the model reported 30 percent peak electrical outages in Maryland, compared to 36 percent officially reported by Baltimore

Gas and Electric (BGE). The model also was able to predict the hardest hit areas using census tract data. Overall, the best accuracy was obtained for Connecticut, Maryland, Massachusetts, and New Hampshire—all crippled by large power outages.

In the days leading up to Irene, utility companies scrambled to organize response crews and borrow equipment from as far away as Texas. In the end, BGE spent \$81 million restoring electricity to customers. Computer modeling has the potential to save utilities substantial amounts of money by facilitating rapid response and helping them best deploy resources.

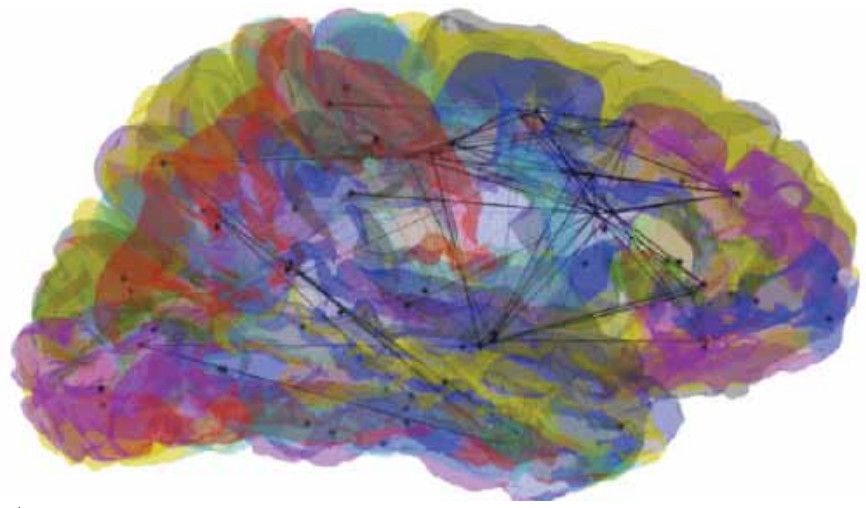
For Guikema, the Irene data also gave him a jump on preparing for the storm. “For a while,” he says, “I was downloading the wind data from Texas A&M on my battery-operated laptop, running it through our model, and then transmitting it to the team via 3-G on my cell phone.”

— Mary Beth Regan

“Collectively reverse-engineering the brain one synapse at a time.”

—THE OPEN CONNECTOME PROJECT MOTTO

Mapping the Mind



The human brain is a masterpiece of circuitry. In a squishy space about the size of an orange, the brain contains 100 billion neurons linked at trillions of critical spots known as synapses that conduct electrical signals to control our bodies, thoughts, and emotions, and make us who we are.

If scientists could diagram every connection, collectively known as the “connectome,” they’d have an anatomical map of brain function and, for the first time, a detailed way to understand what mistakes in this biological wiring cause neurological disease and psychiatric disorders. But given that there are more than 100 trillion synapses, well, that’s kind of a lot of work.

It’s also exactly what the Open Connectome Project is making possible. A Web platform that stores and manages 20 terabytes of brain image data, this Hopkins project puts the data online for scientists worldwide to tap and for users—including laypeople—to view and help analyze and annotate. (The project’s motto: “Collectively reverse-engineering the brain one synapse at a time.”)

“If you look at data online you can see neural structures, synapses, but it’s just image data,” says Randal Burns, associate professor in the Department of Computer Science and director of the Hopkins Storage Systems Labs. “Going from image data to information about connectivity—that’s the central challenge.”

An initiative of Hopkins’ Institute for Data Intensive Engineering and Science (IDIES)—a

SOCIAL SYNAPSES: By analyzing and annotating an anatomical map of the brain, Open Connectome Project participants can help scientists better understand what goes wrong in neurological diseases.

partnership of the Krieger School of Arts and Sciences, the Whiting School, and the Sheridan Libraries—the project is one of several Hopkins efforts aimed at designing computational tools to analyze the unprecedented flood of data collected via digital technologies. Like the Hopkins Sloan Digital Sky Survey, which seeks to map every object in the heavens, the Open Connectome Project leverages crowdsourcing and cloud computing to do large-scale science.

The project was born on a cocktail napkin when Burns met neuroscientist Josh Vogelstein, a postdoc in the Whiting School’s Department of Applied Mathematics and Statistics, at a dinner in March 2010. “Josh had this vision of an open connectome, and I had experience managing large datasets”—laying the groundwork for an ideal collaboration, says Burns.

The data already existed. Most data come from two Harvard laboratories that had collected a mountain of slices of mouse brain that they ran under an electron microscope; more data are expected from such institutions as the Max Planck Institute in Germany. The project also hosts brain data collected from magnetic resonance imaging. Over the past year, Burns and his students built a high-throughput storage system to house the data with Web Services to let users download it. The scientists now are working on making it possible for users to also

upload any brain data they want to contribute—and annotate it. And they’re developing a tutorial that will enable even laypeople to annotate data.

Participants will use a tool specifically designed to identify the neuron, bit of neuron, or synapse associated with each pixel in an image. “You need to know nothing about neuroscience or computers or annotating,” says Vogelstein. They expect to have hundreds of terabytes of data by next year, and petabytes in a few years. Given the scope of the project, the researchers hope many users will contribute the algorithms they write to identify cell boundaries or neurons. This “alg-sourcing” is crucial. Because the project is so vast and has so many parts, the researchers expect to use many algorithms together. In addition to creating tools for image processing, Vogelstein’s brother, Jacob, a biomedical engineer at Hopkins’ Applied Physics Laboratory, is designing modular tools to combine these algorithms.

Since its launch in March 2011, the site has been getting more than 2,000 hits a month. “This is a big movement in open science. People anywhere in the world with Internet access can see and contribute to the most-cutting-edge science,” says Vogelstein. “It takes science out of the ivory tower and makes it available to everyone.”

—Kristi Birch
Visit www.openconnectomeproject.com.

Energy Star

Kathleen Hogan's message is clear: Investment in making our homes and businesses more energy efficient will save us money, create jobs, and lower our carbon footprints.

As deputy assistant secretary for energy efficiency in the Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy, Hogan, who received her PhD in environmental engineering at the Whiting School in 1986, leads the federal government's \$900 million effort to create policy and programs encouraging Americans to save energy.

Hogan's focus now is how to retrofit America's building stock—roughly 5 million commercial buildings totaling about 80 billion square feet, and more than 113 million occupied households, many constructed before energy policy was in place—to be more energy efficient.

Under the 2009 American Recovery and Reinvestment Act, the department created a grant program to demonstrate how to do home improvement retrofits “almost en masse,” she says, making the conversion to energy efficiency more affordable for homeowners while creating work for home contractors. Her office also works with the business sector on strategies for larger-scale energy-efficiency efforts, all in the hope, she says, of “retrofitting millions of homes a year and billions of commercial square feet a year.”

Another program under development would credential home contractors in energy upgrades, which marries well with the Home Energy Score program. The idea is that a home contractor, preferably one who is credentialed, would visit a home and give it a score of 0-10 in energy efficiency. The score would be accompanied by a set of easy-to-implement, relatively

inexpensive energy-saving measures to improve the score, along with an explanation about the impact on their energy bill.

Hogan lives with her husband and two sons, ages 16 and 18, in Baltimore's Roland Park neighborhood, a short distance from the Homewood campus. Since the family moved in a few years ago, they've made their circa 1970 home more energy efficient by installing high-efficiency air conditioning and windows, and they've bolstered their attic insulation and begun using compact fluorescent bulbs. “It's an ongoing project,” she says—and one to which she is firmly committed.

One of the challenges this pioneering policymaker has faced—not only in her current role but also back to her early-career work at the EPA in mitigating greenhouse gas emissions and then 15 years leading the Energy Star program—is “finding things that people want to do, that's in their own interest, that are win-win-win.”

“This is sort of what you learned at Hopkins: If you haven't had an objective to do something before, let's not just assume it's expensive but see if there's a little step to take to build in the new objective as well, and get it done at a reasonable cost.

“There's so much that we can do with technology and innovation if we put our minds to it and that is what will keep making this country competitive and a [world leader]. We want to address the energy resource and technology issues so people can have the lives they envision having—but do it with as minimal impact as possible.”

—Nora George



FELLOW RETROFITTER: Kathleen Hogan, who helped make the Environmental Protection Agency's Energy Star program a national brand for energy efficiency, has updated her own home in Roland Park with high-efficiency air conditioning and windows, and better attic insulation.

THE BUZZ

Engineering Terms in the News

JEDI: An instrument, developed at Johns Hopkins' Applied Physics Laboratory, that will measure energetic particles that flow and are trapped within Jupiter's space environment, known as its magnetosphere. The full name: Jupiter Energetic-particle Detector Instrument.

Digital Dumping Ground:

The wasteland where old, rarely used, and unneeded files pile up inside of computers, depleting precious storage space, bogging down the system's efficiency, and sapping its energy.



Spear Phishing: An email spoof fraud attempt that targets a specific organization, seeking unauthorized access to confidential data. Not typically initiated by “random hackers,” these threats are more likely conducted out of hope for financial gain, trade secrets, or for military information.

Cardiac Resynchronization

Therapy (CRT): A modified pacemaker treatment that synchronizes the heartbeats and resumes normal contractions. Johns Hopkins heart specialists recently have uncovered how the pacemaker works at the biological level.

Once More, with Emotion

When Roger Ebert of the *Chicago Sun-Times* lost his ability to speak due to cancer, he began a journey to find his own voice by way of computer-generated speech. In a 2010 interview on *The Oprah Winfrey Show*, the movie critic demonstrated how a Scottish-based company created a computer program, using recordings of Ebert's own voice, to speak like him. "You'll know it's a computer," Ebert told the audience. "But it will sound like me."

The Johns Hopkins Workshop on Human Language Technology, entering its 17th year, gathers experts on language and speech processing each summer to tackle vexing problems such as how to generate personalized-sounding speech. In July and August, roughly 50 international experts came to the Homewood campus to push science forward in several areas, including the generation of emotional speech.

"The summer workshops have led to a number of significant

breakthroughs in our field," says Sanjeev Khudanpur, an associate professor of electrical and computer engineering and a member of the Whiting School's Center for Language and Speech Processing. The workshops—funded by federal agencies, companies such as Google, and academic institutions—draw renowned researchers, postdocs, graduate students, and carefully selected undergrads. The result: an intense scientific boot camp that produces a year's worth of work in six weeks.

The quest to build a "human speaking box" dates to the 1700s. But it wasn't until the early 20th century that an actual speech synthesizer (as opposed to a speech recording) was exhibited at the New York World's Fair. By the 1990s, hand-held electronic devices could generate speech, but voices remained robotic and stilted. "If we want to have robots that can interact with us, we need speech synthesizers that speak with emotion, with personality," says Alan W. Black, of Carnegie Mellon University, in his own lilting Scottish accent.

During the summer workshop, Black's 10-member team was tasked with the job of generating emotive computer-speak.

Khudanpur describes the need: "If I'm speeding along the highway, and my monotone GPS says, 'Slow down, please. The back door is open'.... I really want it to say, 'SLOW DOWN! The BACK door is OPEN!' Or: 'If I have a robot out on a battlefield, maybe, I want it to be able to say, 'DROP YOUR GUN. NOW!'"

To date, scientists

have focused on using standard techniques of voice spectrum (vibrations) to generate speech. Black's team turned to advances in articulatory features (computerizing how words are formed with the lips, tongue, and mouth) to create more emotive speech.

"We've come up with a new way to generate speech using these articulatory features," Black says.

The advances, he says, could lead to computer software that can accomplish tasks such as taking a man's voice, putting it into a synthesizer, and having it generate a female voice. Or, taking an individual's voice and having the computer translate it into another language such as German. "It might still have a slight English accent," he says. "But it would sound like you."

This, Black says, has huge potential for applications worldwide. For example, if a female American doctor was treating a female patient in, say, Afghanistan, it would be preferable for the speech synthesizer (with translation) to generate a female voice, equipped with emotion and intonation. "You may want compassion; otherwise, you'll get a disconnect."

How close are we? "We're just scratching the surface," Black says. He returns to the example of Ebert, and others such as physicist Stephen Hawking, who also uses a speech synthesizer. Ongoing research should pave the way for computer scientists to build individual voice generators for people without having to rely on hours of that person's own recorded voice.

If a speech synthesizer were to sum that up, it might exclaim: "WOW!" — MBR



PHILIP ANDERSON

So Random

Fluid dynamics, the branch of physics concerned with the behavior of liquids and gases in motion, can explain what happens when cream swirls in a cup of coffee, when wisps of smoke rise from an extinguished campfire, when water burbles down a creek bed. Drop a grain of sand into that creek, for example, and there is an equation that will describe the movement of the sand and pinpoint the one single place where the sand will end up.

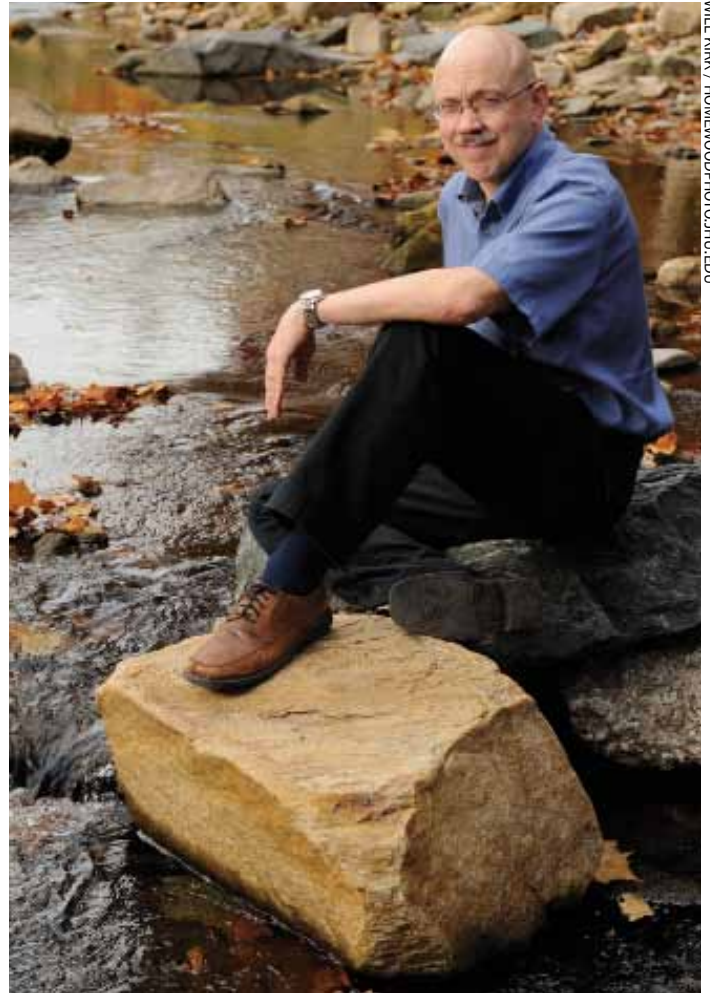
But if a storm rolls in and the water starts frothing, all bets are off, according to Gregory Eyink, a professor in the Department of Applied Mathematics and Statistics at the Whiting School. Using a virtual-reality computer simulation, Eyink has shown that if two identical particles are dropped into a turbulent flow—a flow that is fast and irregular—at the same time and same place, they will end up in completely random spots. “The theories that assume there’s one solution assume smooth velocity,” says Eyink. “But it turns out that in turbulent flow, things are not sufficiently smooth and one solution is no longer true. If you put a particle in it and let it go, it’s totally unpredictable. Where it goes becomes random,” says Eyink, who reported his findings in the May 27, 2011, issue of *Physical Review E*.

Eyink’s work builds on conjectures about particle separation in turbulent fluids made in the 1920s by the physicist (and meteorologist) Louis Fry Richardson. In the mid-1990s, researchers from Europe confirmed Richardson’s conjecture when they studied particle separation in a mathematical model of turbulence. Based on this

model, they concluded that in real fluids, particles will end up in totally random places, a physical phenomenon known as “spontaneous stochasticity.”

Eyink wanted empirical proof. He used a database of computer-generated “virtual reality” turbulence that he created with mechanical engineer Charles Meneveau and computer scientist Randal Burns, both of the Whiting School, and physicist Alexander Szalay of the Krieger School of Arts and Sciences. This database is “real” in the sense that the fluid velocities in it satisfy the same equations of motion as real physical fluids do. Eyink dropped identical virtual particles into the database at the same spot and then tracked their movement. Along the way, he gave the particle random “kicks.” Predictably, the particles followed different paths. However, even as the kicks got weaker and their effects lessened, the particles still went to random places.

Moreover, Eyink’s results were contrary to a basic principle established by Nobel Prize-winning physicist Hannes Alfvén that holds that certain kinds of objects—magnetic field lines (like magnetic lines of force seen with iron filings)—are carried by a fluid as if they were light threads cast into the flow. This phenomenon, known as “flux freezing,” has long been a problematic theory: “It explains many different processes, including how stars form,” says Eyink. “But it has also been observed that many times it doesn’t work—for example, in solar flares.” In Eyink’s simulation, the “threads” of magnetic field-lines did not end up at one location but instead moved randomly. “With this technique it showed up



WILL KIRK / HOMEMODPHOTO.JHU.EDU

UNPREDICTABLE PATHS: Gregory Eyink's new findings on turbulent flow in liquids could help us better understand events in nature.

really clearly,” said Eyink. “The results were amazingly good.”

“Stochastic magnetic flux freezing in turbulent flows should help us to understand violent events in the sun such as solar flares, which can disrupt power and communication networks on Earth, and the generation of Earth’s own magnetic field, which helps to shield us from some harmful radiations and which is presently decreasing, about a 10–15 percent decline over the last 150 years,” says Eyink. — KB

“Everything processed by the cell has to go through the membrane—not just actual molecules but information.”

—KALINA HRISTOVA,
PROFESSOR OF MATERIALS
SCIENCE AND ENGINEERING

Membranes Matter

Human dwarfism, which is even depicted in ancient Egyptian art, is one of the oldest recorded birth disorders. The cause for the most common form, achondroplasia, has been known since the mid-1990s: Mutations in the fibroblast growth factor receptor 3 (FGFR3) gene produce proteins that cause disruptions in the growth of bones and cartilage. The question that remains: How does that happen, exactly?

That’s what Kalina Hristova wants to figure out. And as a professor of materials science and engineering at the Whiting School, she may have the perfect, if not traditional, skills to do it. Her lab is looking at the mechanics and physics, rather than the biology, of what happens in the cell membrane, where these errant proteins—and many other mutant proteins causing other diseases—reside. “Membranes matter because the membrane is the boundary between the cell and the outside world,” she says.

“Everything processed by the cell has to go through the membrane—not just actual molecules but also information. If something is on the outside, it can modify things inside the membrane, and a chain reaction can happen.”

It’s an unconventional kind of research, and Hristova is well suited to take it on. The daughter of an economist and a biomedical engineer, she says she never even thought about being anything other than a scientist. Hristova



WILL KIRK / HOMEWOODPHOTO.JHU.EDU

PROBLEM PROTEINS: Hristova has taken an unconventional approach to her studies on the causes of human dwarfism.

earned her undergraduate and master’s degrees in physics in her native Bulgaria, where a teacher assigned her a project involving cell membranes and she became intrigued by how physics concepts could be applied to biological problems. After earning her doctorate in engineering and materials science at Duke, she took a post-doctoral fellowship at the University of California, Irvine. There, she learned about dwarfism from a doctor and faculty member: “I realized that I could apply my background in materials science toward understanding the molecular basis behind the disorder,” she says.

The recipient of a federal stimulus grant in addition to her grant from the National Institutes of Health, she’s also engineering new tools to do her research. “The first problem is to understand at the molecular level what is happening at the membrane site,” she says. “But a lot of techniques are crude. By developing tools that were not available, we can answer questions nobody else can answer.”

Cell membrane proteins have been difficult to study because commonly used techniques, such as FRET (Förster resonance energy

transfer) imaging, a microscope technology that uses fluorescence to measure protein interactions, does not allow for straightforward data interpretation. So Hristova developed a new FRET imaging method that allows researchers to quantify the protein interactions. Using these novel techniques, Hristova has disproved the common hypothesis that in dwarfism, the interaction between the proteins in the cell membrane has been altered. Instead, she and her lab team found that what is altered is the actual structure of those problem proteins in the membrane. Their findings were published in the *Journal of Biological Chemistry* in 2010.

Hristova, who came to Hopkins in 2001, researches the physics of cell signaling as well as membrane biology. In 2007, she won the Biophysical Society’s Margaret Oakley Dayhoff Award, which is given to a junior woman scientist of promise in the field of biophysics. She says that even when she’s traveling, her mind is always back in the lab, on her work. “We hope that the knowledge we gain will pave the way to the development of new cures.”

— KB

Faculty Awards

From the White House: Cowan Wins PECASE

Noah J. Cowan, an associate professor of mechanical engineering, was selected to receive the Presidential Early Career Award for Scientists and Engineers, the highest honor for scientists and engineers in the early stages of their careers awarded by the United States government.

At Johns Hopkins, Cowan directs the Locomotion in Mechanical and Biological Systems (LIMBS) Laboratory. His research studies how animals process sensory information to control their movements. The group also designs sensory-based robotic control systems inspired by animal models.

"This is a tremendous honor," says Cowan. "And I feel as though I am carrying the torch for all the talented students and colleagues I have been fortunate enough to work with during my career."

Cowan was selected for his innovative research in biologically inspired robotic systems with application to disaster recovery and space exploration and for motivating students to explore careers in science and engineering. His work includes:

- investigating how weakly electric knifefish use sensory feedback to control their swimming, much like humans use feedback from their eyes and inner ear when they walk or run;
- discovering how cockroaches use their antennae to guide their movement along surfaces in their surroundings and using these discoveries to design biologically inspired tactile sensors for robot navigation;



PRESIDENTIAL RECEPTION: Noah Cowan was among 94 U.S. researchers honored by Barack Obama with a prestigious Presidential Early Career Award.

- designing robots that use vision-based control systems when reaching for objects or moving around obstacles; and probing how humans adapt their movement in rhythmic tasks such as walking, running, and juggling.

President Obama in September announced the 94 researchers

who received the award; Cowan was among 21 honorees nominated by the National Science Foundation. Two other Johns Hopkins University scholars received the award this year: Brian S. Caffo and Katherine L. O'Brien, both of the Johns Hopkins Bloomberg School of Public Health.

Sri Sarma, assistant professor of biomedical engineering and a member of the Institute for Computational Medicine, received an Emerging Frontiers in Research and Innovation award from the National Science Foundation to support her research in brain-machine interactive control of prosthetic limbs.



Sri Sarma

Joelle Frechette, assistant professor in the Department of Chemical and Biomolecular Engineering, received the 2011 Office of Naval Research (ONR) Young Investigator Award for her proposal, "Understanding the Role of Hydrodynamic Forces on Wet Adhesion."

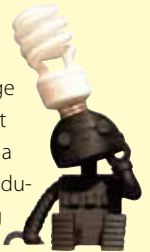


Joelle Frechette

Lab Notes

Tiny Chemo Factories: A novel cancer-fighting strategy, developed by Marc Ostermeier, a chemical and biomolecular engineering professor, shows promising early lab results. Here's how it works: A protein switch inside cells instructs cancer cells themselves to produce their own anti-cancer medication. The hope: Cancer cells will become their own tiny chemotherapy factories, self-destructing.

Robot Red Carpet: Enter da Vinci surgical robot, stage right. In the first-ever Robot Film Festival in Manhattan, a short whimsical film by graduate students in the Whiting School's Laboratory for Computational Sensing and Robotics (LCSR) won the Audience Award. The plot: Students use the da Vinci to play the old-fashioned game Operation. "Robots get way too much bad press," says Kelleher Guerin, a creator of the video, of the robot's superior fine motor skills.



Tweet Talk: Two computer scientists, Assistant Research Professor Mark Dredze and PhD candidate Michael J. Paul, have sorted through 2 billion public Tweets to uncover patterns involving allergies, flu, insomnia, cancer, obesity, depression, pain, and other ailments. Their question: Can you use public Twitter posts to ferret out important public health trends? The answer: yes. Example: Following Twitter enabled researchers to track trends by time and place, such as when the allergy and flu seasons peaked in various parts of the country, and the medicines people used to treat them. — MBR



DATA DRIVEN

As computing ability jumps by leaps and bounds, researchers wrestle with making the best use—and reuse—of all that data.

By Mat Edelson

Illustrations by Mark McGinnis

On July 16, 1969, Apollo 11 left the Earth bound for the moon with the most sophisticated guidance computer of its time.

Built by the finest engineering minds, it held the lives of three Americans and the hopes of the entire planet in its solid-state memory.

All 32 kilobytes of it.

These days, one doesn't have to travel to orbiting satellites to find that kind of computational capacity. Heck, just reach in your front pocket; the average 32 GB iPhone has 1 million times the computing memory that navigated for Neil Armstrong and Co.

Quantifying this quantum jump in artificial intelligence often comes down to an explanation of the law, in this case Moore's law. In 1965, Intel's Gordon Moore noted that the number of transistors that could be placed on a chip was roughly doubling every year. Ever since, Moore's law has held almost true (the doubling has occurred more on the order of every two years, but still...).

Moore's law applied to a computer's processing speed, but clearly data storage has kept pace. Entire genomes can now be stored on drives that fit in the palm of the hand, while galaxies might call for something a little bigger—like a drive the size of a cigar box.

That ability to collect and store data has infiltrated nearly every aspect of the human condition while captivating human imagination. From exploring the heavens to researching repetitive motion injuries, if an action can be observed—whether it's stargazing or typing—it stands a very good chance these days of being quantified and placed in a database.

Organizing all that data—and making it more easily accessible—is arguably the next great wave in computing, akin to the way the Dewey Decimal System brought order to what had been the chaos of referencing the printed word.

“I think of computing as having gone through three generations at this point,” says Greg Hager, chair and professor of computer science at the Whiting School. “We had the hardware generation, which was concerned with constructing the computer, the software generation where we were more concerned with what ran inside the computer, and now the data generation—which is about what computing can do to essentially take data and turn it into usable information.”

Information that for many Whiting School faculty is changing the way they do business and, in turn, impacting how each of us lives our lives...

MODEL HEART

Even before Apollo soared into space, or Gemini, or even Mercury, the human heart was the target of some of the first computational modeling. It is a story Rai Winslow, professor of biomedical engineering and director of the Whiting School's Institute for Computational Medicine, is fond of telling. How, in November of 1960, a lone wolf researcher named Denis Noble published the first paper showing how heart cells—aka cardiac myocytes—functioned, notably how they could fire off long-lasting bolts of electricity, the first clue into how the heart as an organ contracted and acted as a pump.

It was glorious work that, Winslow laughs, Noble conducted under less than ideal conditions at the University of Oxford. “[His model] was done on an old computer, very slow, very little memory—something like 16 kilobytes—it was hard to program and took a long time to even simulate one [myocyte electrical] action potential. The computer was hard to get access to; he sneaked into the basement where this computer was, programmed it at night ... but it was a tour de force of modeling at the time.”

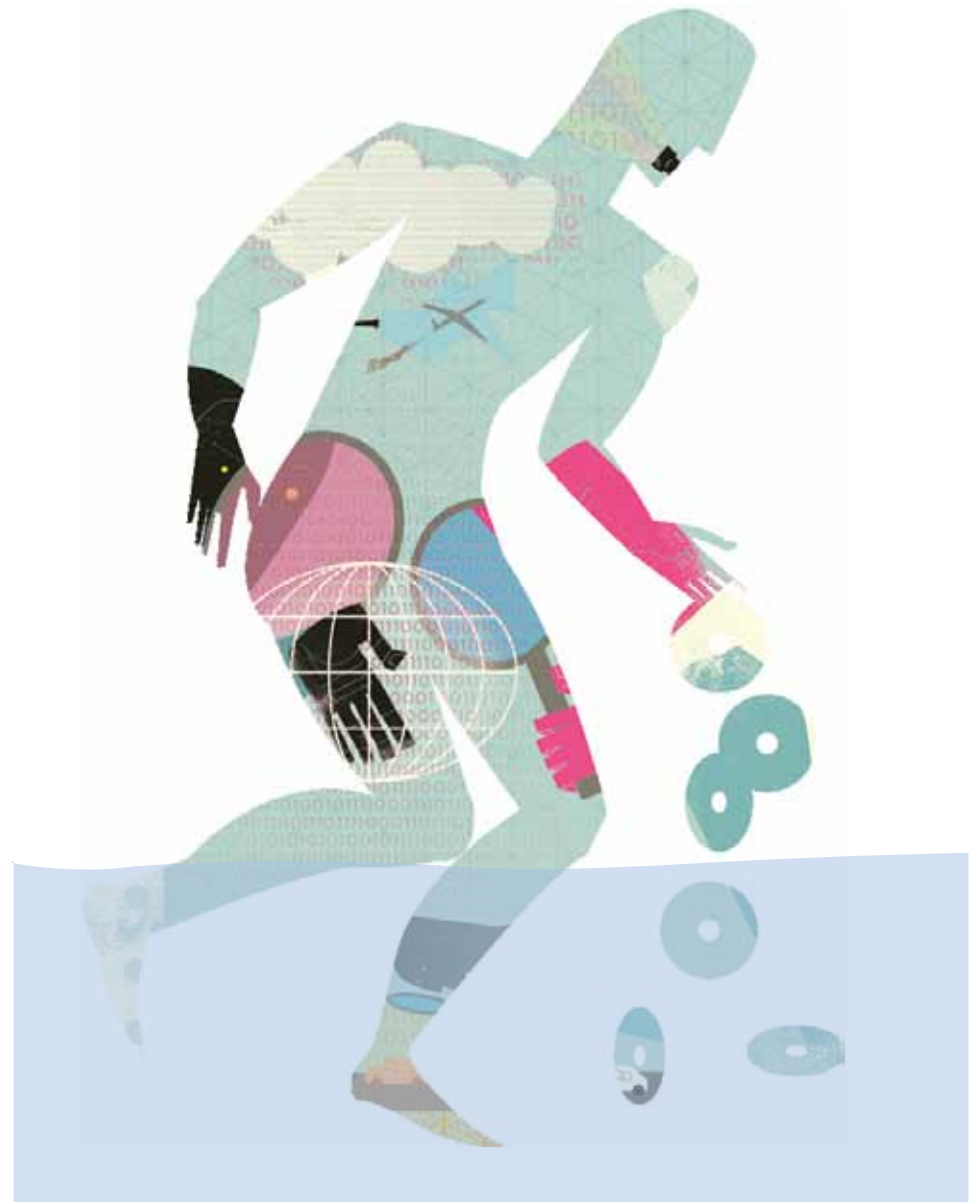
Some 30 years later, that paper and its author changed the course of Winslow's career path. The two met by happenstance and found their work, though separated by a generation, had a computational link. Winslow was model-

ing electrical activity in a different part of the body. He was investigating neural information processing—collecting thousands of readings and millions of data points to reconstruct the electrical action of neurons up and down the visual pathway from the retina to the brain. The goal: to better understand how the eye encoded vision in a way that the brain could process.

“Denis saw how we were using large-scale parallel computing to simulate neural network models, no one had done that before, and his response was ‘Gee...you have [the equivalent of] a heart here. You just need to put in

different [electrical] currents.’” By looking at Winslow's leap from the work of a cell to an entire system, “Noble realized that the cell modeling he had been doing could be translated to the level of tissue and the whole heart using these same computer modeling techniques,” says Winslow.

That's exactly what Winslow has done, embarking on a fascinating journey that has allowed him to model the heart on both a macro- and micro-level. In the 1990s, collaborating with Noble, Winslow uncovered how the heart's spark plug—the sinus node—functioned. It seemed so incongruous to scientists:



THANKS TO WINSLOW'S DATA-RICH MODEL, AT LEAST ONE DRUG COMPANY IS INVESTIGATING WHETHER IT CAN TARGET CALCIUM IMBALANCE TO IMPROVE FAILING HEARTS.

How could a tiny clump of cells located in the northwest corner of the heart essentially run the whole show? “You’d think that the [heart] is so big that node couldn’t generate enough current to do that,” says Winslow.

It turns out the elegant node didn’t have to provide the entire electrical wallop, just a wee oscillation of current—enough to activate the microscopic filaments of atrial [heart] tissue that penetrate deep into the node. Like a roar that starts with a single voice, the node’s spark sends its voltage out the filaments, and the atrial tissue does the rest of the work, convincing other, larger cardiac cells to add their juice to the wave that spreads over the heart, causing it to contract in time.

Winslow had successfully modeled a healthy heart, which led to an obvious question. What happens in a diseased heart marked by notoriously poor electrical timing, such as the common case of congestive heart failure? To model that, Winslow has gone back to where it all started—those cardiac myocytes—but in levels only recently made possible by advanced computer imaging and data processing. Winslow was able to dissect what he says were “terabytes” of information to make a rather startling and somewhat apropos discovery: It turns out that not only is the heart a pump, but each myocyte is also a pump—perhaps many of them—that regulates the flow of calcium, sodium, and potassium throughout the cell. Those internal mechanisms control both the cell’s ability to create energy and the timing by which it fires out of the cell.

Winslow’s models—and the data upon which they are built—have uncovered a con-

nection between failing cells and a lower release of calcium during heart contractions. Armed with that knowledge, Winslow says at least one drug company is already investigating whether it can target the calcium imbalance and perhaps improve failing hearts.

“I think that’s the point of these kinds of models,” says Winslow. “If you find a compound that blocks a particular calcium pump, how does that fit into the big picture of the networks that molecule participates in?”

“It’s a systems-level problem, and that’s the power of these sophisticated models ... to help point out targets in treating disease.”

And that, my friends, gets right to the heart of the matter.

EASY ACCESS: A TOUGH PROBLEM

It’s one thing to create reams of data but quite another to have anyone else come along and make sense of it. That’s the conundrum facing Sayeed Choudhury, associate dean for Library Digital Programs at Hopkins’ Sheridan Libraries. The Sheridan Libraries are the information nexus for all of Hopkins and for researchers around the world. Choudhury’s job is to make sure the digital end—which is quickly becoming the majority of the various collections—remains accessible as data storage technology constantly changes.

That old library model of placing a book on a shelf for a decade until some curious researcher decides to retrieve it is quickly changing. Imagine said researcher opening those pages to find them either blank or horribly jumbled, and you get some idea of the challenge facing Choudhury ’88, MSE ’90, who is both a librarian and a Whiting School alumnus.

“Our view is preservation. When you’re talking about digital content, there are plenty of cases of data generated five years ago where I could not go to a researcher today and say, ‘Could you please give me those data?’” Part of the issue is how and where data has been

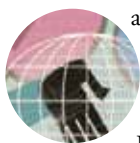
stored. Think of having a 5 ½-inch floppy disk in your possession. Sure there may still be information on it, but it’s like owning a Betamax tape: Where are you going to find a playback unit?

“I’ve said that in five years, a 1-terabyte hard drive [the current standard] is going to be like a 5 ½-inch floppy disk,” notes Choudhury, adding that there’s more than technological obsolescence facing data collection. There’s often a false sense of security, what Choudhury calls “a naïve approach that ‘I’ve got copies of [the data] so what’s the problem?’”

“The problem is that copies get corrupted—you ought to check those copies regularly. And even if you do everything right from the viewpoint of the bits and the media, on a deeper fundamental level, there’s context associated with data. [Researchers] tell you an amazing story of their data and what they’re doing with it, but I can assure you they have often not documented all of that in a way that someone without any knowledge of the work could come along and say, ‘OK, I get it, I can take your data and run my own analysis against it.’”

Given his unique background, Choudhury sees himself as the human interface between researchers who create the data, librarians who want users to make data easily searchable, and software engineers who can design the appropriate algorithms and metadata context to make it so. On a pragmatic level that means he has lots of conversations with everyone from storage manufacturers to scientists anticipating future use of their data.

Working with National Science Foundation grants, Choudhury has reached out to large data collection projects such as the Hopkins-led Sloan Digital Sky Survey, which bills itself as “the most ambitious astronomical survey ever undertaken.” Its goal is to map literally a quarter of the heavens, and that’s a lot of data ... on the order of 140 terabytes. “Sloan can keep its data on disks, back it up, and have IT experts who can fine-tune the databases, it’s part of their budget,” says Choudhury. “We interfaced with this group as their project was winding down about preservation. They concluded it’s preferable for us to provide long-term curation. We have definitely



learned a great deal [from them] that we're applying to other domains or projects."

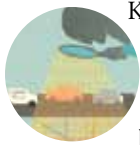
Pretty soon it may be the scientists who are first approaching Choudhury. There's nothing like money to motivate, and Choudhury notes that the National Science Foundation now requires all primary investigators to include a two-page data management plan in their proposals, a guarantee that their results won't end up in the data desert.

Choudhury says his team is helping researchers formulate data retention strategies—"We've heard from people saying, 'Yeah, I understand I have to do this, but honestly, it's useful, because I can't even get back to the data I produced five years ago,'" he says—and also sparking curiosity. As word spreads, Choudhury has found some researchers thrilled that their colleagues' data may be coming online. "[They say], 'That will help with collaboration more than anything, because the best insight I get into somebody's research is the kind of data they produce and the kind of questions they ask about those data.'"

Now that's what we call recycling.

PARTS OF SPEECH

You may never have heard of Sanjeev



Khudanpur, but if you own a phone, you've definitely met some of the women in his line of work. They're universally perky and helpful (or at least they promise to be), and go by a series of All-American Anglo names: Mary, Linda, and perhaps this region's best known example, Julie ... as in "Hi, I'm Julie from Amtrak. Where would you like to go?"

This is the data-intensive world of speech and text recognition software that Khudanpur plies, and "Julie" is just the latest example. "Actually, the earliest was a toy, Radio Rex, from the 1960s. It was a plastic dog, it sat in its little dog house, and if you said 'REXI' loudly enough, it jumped out of the house," laughs Khudanpur, an associate professor of electrical and computer engineering at the Whiting School. Rex was, in his own electronic way, a

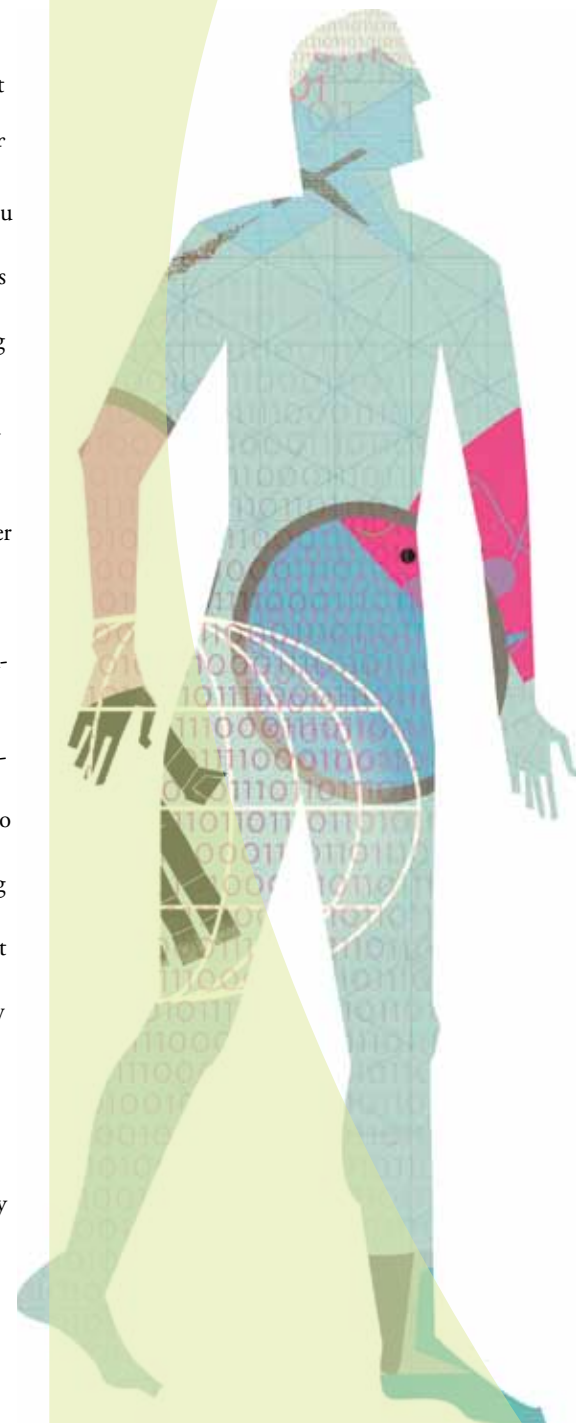
little hard of hearing. "It wasn't really recognizing 'Rex.' You could say 'hex' or 'sex'—anything that had the 'eh' sound in it—and it would respond. If you said 'baby' or 'dog' it wouldn't do anything."

By comparison to Rex's crude Texas Instruments chip, Julie may seem a veritable chatterbox, but to Khudanpur's mind, there's plenty of room for technological improvement in that she works in "a limited domain. If you start asking Julie whether she likes *Phantom of the Opera*, she has no opinion on it, she just wants to figure out where it is and whether you want to go there."

Khudanpur's work at the Whiting School's Center for Language and Speech Processing takes him in the opposite direction, expanding the boundaries of speech and text recognition to create programs that more accurately translate languages. That involves delving into how people really speak to each other—so-called "conversational speech"—versus the way most of us interact with Julie. "We talk to each other very differently than we talk to a computer," says Khudanpur, who has researched the nuances. "People tend to be more cooperative when they're talking to a computer, more measured in their speech."

By contrast, Khudanpur's current speech recognition investigation "is focused on [quantifying] conversational speech, pronunciation variations, dialectal variability, accents, and so on." He notes that people have the ability to discern sloppy pronunciations of words during conversation, to realize that, in a chat about their beloved pet, they may say something that sounds a lot like "diskette" but it's understood by all in the room to mean "this cat." But how do you get a computer to make the right call?

The answer, says Khudanpur, is twofold; one aspect involves sampling thousands of sounds used in speech, looking for the common patterns that can be programmed into a model (think of a computer that could quickly recognize a thick Boston or Baltimore accent, and adjust its translations accordingly). The other side involves creating mathematical formulas that look at millions of complete sentences from which a computer could deduce the likely translation of a given word. In the



example above, Khudanpur says the computer would know “diskette” really means “this cat” if it recognized the context of the adjacent words, as in “The black fur on (‘diskette’) really makes her green eyes stand out.”

Khudanpur says the applications of such work are numerous. On a national security front, software can tap international calls in a way far beyond human manpower, looking for certain words and phrases that could be tip-offs of planned attacks. On a far more benign front, Khudanpur imagines a chip that could search TV not by programming but by spoken content, referring viewers to news and talk shows that offer the most references to a given subject.

For all his accomplishments, Khudanpur says his most interesting work still lies ahead of him—the world of text-to-text translation. As anyone familiar with the phrase “lost in translation” has learned, using a computer to move from one language to another is problematic at best. Khudanpur may be on the way to solving that contextual gap. By pouring thousands of parallel sentences in multiple languages into a database (think of numerous UN translators simultaneously translating the same speech), Khudanpur is creating language matrices where a mathematical process of elimination narrows down a word in one language to its counterpart in another.

“It’s like having millions of necklaces, all with many different colored beads, and I asked you to pick out a subset of necklaces that had one bead of your favorite color,” he says. “If you gave me that subpile, I’d look for the color they all had in common ... and that would be your favorite.”

In any language.

ENERGY SMART

From the production of power to its delivery, Whiting School professors Charles Meneveau and Ben Hobbs are crunching serious numbers to understand alternative sources of energy and the most efficient ways to keep the power flowing to our communities.



Let’s take the latter first. The current system of energy delivery is an arcane and often wasteful one. Hobbs notes that, especially among the 200 utility control areas on the East Coast that include thousands of power plants, there’s almost no storage capacity for electricity. This means producers have to constantly guess at how much electricity their customers need. What’s worse, those guesses have traditionally been made several days out, to account for the lag time it takes to get big, lumbering power plants up and running. Overproduce and energy is wasted; underproduce and the risk of brownouts and blackouts soars. “It’s the ultimate ‘just-in-time’ system,” says Hobbs, the Theodore M. and Kay Schad Professor in Environmental Management and director of the Environment, Energy, Sustainability and Health Institute.

Hobbs’ recent work has looked at creating a smarter energy grid for both producer and consumers. By analyzing usage patterns and making that data easily accessible, he’s hoping to improve communication between neighboring utilities. “Right now, they don’t communicate as well as they should. And one consequence is waste. There’s some generator that’s sitting idle that’s cheap to run while another generator that’s expensive to run is operating.

“There’s also a reliability aspect,” he adds. “There’s a Department of Energy report that lays the blame for the 2003 East Coast blackout on lack of data on how much power was flowing; a utility in Ohio wasn’t aware it was overloading a line, [it] overheated, sagged, and short-circuited, and led to a chain reaction that blacked out New York City. And then there’s coordination; the utilities in Ohio and elsewhere weren’t communicating terribly well. If

BY ANALYZING ENERGY USAGE PATTERNS AND MAKING THAT DATA EASILY ACCESSIBLE, BEN HOBBS AIMS TO IMPROVE COMMUNICATION BETWEEN NEIGHBORING UTILITIES. “RIGHT NOW, THEY DON’T COMMUNICATE AS WELL AS THEY SHOULD,” HE SAYS. “AND ONE CONSEQUENCE IS WASTE.”

they had quickly switched out certain transmission lines, they could have confined the blackout.”

Hobbs’ work is addressing these issues, right down to incorporating weather forecasting. For example, by looking at wind patterns, he says it’s possible to help utilities predict bad-air-quality days and, in turn, encourage customers to use less electricity on those days to lower ozone levels.

That forecasting may well be aided by Meneveau’s research. Meneveau, the Louis M. Sardella Professor of Mechanical Engineering and deputy director of the Johns Hopkins Institute for Data Intensive Engineering and Science, is a turbulence specialist, using sophisticated modeling to predict how air currents interact with their environment. It sounds esoteric but has numerous practical implications. He notes that a better understanding of turbulence influences car, train, and ship designs to reduce losses due to drag. “Even if you reduce the drag forces by just half a percent, that translates into billions of dollars a year to the economy.”

From an energy production viewpoint, Meneveau is researching wind farms, everything from the turbulence they create (and the localized small but definitely recognizable effect on the environment), to the best arrangement of wind turbines for maximum power generation. But from a data storage and sharing perspective, his recent work with the Turbulence Database Group may be the most interesting. It involves simulating and analyzing so-called isotropic turbulence, answering statistical questions like: Given a wind vortex at a given location, what’s the probability that another vortex will be spawned or intersected with later? Such violent but fortunately rare events are associated with how kinetic energy turns into heat generation, a phenomenon that needs to be understood to better model both turbulence and the land and sea effects of wind farms.

It is a question to which 27 terabytes of information have been devoted; that’s the total amount of data in the Turbulence Database Cluster, a public, easily accessible database of detailed wind information that has already informed several papers from researchers scattered around the world.

“It’s nice, because these are the kinds of scientists who would not have been able [because of resources or technical background] to do these simulations themselves. So they were able to access [our database] and now there’s a new kind of science because people who didn’t do very large kinds of simulations before now have this user-friendly way of accessing the data. We think new things may come out of that.”

May the wind be always at their backs.

TO YOUR HEALTH

Personalized” medicine has become a buzzword among physicians, the idea that the key to the best care possible is refining established treatment silos—age, gender, and the like—to get at the underlying unique pathophysiology that causes illness. What’s sustaining that buzz—indeed, what’s likely to make personalized medicine a reality sooner rather than later—is the huge quantity of data being amassed on anyone encountering our health care system.

That data stream is only going to increase as hospitals move to electronic record keeping for patients and more computerized testing comes online. And while it all may seem invasive and raise confidentiality concerns, there’s a growing recognition among researchers that well-managed data can reduce both morbidity and mortality.

Greg Hager, chair of the Department of Computer Science at the Whiting School, points to robotic surgery as just one area where improved data collection offers an opportunity for medicine to advance. The robot can be programmed to replicate a surgeon’s hand movements inside the body, but that’s merely the beginning; it can also be told to record data that reveals a surgeon’s skill and whether that skill is improving, slipping, or staying status quo. “There are more than 7 million surgeries a year, including more than a quarter million done by robotic surgery,” says Hager. “Certainly there’s collective wisdom there that you’d like to bring to bear” on surgical practice, he notes.

Hager’s “Language of Surgery” project is attempting to do just that. His computer science colleague Rajesh Kumar is recording surgeons’ training on the da Vinci operating robot at several sites around the country, including Hopkins. The project uses computer modeling to turn each surgical gesture, each movement of a surgeon’s hand, into quantifiable data, “a system that doesn’t just replicate motion and provide visualization but models what the surgeon is actually trying to accomplish and can gauge what’s going on relative to those objectives.”

So far Hager and Co. have looked at general tasks common to many surgeries, collecting data to answer important questions: “What does it mean to do suturing well? What does it mean to do dissection well?”

Eventually, Hager’s surgical work may intersect with that of Natalia Trayanova, a biomedical engineering professor at the Whiting School. Trayanova has been looking at hearts damaged by infarctions, or heart attacks.

It’s long been known that infarctions kill off heart muscle, but they also create electrical disruptions known as arrhythmias that form around the infarct scars. These impact the proper overall beating of the heart. While certain kinds of arrhythmias in well-charted portions of the heart can be treated with catheter ablation (essentially a burning off of the affected tissue that sustains the arrhythmia), the random location of infarction damage has made ablation an arduous, often ineffective technique—a point-by-point physical poking and burning of the area “[Right now] the procedure lasts four to eight hours, it’s very inaccurate with a high level of complications,” including perforations of the heart, says Trayanova. She and her students may have created an elegant solution.

By taking an MRI of a patient’s chest, Trayanova is able to create a computer model of the patient’s heart that simulates the heart’s behavior from the molecular level to that of the entire organ, including representation of the processes in cells that have remodeled themselves around the infarcted area. The model produces reams of data that help show how portions of the heart will function over a given period of time. The model accurately predicts the arrhythmic activity that arises from the





infarct, allowing electrophysiologists to test for exactly the right places to ablate on the model as opposed to the patient. “We’ve done animal work and it worked very well. We’re now doing human retrospective studies,” says Trayanova.

But perhaps the most immediate clinical use of big data may come in the field of disease prevention. The price tag associated with genome collection and analysis has dropped greatly. “We spent \$300 million to sequence the first human genome; now we can do [an individual’s specific genome] for between \$2,000 and \$10,000,” says Scott Zeger, a professor of biostatistics at the School of Public Health and vice provost for research at Hopkins. This falling cost means that each individual’s personal heredity map may soon be easily accessible to health care providers.

Zeger says that increasing access to genomic information offers much promise. For example, women with breast cancer related to a growth factor produced by the HER-2 gene can now be tested for the gene and, if positive, receive a drug that blocks the gene’s growth-inducing properties. Similarly, since drug action and effectiveness are often determined by which proteins our bodies can—or can’t—produce, being able to eventually catalog each individual’s proteins (a massive sequencing field called proteomics) could ensure that patients receive only those medications their bodies can process.

Uncovering our unique genes and proteins could also predict predisposition to a host of disease states ranging from diabetes to autoimmune conditions. Offering early intervention is becoming more precise thanks to heavy data crunching; as our understanding of cellular function improves, so does detection of sub-clinical markers that accompany the precursors of disease states such as inflammation with cardiovascular disease. To Zeger, this confluence of math and medicine has its own grace, relying on both man and machine to move individualized health forward.

“What’s happening is we’re getting much closer to the real biology that’s going on [in disease-creating states],” says Zeger. “This is a marriage of the information technologists cutting algorithms while letting deep medical pathobiological knowledge guide us.”

Here’s to the happy couple. ●

“WE SPENT \$300 MILLION TO SEQUENCE THE FIRST HUMAN GENOME; NOW WE CAN DO [AN INDIVIDUAL’S SPECIFIC GENOME] FOR BETWEEN \$2,000 AND \$10,000.”

— SCOTT ZEGER,
VICE PROVOST FOR RESEARCH

Big Blue Baby

When an earthquake strikes, when a hurricane hits, what causes screws to separate from sheets of drywall? Steel beams to bend and buckle a fraction of an inch? And just how many small jolts and jostles, torques and twists, does it take before a ceiling caves in or a parking garage collapses? Ben Schafer's "Big Blue Baby," the prized progeny of his Thin-walled Structures Lab in Latrobe Hall's basement, is providing the answers.

— By Abby Lattes

What it is:

The Big Blue Baby (BBB) is a one-of-a-kind, multi-axis structural testing rig.

What it does:

It allows researchers to test the strength and stability of building materials, including their resistance to tremendous vertical and horizontal force, as well as shaking and twisting. Designed and constructed at Hopkins, it's one of only three apparatus in the United States that can combine all of these different forces in one piece of equipment.

Why it's important:

Grad student Kara Peterman explains, "People are always trying to push the limits of materials." Whether it's skyscrapers or the steel racks lining Home Depot's aisles, "we want everything to be thinner, lighter, and stronger."

The conditions the BBB simulate enable Hopkins researchers to write the formulas that determine just how far these materials can be pushed. Their findings help define the optimal design and composition of cold-formed-steel columns, beams, fasteners, and sheathing, and the building codes that will make structures better able to withstand hurricanes, earthquakes, gravity loads, and any other stresses that may come their way.

Schafer is currently using the BBB to study how seismic forces affect cold-formed-steel buildings, up to nine stories high, as part of a three-year \$925,000 National Science Foundation grant he received in 2010.

Stats:

Dimensions: 8' wide x 12' long x 10' high

Conceptual Design: Ben Schafer, the Swirnow Family Faculty Scholar and Professor and Chair of Civil Engineering

Structural Design and Rendering: Rachel Sangree, Associate Research Engineer

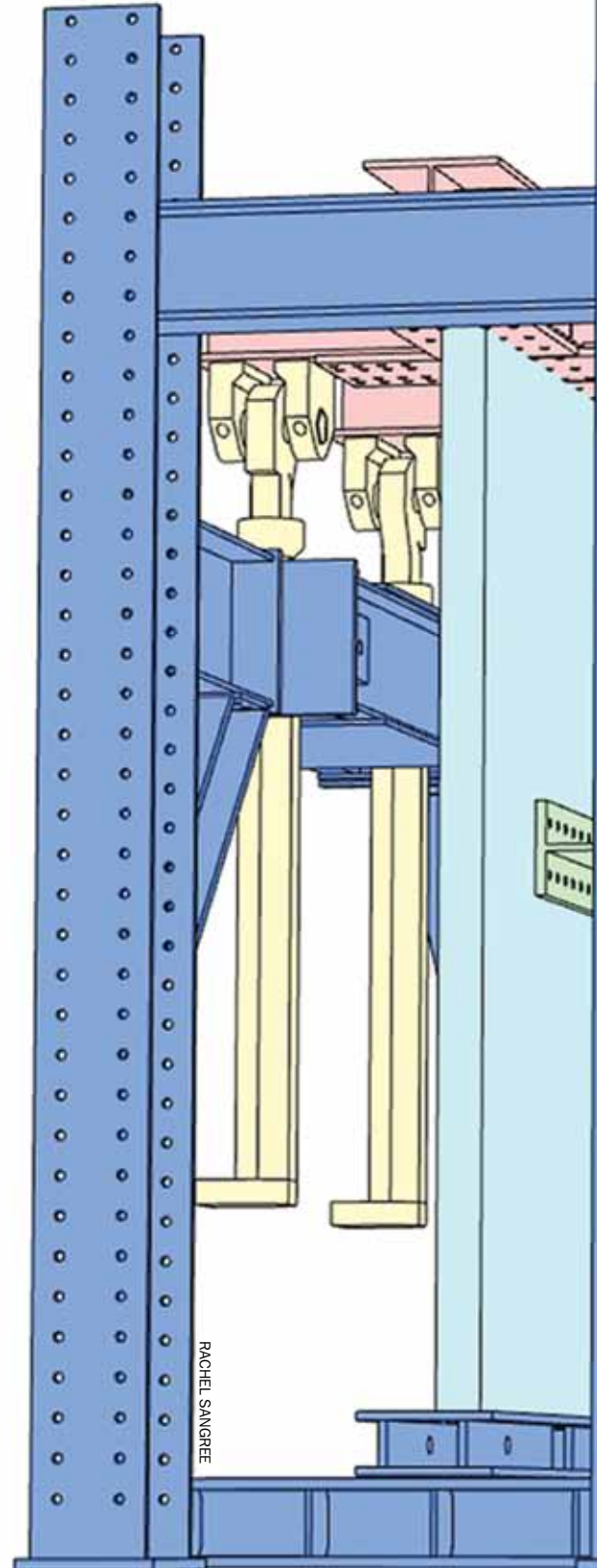
Construction: Nickolay Logvinovsky, Senior Instrument Designer

CAD Model: Microstation provided by: Bentley Systems and Buddy Cleveland '72

External Funding: National Science Foundation, American Iron and Steel Institute



Ben Schafer (center), with grad students Luiz Vieira and Kara Peterman, uses the Big Blue Baby to study how seismic forces affect mid-rise cold-formed-steel buildings.



How it works:

1. Specimen: The wall of a building made of cold-formed steel with sheets of plywood or drywall screwed to it, approximating 1/5 of an actual wall, is placed in the middle of the BBB.

Position transducers are placed on the exterior and interior of the specimen, flush with the sheathing material and the stud. These transducers are used to measure the distance the stud moves when pressure is applied from multiple directions and along with load cells convert these forces and displacements to measurable electrical output: voltage.

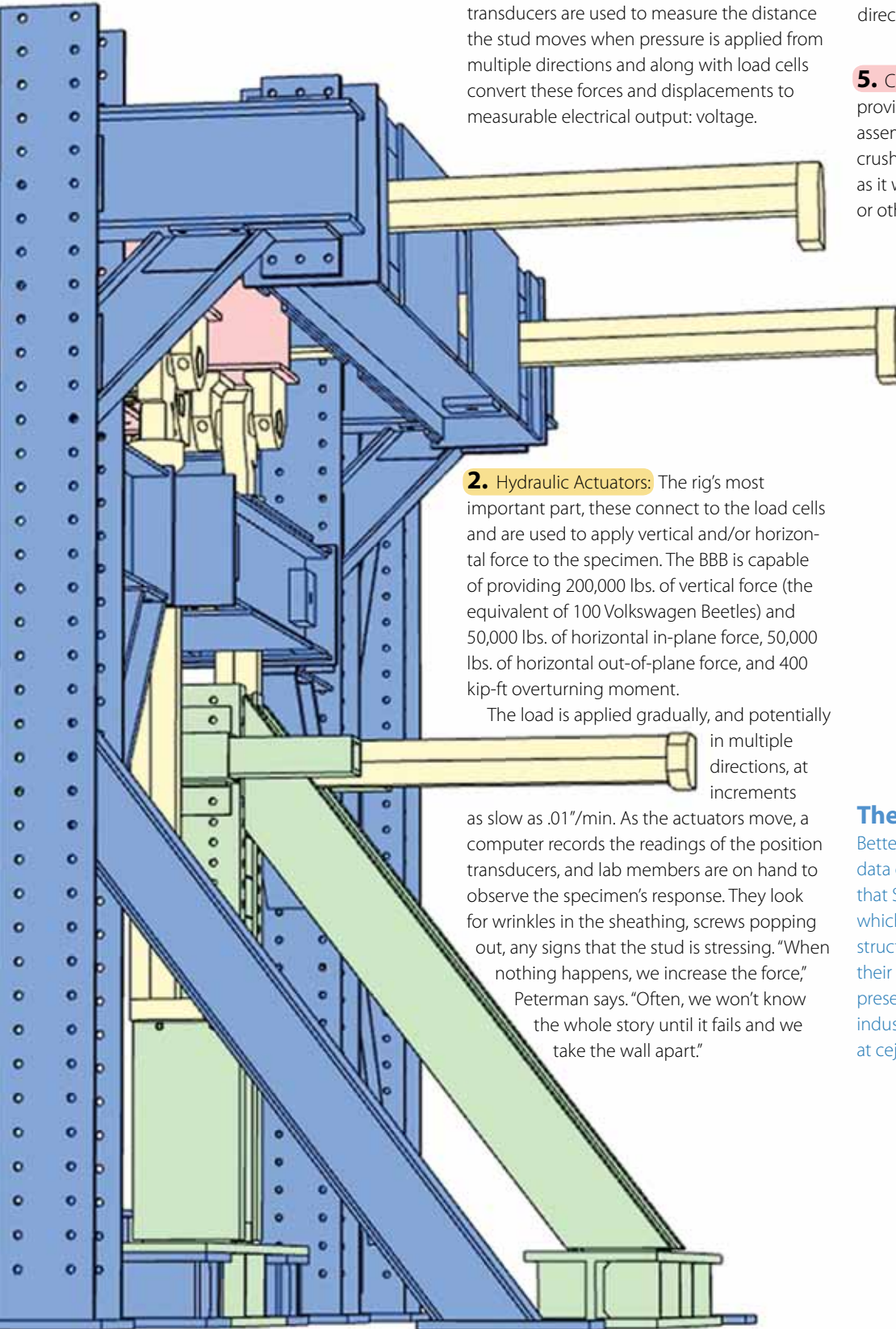
2. Hydraulic Actuators: The rig's most important part, these connect to the load cells and are used to apply vertical and/or horizontal force to the specimen. The BBB is capable of providing 200,000 lbs. of vertical force (the equivalent of 100 Volkswagen Beetles) and 50,000 lbs. of horizontal in-plane force, 50,000 lbs. of horizontal out-of-plane force, and 400 kip-ft overturning moment.

The load is applied gradually, and potentially in multiple directions, at increments as slow as .01"/min. As the actuators move, a computer records the readings of the position transducers, and lab members are on hand to observe the specimen's response. They look for wrinkles in the sheathing, screws popping out, any signs that the stud is stressing. "When nothing happens, we increase the force," Peterman says. "Often, we won't know the whole story until it fails and we take the wall apart."

3. Reaction Frame: Bringing all the forces developed from the actuators back to the ground, and accommodating the multi-axis twists and turns, requires a unique reaction frame.

4. Lateral Reaction Frame: A simpler version of the big reaction frame is used to apply load directly from the side.

5. Controllable Loading Platen: The actuators provide multi-axis movement of this large assemblage of steel so the specimen can be crushed, twisted, bent, or generally abused as it would be during a hurricane, earthquake, or other calamity.



The result:

Better design is the BBB's final byproduct. The data collected by the BBB are used in formulas that Schafer and his students write, most of which are utilized in the design specifications structural engineers use every day; of course their findings are also published in journals, presented at conferences, and provided to industry and the public, online, free of charge at cejhu.edu/bschafer.



LIFESAVING



Jhpiego fellow Sean Monagle, here with a baby, traveled to Nepal to test a promising protein pen that screens for dangerous health conditions in pregnant women.

For biomedical engineering students working in the world's poorest regions, necessity is the mother of invention.

By Mary Beth Regan

When Creighton Petty, a student in biomedical engineering at the Whiting School of Engineering, visited Ethiopia last summer as part of his yearlong master's program, he thought he had prepared himself mentally for the challenges facing the country's health care workers.

He had traveled extensively through Guatemala and Peru as an undergraduate, and he had seen the constraints of poverty. Still, the lack of resources in the African country startled him—rolling electricity blackouts in hospitals, overcrowded waiting rooms packed with patients, shortages of essential medical supplies.

At a top health outpost, for example, health care workers struggled to provide even the most basic care under dire conditions. “Most posts don't have water or power because they are made of trees and mud. This one had a water heater and a sink,” Petty wrote, in the team's daily blog. “But there was one problem: It wasn't connected to electric or water sources, so many of the features were unusable.”

In a nearby hospital, Ethiopian administrators were trying to make sense of 1,000 different pieces of donated medical equipment, manufactured by 300 companies, made in 22 countries—without any repair manuals. “When you explain to a hospital administrator

that you are an engineer,” says Petty, “they automatically think you can fix all this broken equipment. But in many of these countries, the problems are much, much larger.”

Petty and 15 other Hopkins master's students were in Ethiopia, Tanzania, India, and Nepal as part of their course work at the Johns Hopkins Center for Bioengineering Innovation & Design (CBID), an outgrowth of the Department of Biomedical Engineering's undergraduate medical device design program developed by faculty members Artin Shoukas and Bob Allen. The yearlong MSE program, which runs from June through May, includes an eight-week rotation with doctors at Johns Hopkins Hospital (see page 25) as well as a summer trip abroad to understand the health care needs of developing countries.

Now back stateside, the students are working in teams throughout the year to invent a handful of medical devices for markets in both the developed world and in developing nations.

Today, U.S. companies dominate the

\$350 billion global medical device industry, but that trend is shifting to emerging markets. Medical innovators are turning to value-driven engineering, or frugal engineering, to help meet the staggering burden of care for the world's poorest—and often sickest—people.

In May 2011, CBID further strengthened its

Equipment graveyard: Broken medical equipment in Ethiopia.



CREIGHTON PETTY/ETHIOPIA (RIGHT)
GEETA SHARMA/NEPAL

SOLUTIONS



“You cannot be a true leader unless you innovate for the world. That means getting out of your U.S. comfort zone.”

— SOUMYADIPTA ACHARYA,
DIRECTOR, CBID'S GRADUATE PROGRAM

global health initiative by entering a new partnership with the Baltimore-based Jhpiego, a Hopkins affiliate, and the Norwegian nonprofit Laerdal Global Health. The alliance is aimed at tackling health problems facing mothers and newborns in the first hours of life (see Promising Partnership box).

“You cannot be a true leader unless you innovate for the world,” says CBID’s graduate program director, Soumyadipta Acharya. “That means getting out of your U.S. comfort zone and thinking about the very large unmet clinical and public health needs that result in millions of deaths each year.”

When Petty and fellow students fanned out across Tanzania, Ethiopia, India, and Nepal, they were jolted into an immediate understanding of the differing needs in developing countries. “You couldn’t help but be shocked,” says Lauren Smith, who traveled to Ethiopia.

In Tanzania, for example, the largest health care facility in Dar es Salaam was admitting

between 1,000 and 1,200 patients daily. Its two OB-GYN surgical units handled as many as 20 to 28 surgeries each day.

“We were surprised to learn that there are between 70 and 100 births per day at this facility,” wrote Luke Jungles, in his team blog from Tanzania. “One nurse helped to deliver more than 600 babies in three months. We also found out that sometimes up to three pregnant women have to share a single bed.”

But beds were not the only resource in short supply. The students noted a lack of reliable electricity, inadequate methods to clean or sterilize equipment, enormous piles of broken devices, a lack of basic diagnostic care, inadequate waste disposal methods, and widespread shortages of basic medicine. In rural areas, students homed in on the need for simple, easy-to-use diagnostic kits for everything from anemia to cervical cancer to infant jaundice. With doctors in short supply, many countries are “task shifting,” or moving the responsibility for general health care to nurses, midwives, clinical officers—even volunteers. The

Luccie Wo, left, shows health care workers the E-Partogram, which provides early warning signs of danger during labor.

(Left) "I was struck by the bareness, but also the beauty," says Geoff Russell, who photographed this delivery room in a tribal region of Jharkhand, India.

engineering challenge is to design tests that are easy to use but provide enough valuable information to enable users to decide whether patients need a higher level of care.

In many countries, for example, women do not give birth in hospitals. A key problem is determining whether an expectant mother is experiencing serious complications, such as obstructed labor, which can be fatal. Jhpiego estimates that 380,000 women die from pregnancy complications and childbirth each year; 4 million newborns die in their first month; and more than 95 percent of stillborn births occur in developing countries.

In India, students observed the need for treatment of postpartum hemorrhage especially. Says Harshad Sanghvi, Jhpiego's medical director: "Postpartum hemorrhage doesn't occur often. But when it does, it kills." Marton Varady, in his team's India blog, wrote: "Often the hemorrhage starts at a peripheral hospital, where doctors are unable to control it. At that point, the mother only has about two hours or so before the hemorrhaging has to be stopped; this leads to as many as half the mothers dying in transit."

In Ethiopia, Smith and fellow student Luccie Wo met a 23-year-old woman in the



PHOTO: LAUREN SMITH/ETHIOPIA

town of Arba Minch who was emblematic of another challenge facing African women.

At 22, this patient had labored for four days with her first baby—a classic case of obstructed labor. Finally her family provided the necessary money to travel, likely by donkey cart and bus, to a regional hospital.

By that time, the patient's baby had died in utero. The young woman had sustained so much internal damage from the obstructed labor that fistulas, or tears, had occurred internally, rendering her unable to control her bowels. She returned to her family but was unable

to heal completely. By that time, her husband had abandoned her, and her community ostracized her.

"But the saddest part of the story," says Wo, "is that it's not uncommon."

Three CBID master's students from the Class of '11—Sean Monagle, Shoval Dekel, and Peter Li—and one BME graduate, Sunny Chen, now on one-year fellowships with Jhpiego, traveled with the 2012 class to Nepal and Tanzania to field-test products they worked

A PROMISING PARTNERSHIP

Last May, at the Biomedical Engineering Design Day at Johns Hopkins School of Medicine, an international trio announced a \$1.4 million partnership. The "Day of Birth Alliance" is aimed at developing medical innovation to protect the health of pregnant women and newborns during the babies' crucial first few hours of life. The alliance strengthens CBID's Global Health Program by providing funds for student travel, project costs, and fellowships.

Here's a quick glimpse at the three partnering organizations and those who will be leading the charge:

- **Jhpiego:** With its network of 76 programs in 51 countries funded by 38 donors, Jhpiego provides a deep-rooted understanding of global health needs combined with 40 years of implementing innovative solutions in the most



PHOTO: LUCCIE WO/ETHIOPIA

DAY OF BIRTH ALLIANCE: Over 2 million babies and 350,000 mothers die each year on the day of birth.

challenging parts of the world.

Harshad Sanghvi, vice president of innovations and medical director of Jhpiego, is a world expert in health care for women and their families. His office oversees the technical development of innovative medical solutions for low-resource settings. He is a professor at the Johns Hopkins Bloomberg School of Public Health.

- **Johns Hopkins CBID:** The program gives students the structure and support to focus on developing innovative medical devices.

Youseph Yazdi, executive director of the CBID program, serves on the faculty of the Department of Biomedical Engineering as well as the Johns Hopkins Carey Business School. He also oversees the Coulter Translational Research Partnership.

- **Laerdal Global Health:** This partner provides expertise and assistance with manufacturing and distribution of innovations.

Tore Laerdal is chairman of Laerdal Medical, a leading health care training material company in Norway. Laerdal's nonprofit unit, Laerdal Global Health, has pledged to develop innovative medical products to help reduce global infant mortality by 2015.



PHOTO: SUNNY CHEN/TANZANIA

In Tanzania, an infant at a crowded health care facility is weighed using an age-old method.

on last year. Their simple, cost-effective devices have attracted interest from nonprofit groups, foundations, and corporations for having the potential to save lives.

Monagle is spearheading the partnership's efforts to market a low-cost antenatal kit to screen women for complications that develop during pregnancy. He began working on the project with a team of biomedical engineering undergrads. The idea has taken off in the last year, landing him on *CNN Newsroom* and in *Time* magazine, and garnering a \$100,000 grant for the project from the United States Agency for International Development (USAID).

Simply, his team innovated on the idea of a urine dipstick to test for dangerous maternal health conditions such as preeclampsia and diabetes. They created a set of pens, like Magic Markers, that can be used on special paper and contain reagents to test for elevated protein levels in urine.

In August, Monagle field-tested the device in two rural health facilities in Nepal with Jhpiego. Local nurses prepared the test by marking filter paper strips with the reagent pen. The team interviewed 600 consenting women who had used the strips to test their own urine for high protein levels. "From the initial reactions, they loved it," Monagle says.

Project sponsor Jhpiego hopes to keep production costs to as little as a half-cent per test, compared to as much as 50 cents for standard dipstick tests. "Our ultimate goal has always been to get these to community health workers, who can take them house to house to women who aren't receiving any prenatal care," Monagle says.

In Tanzania, Dekel and Li were testing the E-Partogram, which they hope will provide the early warning signs of possible complications during labor. Traditionally, health care workers use a paper partogram to chart labor by plotting variables such as heart rate, cervix dilation, and contractions. Widely used in developing nations after being backed by the World Health Organization, the partogram requires more than a basic level of medical knowledge.

"I read graphs all the time, and it's complicated for me," says Dekel. Imagine being a

semi-skilled provider doing this in the middle of an isolated rural area while monitoring a difficult labor, she says.

Dekel is working with Jhpiego's medical director, Sanghvi, an international expert on obstetrics and gynecology, to develop an easy-to-use electronic partogram.

She envisions a handheld device that receives data about maternal heart rate and fetal well-being. The device then charts the progression of labor. If a woman shows signs of complications, the device signals alerts. If complications occur, it signals an alarm to seek a higher level of care.

The challenge is keeping the E-Partogram affordable. Right now Jhpiego is trying to develop a prototype for a target cost of \$50.

In July, Jhpiego was awarded a \$250,000 "Saving Lives at Birth" grant, sponsored by USAID, the Bill & Melinda Gates Foundation, the World Bank, and others, which enables Dekel and Li to refine the design and continue field-testing.



PHOTO: SUNNY CHEN/TANZANIA

Luke Jungles, far right, demonstrates the easy-to-use protein pen that tests for elevated protein levels in the urine of pregnant women.

MAKING THE ROUNDS

It's shortly after 2 p.m. on a summer day, and Hopkins spine surgeon Jay Khanna, associate professor of orthopaedic surgery and biomedical engineering, is completing his third delicate spine surgery of the day. At his side is John-William Sidhom, a master's student in the Johns Hopkins Center for Bioengineering Innovation & Design (CBID) program, who has been observing Khanna's every move.

Sidhom studied biomedical engineering as an undergraduate at University of Michigan and already has one U.S. patent on an orthopedic technology under his belt. Today he stands on a step stool watching as Khanna deftly removes a severely herniated disk from the neck of a 47-year-old woman. Then, using a drill, Khanna flattens the endplates of the vertebral bodies, above and below the disk space, to make room for placement of a bone graft.

For a student intent on attending medical school, Sidhom is exhilarated by this opportunity to work alongside top Hopkins physicians as part of his yearlong master's program in medical innovation. But at Good Samaritan Hospital in Baltimore County, he isn't in the operating room to learn the finer points of surgery. He is looking at the entire surgical process—at the tools, the monitors, the materials—as an engineer. In operating rooms across Johns Hopkins Hospital and other facilities, his 15 CBID classmates are undertaking similar investi-

gations. Their goal: to engineer new tools and methods that will improve the way health care is delivered.

"I can give most clinicians a problem, and they think about it in the same way every time. In a sense, our ability to innovate is constrained by our medical education," says Khanna, who has served for three years as CBID's clinical director.

"But our young engineers are incredibly intelligent, nimble, and solution-oriented. They think outside the box, and they just come at things in a different way," he says.

This eight-week stint spent inside Johns Hopkins Hospital is one key to the success of the CBID program, which already has hit a few home runs. From student projects, for example, has grown Cortical Concepts' specialized pedicle screw that allows surgeons to operate more easily on patients with osteoporosis, as well as BOSS Medical's novel method to retrieve bone for grafting.

Over the next nine months, Sidhom and his master's classmates will draw on what they've learned here at the hospital as they work in design teams to create innovations for the high-tech medical device market in the U.S., as well as global health projects for developing countries.

As Sidhom takes a break from observing everything from joint replacements to spine surgery, he says: "Our professors have asked us to remain open-minded. So I'm taking a broad view, to see if we can come up with an innovative way to improve an area of medicine."

—MBR



Jhpiego fellow Shoval Dekel, right, shows a health care worker the E-Partogram, a product she helped develop as a CBID student.

Back in Baltimore, the Class of 2012 CBID students spent much of the fall sifting through ideas from their trip abroad as well as their summer rounds at Hopkins Hospital. They will devote this year to working on proprietary prototypes that they hope will be well received by the marketplace and nongovernmental agencies.

Since the launch of the biomedical design program at Hopkins nearly a decade ago, undergrads and master's-level students have participated in roughly 50 medical device projects for external clients, filed for more than 25 provisional patents, and applied for 12 full patents.

Students alone have gone on to form six startup companies, and the 2011 class earned over \$160,000 in prize money and in-kind donations to aid startup ventures. That came on the heels of a CBID group winning the 2010 Wharton Business Plan Competition, which earned them \$20,000 and an invitation to ring the NASDAQ Closing Bell. In addition, CBID's global health projects have attracted nonprofit money from organizations such as USAID.

CBID Executive Director Youseph Yazdi has the job of overseeing the program, which runs at a dizzying pace. He teaches and mentors students. And he spends time raising money to expand the program and get



CBID students Lauren Smith, left, and Divya Maxwell, right, make the rounds with cardiothoracic surgeon Ashish Shah at Johns Hopkins Hospital. Students spend eight weeks with doctors at the hospital and other facilities.



“We’re spending 17 percent of our GDP on health care in this country. ... That’s a huge number. We don’t need to spend more money. We need innovation that is more efficient, performs better, and costs less money.”

— ELLIOT MCVEIGH,
MASSEY PROFESSOR AND DIRECTOR,
DEPARTMENT OF BIOMEDICAL
ENGINEERING

innovations such as the antenatal testing kit and E-Partogram off the ground.

Yazdi joined Hopkins from Johnson & Johnson (J&J), where he was the corporate director in the Office of Science & Technology. He was drawn to CBID, he says, because Hopkins has “all the essential ingredients to be a world leader in medical innovation.”

He wasted no time. So far, he has raised \$350,000 from J&J; Becton, Dickinson & Co.; GlaxoSmithKline; and others for a Technology Accelerator Fund that provides funding for CBID projects before and after students graduate.

In addition, Elliot McVeigh, chairman of the Department of Biomedical Engineering, recently tapped Yazdi to oversee a new Coulter Foundation Translational Partnership Program that will provide Hopkins biomedical researchers and students with \$5 million in bridge financing over five years. Approximately six projects a year will be funded, with grants ranging from \$25,000 to \$120,000. The money, awarded in May, will be aimed at translational research.

CBID student Adam Clark, left, gives small gifts to a child outside a dispensary in rural Tanzania.

What’s more, CBID will continue to partner with groups like Jhpiego. In the last several months, for example, CBID has teamed up with Jhpiego on partnerships with both USAID and GE Foundation. McVeigh, from his Clark Hall office, says this investment in value-driven engineering products—simple, safe, and cost-effective—will pay off abroad and at home.

“Look,” says McVeigh, “we’re spending 17 percent of our GDP on health care in this country. ... That’s a huge number. We don’t need to spend more money. We need innovation that is more efficient, performs better, and costs less money. That’s where the winners will be over the next half century.

“We are building a program that will improve health care delivery not just in developed countries, but it will benefit developing countries, too. ●



FURTHER AFIELD: The first cohort of Raytheon employees received their master's degrees at a ceremony at Arizona's Pima Air and Space Museum.

Currents

Whiting School News

All Systems Go at Raytheon

In early June, at the stunning Pima Air and Space Museum in Tucson, Arizona, 22 engineers from Raytheon Missile Systems put their own careers on a flight path to success as the first graduating class of an innovative program with the Whiting School.

The employees earned master's degrees in systems engineering from the Whiting School but attended classes at their Tucson location. Currently, there are 200 Raytheon employees enrolled in the program.

The graduation marked a milestone for the JHU-Raytheon partnership, launched in 2009. The program is novel because it allows Engineering for Professionals (EP) faculty to design a graduate-level curriculum tailored to serve the needs of the defense contractor.

The approach provides academic rigor, while giving faculty the flexibility to integrate real-world Raytheon projects as case studies. The first five core courses of the master's curriculum are standard across the company; the remaining five courses are chosen specifically to meet the unique systems engineering education needs of each Raytheon business unit.

"Systems engineering is a mindset. It provides a different way of thinking about your job," said Raytheon's RMS chief engineer Ronald D. Carsten, at a celebratory dinner for the graduates.

The classes, conducted after work hours, incorporate video conferencing, Web tools, and face-to-face classroom sessions. They also leverage the expertise of the Hopkins Applied Physics Laboratory—a leading center for engineering research and development for the federal government—and are team taught by practicing Hopkins systems engineering instructors and Raytheon subject matter experts.

"The partnership provides a common organizational framework," says Dexter Smith, associate dean for EP. "But some courses are specific to the mission of each business unit."

Raytheon Co., headquartered in Marlborough, Massachusetts, employs 72,000 people worldwide and works across sectors including integrated defense, intelligence, missile systems, and space. Raytheon Missile Systems, one of six Raytheon business units, employs 12,500 people and reports sales of \$5.7 billion.

Systems engineering is critical to Raytheon's business because it focuses on how complex projects should be designed and managed over their life cycles.

"This program is a great way to address our need for systems engineering," says Mark E. Russell, Raytheon's vice president for engineering, technology, and mission assurance.

The partnership program currently includes cohorts from three Raytheon business units—Space and Airborne Systems, Technical Services, and Missile Systems—and reaches across three states: Arizona, California, and Indiana. In 2012, a cohort from Texas that will include the Network Centric Systems business unit will be added.

The JHU Systems Engineering Master's Program is offered in traditional classroom settings throughout Maryland as well as fully online for distance students across the country. Coupled with offerings to other partner companies, the program has nearly 900 active students, the largest in the nation in systems engineering.

—With reporting by Juliana Wood

Expert Opinion

Q. What can Johns Hopkins do to STEM the crisis in K-12 preparation in science, technology, engineering, and math?

By David W. Andrews
Dean of the Johns Hopkins
University School of Education

Last year, a front-page story in the *New York Times* described how U.S. educators were “stunned” that high school

or 25th in most categories. This should be a massive wake-up call,” and in a State of the Union address, President Obama made an urgent plea to ensure that “all children have the basic science, technology, engineering, and math (STEM) literacy necessary to be full participants in our economy and our democracy.”

What can we do at Johns Hopkins?

First, we shouldn’t respond to this national crisis by simply generating a host of engaging programs that magically get kids interested in science, technology, engineer-

ing, and mathematics. While this may be a start, we need to strategically consider and test programs that have high impact; take advantage of an extraordinary opportunity to tap the resources and expertise of the greater Johns Hopkins community and work together across disciplines to create highly qualified STEM educators and graduates; and position STEM as a critical pipeline issue.

Students who fall behind in math and cannot read have a very difficult time seeing themselves as a scientist or engineer. No matter how exciting we make the jobs look, there is a disconnect between their skills and knowledge and what it will take to work in these professions.



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students in Shanghai, China, far outscored their counterparts in other developed countries in literacy, math, and science. The results showed that the United States was slipping in all categories and raised questions about our country’s ability to be competitive in the global marketplace.

A number of leading voices in education and politics understand the urgency for a call to action. U.S. Secretary of Education Arne Duncan said, “The brutal fact is that many countries that are far ahead of us are improving more rapidly than we are. We rank 24th

or 25th in most categories. This should be a massive wake-up call,” and in a State of the Union address, President Obama made an urgent plea to ensure that “all children have the basic science, technology, engineering, and math (STEM) literacy necessary to be full participants in our economy and our democracy.”

What can we do at Johns Hopkins?

First, we shouldn’t respond to this national crisis by simply generating a host of engaging programs that magically get kids interested in science, technology, engineer-

ing, and mathematics. While this may be a start, we need to strategically consider and test programs that have high impact; take advantage of an extraordinary opportunity to tap the resources and expertise of the greater Johns Hopkins community and work together across disciplines to create highly qualified STEM educators and graduates; and position STEM as a critical pipeline issue.

Students who fall behind in math and cannot read have a very difficult time seeing themselves as a scientist or engineer. No matter how exciting we make the jobs look, there is a disconnect between their skills and knowledge and what it will take to work in these professions. This mismatch does not go unrecognized by the students themselves. If we focus only on those students who have clearly demonstrated the academic acumen to compete in these disci-

Finger Lickin' Good, Across the Globe

Back during their Homewood days, David Gibbs '85 and his roommates would make a late-night run to the KFC on St. Paul Street once a week or so for their so-called "second dinners," usually a two- or three-piece combo meal, depending on how much money they had in their pockets.

Their fried chicken runs foreshadowed an unexpected career. Today Gibbs is chief financial officer for Yum Restaurants International, responsible for the strategy and direction of KFC, Taco Bell, and Pizza Hut outside the United States and China—more than 14,500 restaurants in 120 countries.

As a mathematical sciences student in the Whiting School, Gibbs lived with teammates from the tennis and basketball teams and talked about a career on the tennis court or at a blackjack table. For his senior thesis, "Card Counting in the Eight-Deck Blackjack Game," he developed a computer simulation and tested his theories and approach with Delta Upsilon fraternity brothers in Atlantic City. But while he was having fun, he was working hard, too.

"I went on to business school at Duke and started a PhD at Stanford. But the hardest thing I've done is get an engineering degree at Johns Hopkins," says



COLONEL SANDERS' LONG MARCH: At a Kentucky Fried Chicken in Shaanxi Province, China, customers can also order congee (Chinese-style rice porridge) and a Beijing Chicken Roll, along with a bucket of Original Recipe.



Gibbs, who now lives in Dallas with his wife and children. "I remember that first physics exam freshman year was a great awakening. I realized the only way you could get through Hopkins Engineering was to put in the time."

A summer internship at IBM helped him realize he didn't want to take the traditional path of an engineer, and after graduation he accepted a job at an investment bank. He decided that to succeed on Wall Street he would need an MBA and left after a year for Duke's Fuqua School of Business, where he was recruited in 1989 by

PepsiCo to scope sites for new Taco Bell restaurants in the mid-Atlantic. Through mergers and acquisitions he rose up the ranks, most recently serving as Pizza Hut's CFO for four years. He was named to the position in the international group this year.

Yum is the world's biggest restaurant group, if you look at the numbers the right way, and Gibbs said his group is now focused on growth in five key areas: Russia, Africa, Germany, India, and France. (Of note: KFC restaurants in France outperform all other country cohorts in sales and profit margins.) This summer KFC entered Kenya and Ghana, becoming the first Western brand to open in East Africa, and Gibbs visited Nigeria in August to begin expansion there.

Yum is also a leader in corporate social responsibility, with a company-wide advocacy campaign that has raised close to \$85 million for global hunger relief since 2007. With offices quite literally around the world, Gibbs spends about a third of his time traveling and says it's not unusual for him

to start the day with a conference call on the way into his Dallas office or to end with another call late into the night to accommodate the 24/7 nature of global time zones.

The restaurants under Gibbs' purview are more than a world away from the Charles Village KFC he frequented in college, and he says that consumers familiar with Yum Brands state-side might not recognize it abroad. For example, in Brazil, where it's uncommon to eat with the hands, fried chicken is served with a knife and fork; and in India, where many people are vegetarians, the Taco Bell menu has abundant meatless options. In Asia, seafood is Pizza Hut's No. 1 topping, and egg tarts are a popular KFC dessert item.

Beyond customizing products for local tastes and customs, the group also has to manage a global array of labor laws and business practices—such as closing multiple times a day for prayer in the Middle East. —Nora George

Alumni
Making
News

A Dream Realized

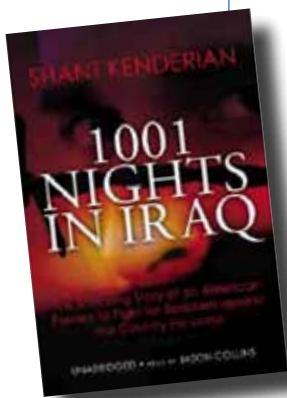


A LONG ROAD TO HIS PHD:
Kenderian, with his proud family.

“It’s a strange story,” starts Shant Kenderian, MS, PhD ’02, over the phone from his lab in Southern California. “So how much do you want to know?”

During the summer before his senior years of high school in 1980—he’d just taken the SAT exam so he could apply to engineering schools that fall—Kenderian returned to his native Baghdad to see his estranged father.

When the Iraq-Iran war broke out, despite status as a permanent U.S. resident, his Iraqi citizenship prevailed and he was not permitted to leave. After earning an undergraduate degree in engineering, he was forced into military service. He hatched a plan to be captured by the Americans, expecting to be liberated in their hands. Instead they suspected he was a Saddamite spy and held him as a prisoner of war. The details are



wrenching and powerful, and best told in his memoir about the experience, *1001 Nights in Iraq* (Simon & Schuster, 2007).

Yet his post-POW story is almost as compelling. Back in the United States, Kenderian resumed his plans, earning a master’s degree from Cal State before heading east to the Whiting School for his PhD. Today he lives with his wife and their three children in Pasadena, California.

Q. *When you left to visit Iraq, a tremendous set of obstacles interrupted your plan to return to the U.S., yet you never lost sight of that dream. How?*

A. When the Americans picked me up, I had a book on nuclear physics and quantum theory. That scared them and they took it away. But I’d known since I was 12 that I would get a PhD in engineering. I had clarity and knew what I had to do. When I was released, I just thought: *What do I have to do next?* I came back to the United States with only my uniform; no papers to show I had my engineering degree. So I took the Engineer in Training Exam, passed, and Cal State gave me a chance.

How did you end up at Johns Hopkins?

I had four cousins there. At the time I was working on the international space station project, and my cousin told me Johns Hopkins had a good materials science program. One thing led to another, and I got to Hopkins. And then I finished my PhD requirements in three and a half years [with a dissertation titled “Advanced Ultrasonic Techniques to Determine the Structural Integrity of Rail Steel”].

Since 2005, you have been with The Aerospace Corporation, doing work in support of the U.S. military. Is that ironic?

There’s irony in my whole life. I was a POW held in isolation by the Americans, and now I work with a company doing nondestructive testing on rockets and satellites for the Air Force before they fly. If there’s a problem with a structure, we go ahead and solve it. That all just adds to the irony. Another twist: One of my former interrogators wrote a glowing letter of recommendation for me to get this job. People use “the American dream” as a cliché, but there’s great truth and depth to it.

The Marines held you in isolation. At one point, you had neither a toothbrush nor a change of clothes for almost three weeks. How did you get through that?

I asked for my books, instead they gave me a Bible. I started reading it from sunrise to sunset, just to keep my mind busy. I didn’t want my mind to stray out of control. That didn’t keep me focused, just busy. I convinced myself my situation was normal.

How has the experience shaped you?

I think things don’t bother me very easily. If there is an obstacle, I don’t get daunted easily. I don’t get overwhelmed. I had a plan and I stuck to it. A lot of people have plans; short-term plans work well, but with long-term plans things begin to slip. The POW experience was tough, but it taught me to be more resilient and patient. I think that helped me through my education, and helps me now as an engineer.

—Interview by Nora George

Engineering a Future for Others

HARRIS BELMAN was a bright and earnest teenager from Baltimore with his heart set on studying electrical engineering at Johns Hopkins University, but his parents could not afford tuition. A scholarship made his dream become a reality, and he studied hard, graduating in May 1964. A few days after commencement he wed his high school sweetheart, Elaine. Belman went on to a robust and respected career in systems integration, spanning three decades with IBM and a recall from retirement in 2002 to head up a major global defense company's homeland security systems. Together Harris and Elaine raised two boys with serious learning disabilities, and traveled the world, maintaining close relationships with childhood friends and enjoying each day together.

In 2003, Harris was diagnosed with multiple myeloma, a bone marrow cancer that normally strikes later in life. He bravely battled the disease for three years before he died in 2006, at age 61. Before his death, he wrote the eulogy that would be delivered to the hundreds of family and friends who gathered for his funeral, leaving them with these thoughts:

"My life has been very full. I have done things and visited places that others can only dream about. My career had many



great accomplishments delivering complex systems to my customers and included the careers and lives of my coworkers. Continue to remember me with a smile on my face."

To Elaine, Harris also left a life and a legacy to celebrate. After she ensured her sons would be provided for, she turned to the Whiting School to establish a scholarship that would support an aspiring young engineering student—someone not unlike Harris Belman in 1959. This is so important to her, in fact, that she, her family, and friends continue to honor his legacy by commemorating special occasions with contributions to the



Elaine Belman and William Borch '10, a recipient of the Harris J. and Elaine Belman Scholarship.

scholarship. To date, the Harris J. and Elaine Belman Scholarship has already supported four students, each of whom Elaine has met over lunch at the Homewood campus.

Elaine also has generously created a bequest directing a gift from her estate to benefit scholarships at the Whiting School.

"When I talk with the scholarship students, I remember how Harris valued being able to attend such a prestigious college," says Elaine. "Knowing we gave a similar opportunity to someone else, someone who has the potential to make the world better—Harris would be beaming."

To learn more about making a bequest or other planned gift to benefit the Whiting School, please contact Andra Lee in the Whiting School Office of Development and Alumni Relations, 410-516-8723 or engineering@jhu.edu.



MIKE OJESINSKI

DESIGN DAYS: Walter Krug (left) and Mike Franckowiak, shown here in 1994, spent decades working together in the Maryland Hall Machine Shop. Krug retired recently after 37 years at Johns Hopkins.

End of an Era

Julian Iordachita says that most conversations with Walt Krug, the Maryland Hall Machine Shop legend, started out with a simple question. “What do you think of this design?”

Krug, an adherent of the “can-do” philosophy, always had the same reply: “Let’s try to make it work.”

Krug, who retired in August after 37 years as the shop’s senior instrument designer, will be sorely missed by students and faculty across Johns Hopkins, says Iordachita.

“Walt is a true professional. When I went down to the shop, I always knew what I needed, and Walt would give me feedback on what is and what is not possible. Sometimes we were trying to build something and he would instantly realize a mistake in the design. He came up with a very good solution—every time,” says Iordachita, an assistant research professor in the Department of Mechanical Engineering.

Iordachita once gave Krug a design for a small, snakelike robot for surgical applications. The robot’s grasper mechanism, a pair

of jaws, had to be precisely hewed to the hundredth of a millimeter. Krug successfully manufactured the device’s claws and drive system and, not surprising to Iordachita, the robot performed perfectly.

“Indeed, it was a piece of art,” says Iordachita.

Krug, a famously humble man who eschews the spotlight and didn’t want to be interviewed for this story, joined Johns Hopkins in 1974 after stints with Martin Marietta, a shoe factory, and the AAI Corporation. Mostly self-taught, Krug read voraciously to keep up with the latest in design work.

Over the decades, he and his Hopkins partner in design, Mike Franckowiak, built, tweaked, and repaired devices and instruments for students and scientists at Homewood and across the Johns Hopkins enterprise, with additional work coming from other area colleges including Loyola and the University of Maryland. In the shop, located on the ground floor of Maryland Hall, they wrestled with the most complicated of engineering research ideas, prototypes, and inventions.

They fashioned parts for a submersible camera, a water tunnel, robotic arms that eliminate even

the slightest human hand tremors, and instruments of all kinds. A recent list of projects includes an MRI-compatible robotic system for prostate intervention and parts for an axial turbo-pump test facility.

Franckowiak recalls that some faculty would walk in simply with a sketch on a piece of paper or napkin. One professor cut out a design from his newspaper. Krug knew just what he wanted and created it. The duo has also been asked to fix or duplicate plumbing parts, sewer drains, lampposts, screws, or whatever piece of plastic, metal, or wood was needed.

“Walt and I would try to do anything,” says Franckowiak. “We got all kinds of crazy ideas but were game for all of them.”

Lynda Barker, the Machine Shop’s administrator, says that faculty sometimes came to Krug with a not yet fully formed thought. “They would say, ‘I want to do this, or the outcome to be that.’ Walt would pick it up from there,” she says.

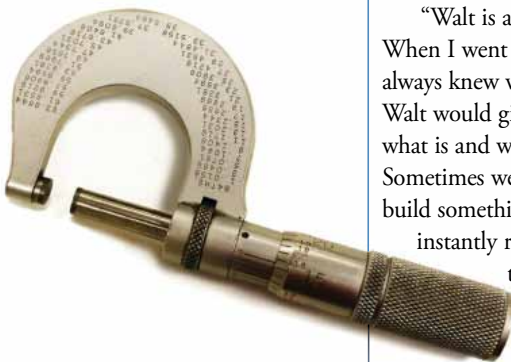
Franckowiak, who knew Krug for 40 years, has remained on at the shop, but already, he says, “I miss him terribly.”

“Walt is brilliant at what he does. We fought like cats and dogs sometimes but got on real well. His wife thought I was an angel for putting up with him for 40 hours every week these past four decades,” Franckowiak says with a laugh.

Says Iordachita: “I trust those guys. Their solutions were much more practical than what I proposed. I learned a lot from them.”

And so did generations of students and faculty.

— Greg Rienzi



Forever a Blue Jay, Forever an Engineer



Walter S. Brown is looking forward to his 86th season as a Blue Jays fan.

The eldest son of a third-generation builder who helped the city recover from the Great Baltimore Fire of 1904, Walter S. Brown, CE '28, has always demonstrated the practicality of an engineer. To wit: He decided to attend Johns Hopkins University because he lived with his family just four blocks north of the Homewood campus and could walk to school.

"It was the logical choice," says his son, Robert W. Brown (a mechanical engineer).

It was 1925 and Walter Brown had just graduated from the Baltimore Polytechnic Institute, the high school founded in 1883 to focus specifically on engineering studies. Given Poly's rigorous curriculum, graduates could go on to Johns Hopkins University and complete a bachelor's degree in just three years.

Back then, the Homewood campus was a tenth the size of what it is today, Walter Brown estimates, and men's lacrosse was

all the rage. Freshmen had to get a ticket to every lacrosse game or risk receiving a paddling from upperclassmen, he recalls. Undefeated in 1926 and 1927, the Blue Jays won national championships in each of Brown's three years on campus, even representing the United States in its 1928 Olympic lacrosse debut in Amsterdam. Brown remains a fan today.

Beyond lacrosse, Brown remembers spending most of his time in Latrobe Hall with the 18 other men in his civil engineering class, including his younger brother Winfield Brown, CE '28, now deceased. Ever the engineer, Walter Brown particularly remembers from his campus days Latrobe Hall's thick roof. "Whenever I think of a slate roof, I think of Hopkins' slate roof. That's what you call a 500-year roof."

Soon after graduating, Brown received a letter from the B&O Railroad looking for Johns Hopkins civil engineers to apply for jobs. He

went on to spend 37 years with the company, maintaining bridges and buildings and redesigning the double track in the Howard Street tunnel so the taller freight cars could run in the center, where there was higher clearance. When the company's corporate offices moved out of state in 1965, Brown joined the Maryland Public Service Com-

mission, where he was chief engineer until his retirement in 1974.

Brown, who now lives in a retirement home in Sykesville, Maryland, was married to the late Lydia Mary Burbank Brown for 61 years, and they had three children. At 106, he is looking forward to the 2012 lacrosse season and his 86th season as a Blue Jays fan.

— NG

Walter Scott Brown turned 106 on September 17 and looks forward to celebrating his 84th class reunion this spring. Is he the Whiting School's oldest living alumnus? If you are or you know of another venerable graduate who has hit the century mark, please let us know by contacting the Whiting School at engineering@jhu.edu or (410) 516-8723.

New Faculty

APPLIED MATHEMATICS

Daniel Robinson joins Applied Mathematics and Statistics as an assistant professor. Robinson completed a postdoctoral fellowship at Northwestern University, after receiving his PhD from the University of California, San Diego. His general research area is optimization, which lies at the interface of applied linear algebra, operations research, and applied mathematics.

CHEMBE

Zachary Gagnon joins Chemical and Biomolecular Engineering as an assistant professor, after serving

as a postdoc at the Johns Hopkins School of Medicine. He completed his PhD at the University of Notre Dame. His work focuses on how electric fields interact with fluid interfaces to induce precise injection and selective mass transport. The goal is to apply electro-fluidic phenomena to protein purification, cell migration, and rare cell isolation applications.

Rebecca Schulman joins Chemical and Biomolecular Engineering as an assistant professor from the University of California, Berkeley, where she was a Miller Fellow in physics. Her research centers on

new methods to build synthetic materials that model the structure and behavior of cells and tissue.

CIVIL ENGINEERING

Somnath Ghosh joins Civil Engineering as the Michael G. Callas Professor in Civil Engineering, with a secondary appointment in Mechanical Engineering. He arrived at Hopkins in April 2011 from Ohio State University, where he was the John B. Nordholt Professor in the Department of Mechanical Engineering. He works in the area of computational mechanics and materials, a rapidly growing discipline that develops and uses

computational methodologies to characterize, predict, and simulate physical events and engineering systems. His Computational Mechanics Research Laboratory is located in Latrobe Hall.

COMPUTER SCIENCE

Vladimir Braverman joins Computer Science as an assistant professor from the University of California, Los Angeles, where he received his PhD. His work focuses on algorithms for data streams, communication complexity, and related areas.

From the Archives

Biomedical Engineering at 50

Even as a teenager, Roger Hajjar '86 thought big, and those grand thoughts brought him to Johns Hopkins in the early 1980s.

Planning on a career in medicine, Hajjar chose Johns Hopkins' Biomedical Engineering program based on its stellar national reputation and perennial No. 1 ranking. While just a decade old at the time, the undergraduate BME program at Homewood was built upon 20 years of groundbreaking work by School of Medicine faculty—work that essentially gave birth to the field.

"I knew Johns Hopkins was a big player," says Hajjar, a heart failure specialist who is now research director of the Wiener Family Cardiovascular Research Laboratories at the Mount Sinai Medical Center in New York and the founder of several successful startup companies. "They offered a superior learning environment and the academic rigor I was after."

For decades now, the Biomedical Engineering Department has attracted the best and brightest, like Hajjar, from the United States and abroad.

The department traces its roots

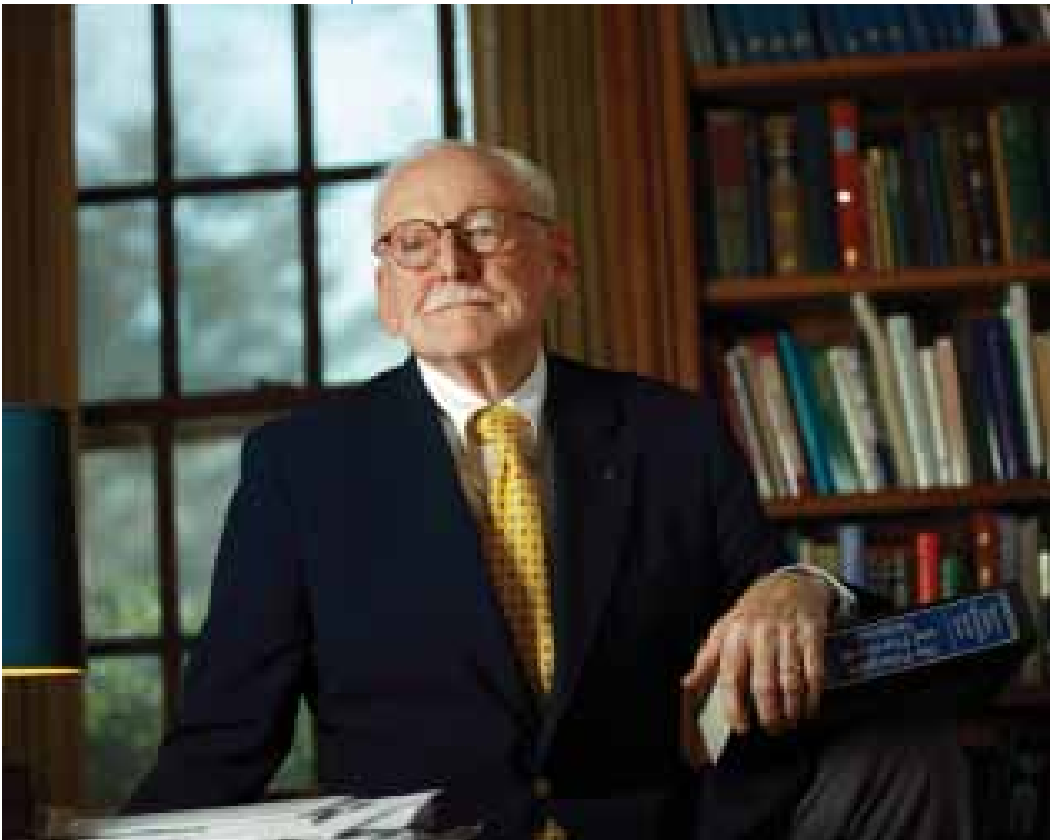
to the 1950s and Samuel Talbot.

Talbot, who earned his doctorate in physics from Harvard, joined the Johns Hopkins School of Medicine to continue his work in biophysics. In his lab, Talbot fabricated devices that could measure the electrical potential in muscle fibers and the human heart. He also advanced physiological optics, including the invention of the optic stimulator to observe retinal cells and neurons. His pioneering work would lead the Department of Medicine to create a biophysical division to produce more clinical tools.

In the 1950s, Johns Hopkins doctors and scientists developed the first cardiac defibrillator, based on the work of School of Engineering dean and electrical engineer William B. Kouwenhoven. Realizing the potential for even more advances, Talbot championed the creation of a biomedical engineering division, launched in 1962 as part of the Department of Medicine.

In 1965, Talbot departed for the University of Alabama to start a new biomedical engineering program there. A committee, led by famed neuroscientist Vernon Mountcastle and Department of Medicine chair A. McGehee ("Mac") Harvey, recommended that the school look for a successor to Talbot and create an independent biomedical department.

The university tapped Dick Johns (Med '48), who joined Johns Hopkins in the 1950s and had worked alongside Talbot as a medical student and later became the first professor and chairman of the new sub-department of bio-



MIKE CIESIELSKI

As the first chair of Biomedical Engineering at Hopkins, the School of Medicine's Dick Johns started with five faculty members and 15 graduate students.

medical engineering. It started out with five faculty and 15 graduate students.

In 1970, biomedical engineering became a full and separate department in the School of Medicine, and Johns was named its founding director. A full-time undergraduate program in biomedical engineering would go on to be introduced on the Homewood campus, one of the first programs of its kind in the nation. The program was championed by Moise H. Goldstein Jr. and Stanley Corrsin, a pioneer of fluid mechanics who had previously chaired the Department of Mechanical Engineering.

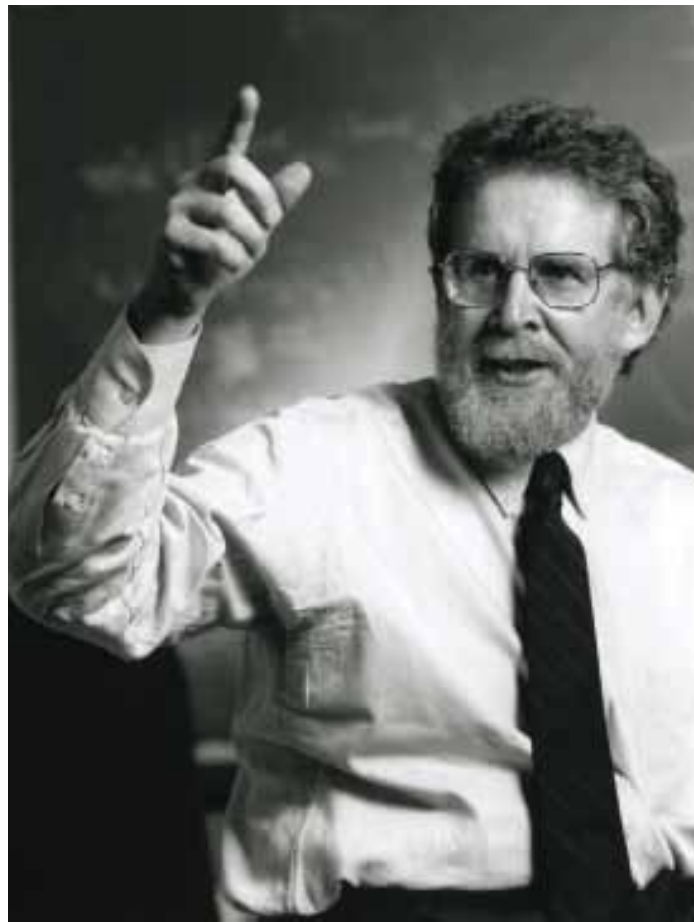
Under Johns' leadership, the department would expand to encompass research in speech and hearing, cardiovascular control, and myocardial mechanics. In his own research, Johns helped develop a 3-D radiography system that would give physicians a "real" image and allow for structures behind dense organs to be observed; it proved revolutionary.

"From the beginning, the essence of what we do is combine quantitative physics and math to solve real-world biomedical problems," says Johns today.

One of the department's first hires was Murray Sachs, who studied electrical engineering and auditory physiology. At Johns Hopkins, Sachs conducted important research on the encoding of sounds in the inner ear and the brain.

Sachs said that Johns set the tone for the department's success.

"It was very exciting to be here at that time," Sachs says. "Dick Johns made it exciting. He estab-



BILL DENISON

Murray Sachs, who served as director of Biomedical Engineering from 1991 to 2007, says the key to the department's considerable success has been its interdisciplinary nature.

went on to earn his medical degree from Harvard before starting on his career in research on gene therapy for congenital heart failure.

Sachs, who succeeded Johns from 1991 to 2007 and served as Massey Professor and director of the Department of Biomedical Engineering, says the key to the department's success is its interdisciplinary nature.

Today, the department has grown to more than 40 faculty members, 500 undergraduate students, and 230 graduate students. The master's and undergraduate programs, combined, are the largest in the School of Engineering.

Elliot R. McVeigh, the Massey Professor and director of Biomedical Engineering since 2007, notes that the department continues to make huge strides, especially in computation modeling. "We've done whole heart simulation from the cell up. We have developed MRI guided interventional procedures, and ways to deliver drugs and chemotherapy agents under image guidance."

Looking ahead, McVeigh says the department will continue to focus on the fundamental understanding of two of humankind's great foes: cardiovascular disease and cancer. "We want to understand how these diseases develop and find interventions to eliminate them. Biomedical engineering will help us get there." — *Greg Rienzi*

Today, the Department of Biomedical Engineering has grown to more than 40 faculty members, 500 undergraduate students, and 230 graduate students. The master's and undergraduate programs, combined, are the largest in the School of Engineering.

lished a department in his own image: extreme collegiality. We never voted on anything; everything was decided by consensus on the basis of good, sound science."

In the 1970s, biomedical researchers at Johns Hopkins helped refine pacemaker technology when they invented the first implantable device that could be recharged inside the body. A decade later, researchers developed the first implantable defibrillator, a tiny device known today as an ICD, to help those with unpredictable and potentially fatal heart-beat irregularities.

Roger Hajjar says he wanted to build upon this tradition of excellence.

He studied with award-winning chemistry professor Ruth Aranow; Bill Hunter, internationally known for his research on heart contractions; and Kiichi Sagawa, the father of cardiac mechanics.

"I was very proud to be working in [Dr. Sagawa's] lab. I learned so much working with him. Johns Hopkins gave me the know-how and a foundation for my success. There was a lot of emphasis on critical thinking," says Hajjar, who

Final Exam | Cool Ideas

WILL KIRK / HOMEWOODPHOTO.JHU.EDU



ENERGY WELL SPENT: Seniors Kristen Hum and Julie Ufford make note of the wattage of a light bulb at Baltimore's Eubie Blake Center.

On a sweltering July afternoon, during the hottest summer on record, Kristen Hum '12 paused as she entered the Eubie Blake National Jazz Institute and Cultural Center in downtown Baltimore. The geography and environmental engineering major turned to her classmate Julie Ufford and whispered, "Did you see it? A broken window." Cool, refreshing air, and the energy it took to produce it, seeped out into the stifling city.

Hum jotted her observation quickly on her checklist, before joining Ufford and Yashar Afkari '13, a biology major, in the lobby. The students were there as part of the Climate Showcase, a program run by Johns Hopkins' Office of Sustainability and sponsored by Baltimore City through an Environmental Protection Agency stimulus grant. For the past two summers, this initiative has enabled six undergraduates to assess the energy efficiency of Baltimore nonprofit organizations and provide these often cash-strapped institutions with money-saving, environmentally friendly strategies.

The Eubie Blake Center, on Howard Street in Baltimore's Mount Vernon neighborhood, is housed in two sprawling, late-19th-century row houses—hardly the portrait of modern-day energy efficiency. One building was the original site of the University of Baltimore Law School; the other a factory

where false teeth were manufactured.

On this summer day, the buildings buzzed with a wide range of activities. Upstairs, young students rehearsed in the dance studio, recorded a jazz performance in a gallery, and painted ceramics in the art room, while downstairs, visitors enjoyed an exhibition devoted to Blake, Billie Holiday, Cab Calloway, and other Baltimore jazz legends. But for the Hopkins engineers, this was no jazz joyride. They meant business.

After meeting with the center director, Troy Burton, and learning about the building and its uses, the team set off on a fact-finding tour. Over the next two hours, they measured, calculated, observed, and noted everything from the wattage of elevator light fixtures, temperature changes caused by drafty windows, toilet flush times, and computer monitor settings to details about the building's cooling system. All this was needed for the sustainability assessment they would present to Burton at week's end.

"This started a few years ago with a couple of engineering students who realized there was a lot the university could do to conserve resources in its own buildings," says Davis Bookhart, director of JHU's Office of Sustainability. "They came up with a list of easy-to-implement, low-tech ideas—like adding occupancy sensors to rooms—that could make a big difference over time." Bookhart hired the

students as interns, acted on their suggestions, and then worked with the city to expand the JHU program to benefit the Baltimore community.

Each student team visits two organizations per week. Mondays are devoted to introductions and tours, Wednesdays to meetings with staff to learn about behaviors that impact energy usage, and on Fridays, the teams present their findings.

"The most satisfying parts are saving the organizations money and learning about the work they do," says Ufford. "Often, we can connect them with programs and resources they didn't know about."

Among the students' suggestions for the Eubie Blake Center: lower the temperature of the hot water heaters, contact BGE to get a free lighting audit and occupancy sensors and recover up to 80 percent of the cost of retrofitted light fixtures, and insulate the fourth floor ceiling. Estimated savings by switching to energy-efficient LED light bulbs included \$30 a year for one exit sign and \$100 a year for an elevator light and up to \$1,700 over two years by replacing the lobby fixtures. The biggest bang for the buck? Installing programmable thermostats that could cut heating and cooling bills by up to 30 percent.

In downtown Baltimore, during a sweltering summer, that's a cool idea. —Abby Lattes

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Kevin J. Hemker (right), professor and chair of the Department of Mechanical Engineering, was named WSE's Alonzo G. Decker Professor of Mechanical Engineering on May 16, 2011. He is shown here with John W. Hutchinson, his mentor at Harvard's School of Engineering and Applied Sciences.

K.T. Ramesh, professor of mechanical engineering, was installed on April 8, 2011, as the Alonzo G. Decker, Jr. Professor of Science and Engineering



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