LEHIGH UNIVERSITY

2016

VOLUME NO. 1

LEHIGH RESEARCH REVIEW

SCHOLARSHIP, DISCOVERY & THOUGHT LEADERSHIP

AT LEHIGH, WE FOSTER A CULTURE OF DISCOVERY AND CREATIVE EXPRESSION, BUILT ON OUR RECOGNITION THAT NEW UNDERSTANDING AND A SPIRIT OF INQUIRY ARE OUR GREATEST CONTRIBUTIONS TO SOCIETY.

LEHIGH RESEARCH REVIEW

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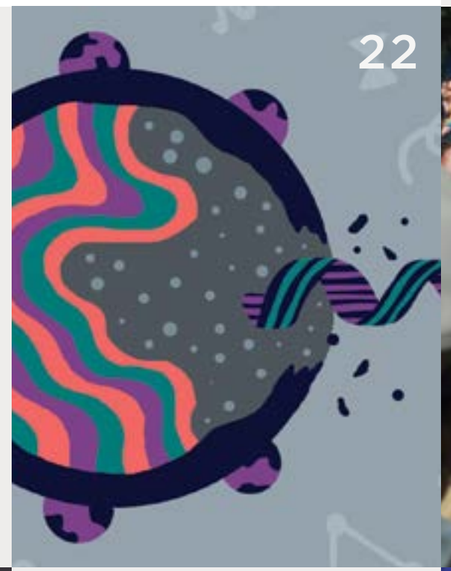


A TRADITION OF DISCOVERY

During his transformative tenure as Lehigh's eighth president, Martin Dewey Whitaker made a bold and ultimately crucial decision—one that would shape the future of the university and catapult it into an unprecedented era of discovery.

Whitaker, a world-renowned physicist, believed in the power of new knowledge to change the world for the better, and he believed, too, that if Lehigh was to maintain its position at the forefront of higher education, it needed to vastly expand its research enterprise. With the support of the board of trustees, Whitaker pushed forward on an ambitious plan to do precisely that.

Over the course of his tenure, Whitaker would spend nearly half of the university's endowment to build new laboratories, hire new faculty, and create new programs to support the brilliant minds that were increasingly calling the university home. By the time he left office in 1960, thanks to his keen vision and the steadfast support of Lehigh's trustees, the university he led had been completely and utterly changed: It was a bigger, stronger, more intellectually powerful Lehigh. It had become, in other words, a true research university.

"WE BELIEVE IN RESEARCH AS AN AGENT OF POSITIVE SOCIAL, CULTURAL, POLITICAL AND ECONOMIC CHANGE."

More than a half-century later, Whitaker's investment continues to pay impressive dividends—not only for Lehigh, but for the world far beyond South Mountain as well.

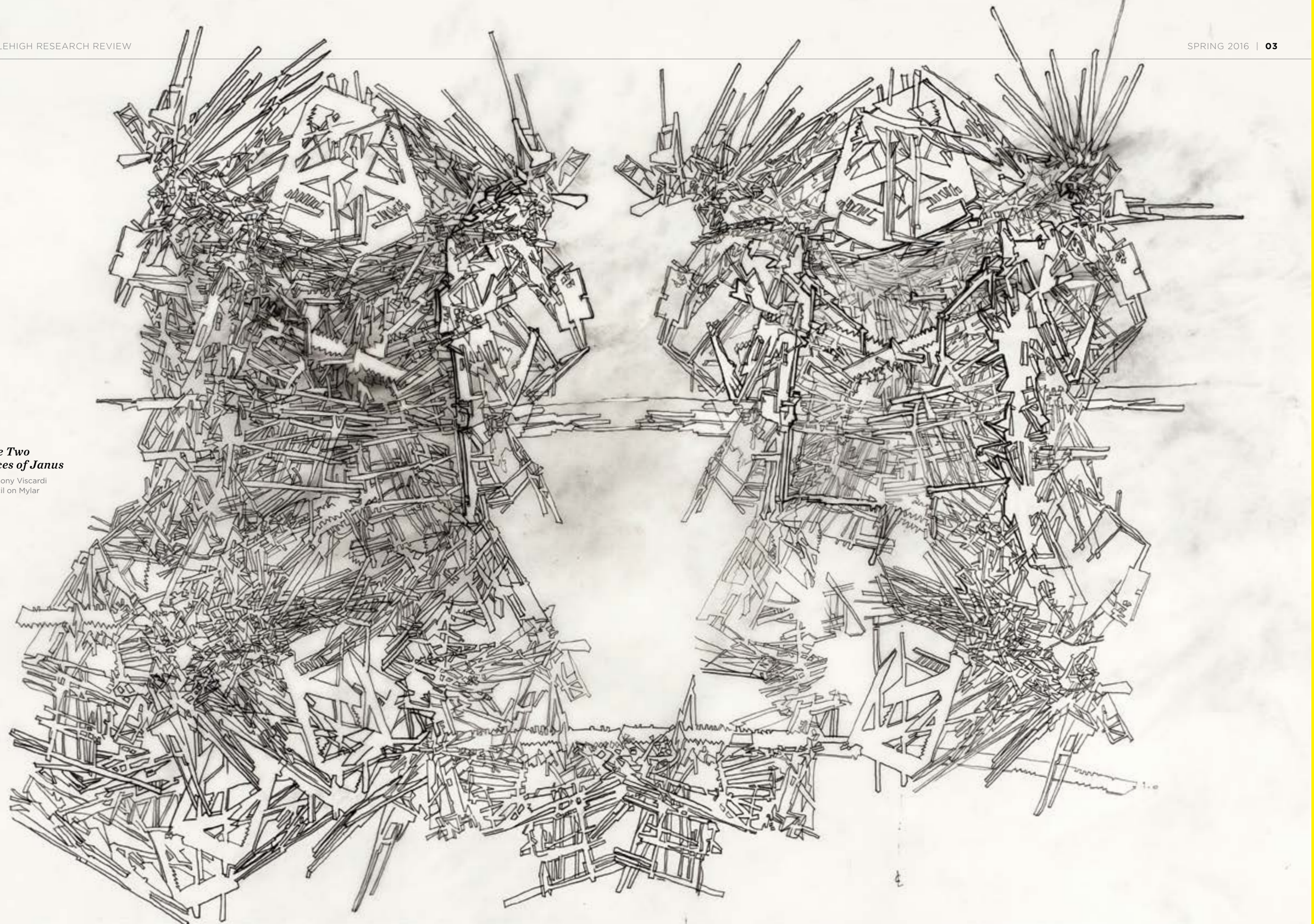
Great research—important research—is deeply valued here at Lehigh. We take enormous pride in our ever-expanding efforts to support our faculty in their work because, like Whitaker, we believe in research as an agent of positive social, cultural, political and economic change. And we remain committed to fostering an environment in which our researchers are encouraged to take on the greatest of challenges, with the confidence that they can and will deliver the most innovative of solutions while also developing the next generations of researchers through our graduate students.

In the pages that follow, you will read about just some of the exciting scholarship and research that is happening here at Lehigh. From the social and natural sciences to the arts and humanities, from business to education, our faculty is engaged in work that we find fascinating, inspiring—even revolutionary. We have been consistently impressed and often amazed by their work, and we hope you will enjoy reading their stories.

Sincerely,

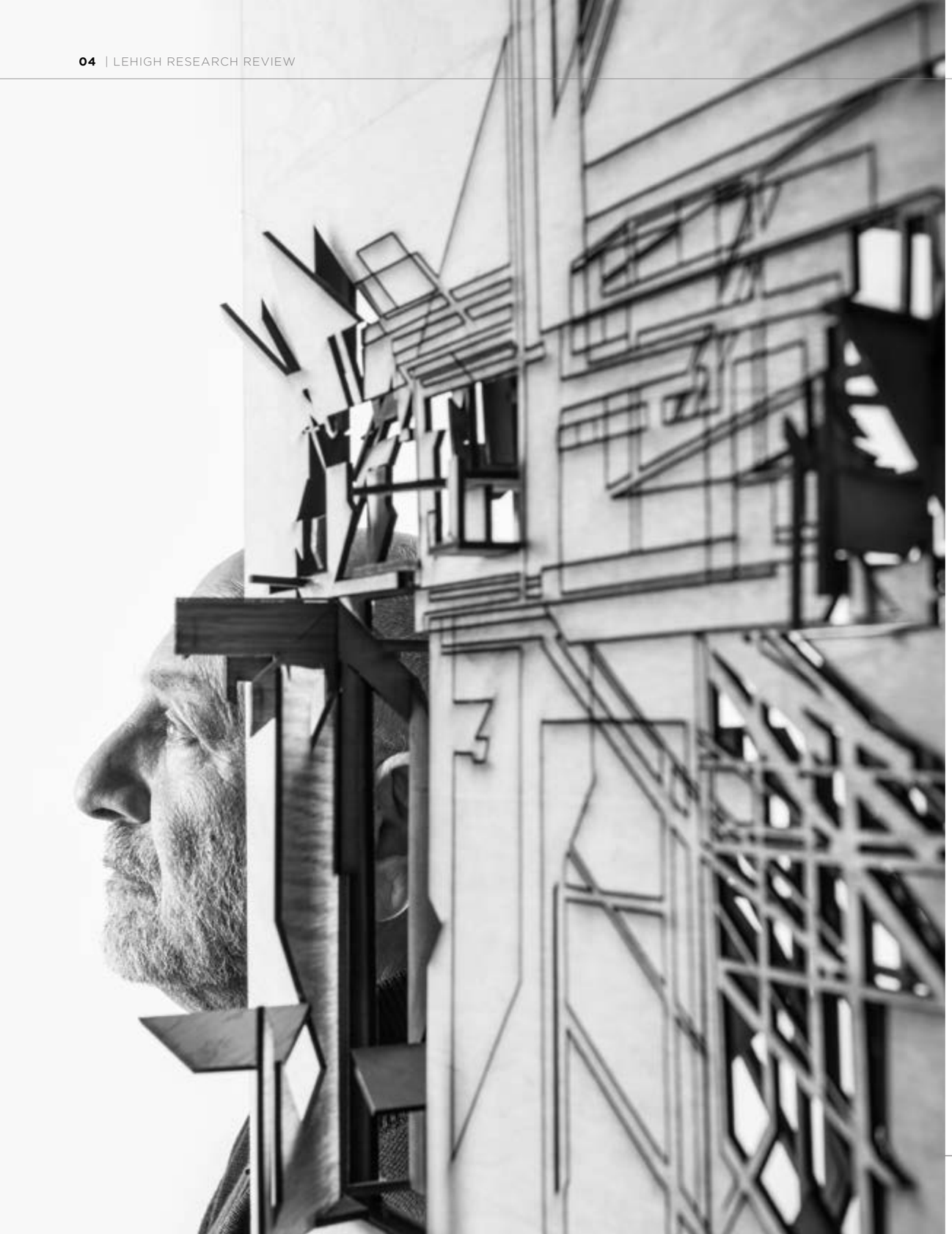
John Simon
President

Pat Farrell
Provost



The Two Faces of Janus

Anthony Viscardi
Pencil on Mylar



ART & ARCHITECTURE

CASTING AND CAPTURING SHADOWS

Contemporary architectural practice often employs computer-generated algorithms to generate form. Anthony Viscardi engages shadows to do the same by asking the simple question, "If an object can cast a shadow, can a shadow cast an object?"

Anthony Viscardi's art investigates the phenomena of shadow mapping. His work has been exhibited in U.S. and European galleries.

Photography by **Ryan Hulvat**

As a child, Anthony Viscardi tried to hide from his shadow. Today, he seeks them out. As a professor of art and architecture at Lehigh, Viscardi encourages his students to move beyond digital algorithms as they work to create humanly habitable space. He urges them to engage more dynamic processes of natural phenomena that ignite the imagination through experience and observation. A recurrent theme in Viscardi's pedagogy and professional work as an artist is the phenomenon of light and shadow as the progenitor of form.

Viscardi was drawn to light and shadow as relevant design and energy-conservation considerations early in his career while serving as partner and principal designer for an architectural design firm in Atlanta from 1979 to 1992. Subsequently, while teaching art and architecture at Georgia Tech, Morris Brown College and the Atlanta College of Art, he began to formulate a pedagogy that embraces the shadow as a means to generate form.

When Viscardi arrived at Lehigh in 1992, Ricardo Viera, professor of art and director and curator of Lehigh University Art Galleries, curated a solo exhibition of Viscardi's shadow work to introduce him to the community. Since that time, Viscardi's fascination with the shadow has proven to be an inexhaustible premise for inquiry, serving both his academic research and teaching as well as his personal work as an artist.

In speaking of his art, Viscardi says, "In essence, I steal the shadow of the object by tracing its outline, recording its form as it is transformed over time to create a sort of shadow map, from which I construct new objects or drawings."

For each piece, Viscardi constructs a three-dimensional model and intermittently traces its cast shadow to create a record of the sun's angular changes throughout one day. The design of the object is transformed over time as the ever-changing shadow directs. He employs a variety of techniques: For some drawings he traces the shadow using pencil on Mylar or ink on watercolor paper; for others, he employs airbrush. When finished, Viscardi discards the generative model—a work of art in and of itself—leaving only captured shadows, a record of how light interacted with an object in a certain place and time. He is currently exploring laser cutters, 3-D printing and CNC (computer numerical control) machines to inform his work.

Viscardi was awarded a coveted MacDowell Colony Fellowship to continue his visual investigations of shadow mapping during his 2011-12 academic sabbatical. The MacDowell Colony is the oldest artists' colony in the United States and has hosted the likes of Leonard Bernstein, Aaron Copeland and Milton Avery. Talent is the sole criterion for admission. Viscardi's experience at the MacDowell Colony, he says, helped to define him as a professional artist, independent from his role as an architect/academic.

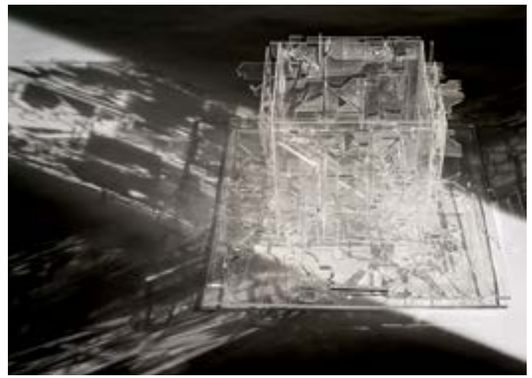
In 2013, Viera curated Viscardi's second solo show at Lehigh to exhibit the MacDowell-based work. The Zoellner Gallery exhibition, "Tracing Time to Measure Space," drew one of the gallery's highest opening attendances ever.

Viscardi, whose work has been shown at galleries in New York, Philadelphia and numerous European cities, says he prefers not to begin a piece with preconceived ideas.

"There is something about the slow act of drawing and making small models that allows your mind to daydream and to meander," he explains, "and so connections are made, sometimes through mistakes, that aren't self-conscious or stereotypical." This is an advantage that modern technology doesn't always provide, he says.

It takes perseverance and dedication to make great architecture, Viscardi says, and he wants his students to embody that strong ethical stance. The same is true of his art.

"If you're going to make something, let it be meaningful," he says. ●



Anthony Viscardi is a nationally and internationally known scholar-teacher in the design and art of architecture. Viscardi spent the 2013-2014 academic year as Artist-in-Residence at Lafayette College's Experimental Printmaking Institute, where his drawings assumed a new form through printmaking techniques such as collagraphy, etching, silkscreen and laser cutting. He received his master's degree in architecture from the Georgia Institute of Technology.

Complex Feelings

Like many of Shakespeare's characters, Hamlet experiences emotional ambivalence.

MANAGEMENT

TO LEAD OR NOT TO LEAD?

Naomi Rothman says emotional ambivalence, often read as indecision, can help leaders make better decisions. The problem? It may also make them look weak—and cost them their influence.

Vladimir Putin is known for aggressive leadership—but may be better served by occasional indecision.

Naomi Rothman grew up in a house filled with conversations about ambivalence.

And yes, she says, that was a good thing.

Rothman's father was fascinated by Shakespeare's plays, and he made it a point to bring his daughter along to as many of The Bard's plays as possible. Along the way, Rothman, assistant professor of management, says she came to appreciate one of the recurring themes of Shakespeare's work: The simple but undeniable idea that because much of life is a great deal more complex than we'd like it to be, emotional ambivalence—the state of having mixed feelings or strong but contradictory feelings about something or someone—is not only completely natural, but absolutely inevitable.

"Shakespeare's plays are infused with ambivalence," Rothman says. "The relationships in his plays are complicated and nuanced. The reality is, most things in life aren't as simple as we'd like to think they are, and people often have very complex feelings about situations in their lives and about the people that they live with or work with."

Today, Rothman is using her long-standing interest in the complexity of life—and the ambivalence it often elicits—to try to understand not only how ambivalence helps leaders make better decisions, but also when and why it negatively impacts the way those leaders are perceived. Rothman has explored these dynamics in any number of settings—from politics to business to healthcare. But one recurring theme ties all of the work together: Though emotional ambivalence often serves leaders well when it comes to decision-making, many observers have a hard time accepting that fact.

"I completely understand the need for leaders to be at times decisive, which can help them appear strong and powerful in the face of competitors or in times of conflict," she says. "But we have to understand that there is also a time and place for experiencing and even expressing contradictory states such as ambivalent emotions."

Rothman helped uncover the surprising importance of ambivalence in a 2013 paper, co-authored with colleagues from the University of Michigan. She found that when individuals felt emotional ambivalence (both happy and sad) about a certain problem or situation, they were more likely to be open to alternative perspectives relative to when they felt happy or sad alone. This was important, because as the study revealed, forming a judgment based on multiple, diverse perspectives helped the ambivalent individuals reduce errors in subsequent forecasting decisions. The authors went so far as to say that emotional ambivalence can help people to see the world in new ways and could even expand their overall cognitive abilities.

"We have learned that when individuals feel mixed emotions about a decision, this leads them to seek diverse perspectives and to even gather pieces of information that may conflict with each other," she says. "This openness to divergent perspectives actually allows individuals to make better decisions presumably because, when combined, the errors within those different pieces of information can be canceled out."

The value of mixed emotions, then, is clear. The problem, Rothman says, is that those benefits must be weighed against the fact that, according to her other research, there are a number of situations in which many people simply don't believe leaders should be ambivalent about anything, and so leaders are penalized for showing their ambivalence in those contexts. In a series of studies conducted over the past three years, Rothman has found that when individuals outwardly express ambivalence, they are more likely to be viewed as submissive, indecisive or even incompetent. In a competitive context, this could open up ambivalent leaders to more aggressive tactics from rivals, while in other contexts—politics, for instance—it can create the perception that they are not fit to lead. To put it simply, ambivalence hinders their influence—even though it really shouldn't.

> "DECISIVENESS ALONE IS NOT A GOOD ENOUGH REASON TO CHOOSE SOMEBODY TO BE A LEADER. WHEN WE CHOOSE THAT PATH, WE HAVE THE POTENTIAL TO MISS OUT ON THE VALUE OF AMBIVALENCE."

Rothman hopes her work can help drive people to overcome this inherent bias and reconsider what it is they really want in their leaders, as well as inspire managers to use ambivalence as an influence tactic effectively, such as after establishing cooperative norms for engagement. ●

Naomi Rothman received her Ph.D. from the Stern School of Business at New York University. Her research focuses on the social consequences of emotions in the workplace, power, justice and negotiations.

SOCIOLOGY

AN ECOFEMINIST PERSPECTIVE ON HEALTH

Climate change is the biggest global health threat of the 21st century, according to the 2015 UCL-Lancet Commission on Health and Climate Change. Kelly Austin examines its impact on women's health.

When environments are degraded and forests are cut down, people are forced to plow harder, walk longer to find firewood and water, and dig deeper wells. The added physical strain of this work impacts their health, and severe hunger and a lack of clean water affect their ability to stave off infection.

In less-developed nations, says Kelly Austin, those overworked individuals are primarily women.

In places like Latin America, Africa and Southeast Asia, men are more likely to be engaged in the formal market, says Austin, assistant professor of sociology. Gender dynamics lead women to be the liaisons who turn environmental resources into usable household goods. Women plow the fields, grow the food and search for water. Additional time spent on these tasks prevents women from pursuing educational and economic opportunities that might improve their status and therefore have a positive impact on their health.

Austin's research examines the intersection of the environment and health—how changing environmental conditions impact the physical well-being of those living in poor nations. She recently co-authored a paper in the professional journal *Social Problems*. The paper, "Ecological Losses are Harming Women: A Structural Analysis of Female HIV Prevalence and Life Expectancy in Less-Developed Countries," links environmental degradation to the health of women in poor nations.

Informed by ecofeminist perspectives, which link women's well-being to environmental well-being, the study analyzed the direct and indirect effects of ecological losses on female health outcomes in a structural equation model of 136 less-developed nations. Austin and her co-author, Laura McKinney of Tulane University, found that ecological losses are tied to female HIV and reductions in women's longevity via increased HIV rates, hunger and diminished health resources.

Austin and McKinney found that, in particular, changes to the environment and a decreasing ability to meet household needs significantly impact women's HIV status.

Denied opportunities to earn money due to social inequalities, and faced with the effects of ecological loss on their ability to acquire needed resources, some women turn to what's commonly known as the "food-for-sex trade."

"When women are unable to get the resources they need, like food or water or fuel or firewood, they are maybe more likely to engage in unsafe sexual practices—trade their bodies for money or maybe enter into relationships with older men to secure some economic stability," says Austin. "It's much more likely that those older men have had multiple sexual partners, so they're more likely to be HIV positive. So there's this trickle-down effect."

The relationship between environment and health, Austin and McKinney claim, is likely cyclical and intergenerational "in ways that exacerbate and compound the strife experienced by each successive generation." Developmental and epidemiological approaches to improving women's health may benefit from including environmental dimensions as a key area of concern.

Austin hopes that her research might draw attention to women as essential participants in the global conversation about climate change.

"A phrase I hear a lot in my work in Uganda is, 'It's women who work the land, but men who own it,'" says Austin. "If we really want to think about stewardship of the environment and how we're going to mitigate the effects of climate change, it's really women who should be leading the discussion."

Further Examination

Austin plans to take her examination of environmental degradation and women's health even further with two more studies. One, currently under review, examines how in societies where women have better socioeconomic standing or more decision-making power, there is less death, illness, hunger and displacement from climate-related disasters. Austin found that women tend to rechannel power into provisions for sanitation systems, schools and other infrastructure that help to mitigate a natural disaster's impact on the population.

"It doesn't stop the flood or hurricane from occurring ... but if you have an improved sanitation system, the chance of it leading to a cholera outbreak is much less in the wake of a flood than if you just have a pit latrine," says Austin.

In a third study, Austin and her colleague will look at how being impacted by climate disasters relates to female HIV, bringing their examination of HIV, women and environmental change full circle.

Kelly Austin's research interests include globalization and development, global health and the environment. She employs both quantitative and qualitative research methods and received her Ph.D. from North Carolina State University.

Less Rain, More Work

A lack of rainfall impacts harvests and the availability of drinking water. In less-developed nations, women carry the burden of environmental change.

Seeking Answers

"A big part of this is using our observations to develop theories of how these objects should behave, to create the models that are at the core of what we know about how the universe works," Pepper says.

ASTROPHYSICS

THE SEARCH FOR OTHER WORLDS

An 'extremely little telescope' produces big results in Joshua Pepper's search for extrasolar planets—and the possibility that some of them might actually resemble our own.

The constellation Andromeda (above), where the first KELT discovery is located.

Illustration by **Hvass & Hannibal**

In 1988, astronomers found the first extrasolar planet. Today, the number of bodies found that orbit stars other than our Sun is close to 2,000. They are a source of speculation about other Earth-like planets and inform astrophysicists' body of knowledge about the formation of star systems.

Astrophysicist and assistant professor of physics Joshua Pepper has been chasing exoplanets since his graduate school years at Ohio State University. While studying a black hole problem, he helped formulate a plan for a NASA mission to find exoplanets using the transit method, which examines an apparent periodic dimness in a star due to a planet passing in front of it. Pepper realized that he could design and build a telescope dedicated to finding exoplanets.

Pepper's initial project has evolved into the Kilodegree Extremely Little Telescope (KELT) survey. It uses two robotic programmable telescopes, one in Arizona and the other in South Africa. The survey has confirmed 15 exoplanets using the transit method.

Lehigh, Vanderbilt University and Ohio State run the KELT project together, and the project's low-resolution telescopes are dwarfed by other telescopes that have apertures of several meters in order to stare at tiny sections of the sky at high resolution. The wide-angle KELT view of the universe, by contrast, comes from a mere 4.5-centimeter aperture with a high-quality digital camera and lens assembly that captures the light of 100,000 stars with each exposure.

"The goal of KELT is to discover more planets that are orbiting the brightest stars we can see. In essence, those give us the very rare, very valuable planets," Pepper says. Planets orbiting bright stars are easier to characterize with follow-up observations that provide more information about mass, size, density, orbit, radiation patterns and atmospheric composition.

A sophisticated software program helps narrow down the 3 to 5 million stars observed over the whole survey to roughly 5,000 that bear further scrutiny. When enough data has been gathered that can be attributed to transiting planets, the most likely exoplanet candidates are selected, and members of a secondary cohort of researchers perform their own observations and analyses.

The ability to confirm an exoplanet's existence hinges on the precise measurement of its host star's brightness. The typical operation of the KELT scopes involves observing a single star several times a night for about five years. In the process, astronomers gather at least 8,000 brightness data points. A complete graph reveals a line representing that star's brightness profile, including any periodic dips in brightness.

Once exoplanet status has been determined, astronomers can use the host star's change in brightness, or transit depth, to calculate several figures that paint a fuller portrait of the planet. They can measure its radius and the extent of its atmosphere. The gravitational wobble the planet causes in the star helps them figure out the planet's mass and then the density. Using transmission spectroscopy to examine the transit depth leads to information about the atmospheric composition.

How many of the 1,984 planets found so far by KELT and other telescopes could be habitable? The answer is probably still far in the future, Pepper says. For now, astronomers are still trying to decide what defines an Earth-like planet.

The first KELT discovery, KELT-1b—a brown dwarf located in the constellation Andromeda—is too cool to be a star and too hot to be a planet. Fewer than a dozen brown dwarfs have been found that transit a star, and KELT-1b has the brightest host star of any transiting brown dwarf ever found. A bit larger than Jupiter in size, it is nevertheless about 30 times Jupiter's mass, making it a highly unusual specimen.

"Clearly, this brown dwarf doesn't fit the theoretical models, so the models need to be adjusted. That's a game changer," Pepper says. Astronomers theorize that KELT-1b's inflated size is due to extremely intense radiation from its host star.

Pepper is now looking for targets for the upcoming NASA Transiting Exoplanet Survey Satellite (TESS), slated to launch in 2017. TESS will survey the entire sky for 200,000 of the brightest stars, in the hope of finding small, rocky planets. In the first two years, the orbiting telescope will sweep 90 percent of the sky and continue until it has covered the entire sky visible from anywhere around Earth.

"There are still a ton of questions out there. We're still trying to figure out if other solar systems are like ours, if planets like the Earth are common or not," Pepper says. "The potential of this line of research is absolutely enormous." ●

"THERE ARE SO MANY AREAS OF OPEN QUESTIONS AND SO MUCH COOL SCIENCE STILL TO BE DONE."

Joshua Pepper received his Ph.D. from Ohio State University and completed his postdoctoral studies at Vanderbilt University. His research involves the discovery of extrasolar planets with particular focus on the KELT project.

Initial Exploration

Bone-forming cells (rendered in white) attach to the biologically receptive TAMP surface to send out extensions to explore the scaffold microenvironment.

A NEW VISION FOR GLASS

A personal challenge from a respected colleague set Himanshu Jain in search of ways to put glass to use in important and innovative applications. His work has placed the material at the forefront of the budding field of biomedicine.

Himanshu Jain has a knack for engaging in conversations with just the right people at just the right time. In 2004, a casual chat with the person sitting next to him at a banquet in Cairo, Egypt, ended up guiding much of his research over the next decade. The result—thanks in part to additional fortuitous hobnobbing later—has been groundbreaking advances in a significant area of biomedical materials research.

Jain, the T.L. Diamond Distinguished Chair in Engineering and Applied Science and professor of materials science and engineering, had his momentous conversation at a workshop with colleagues from the United States and Africa. Seated next to him was Mona Marei, who headed the tissue-engineering lab at Alexandria University's Faculty of Dentistry. "We started chatting, and when I said I worked on glass, she said, 'You guys are no good,'" Jain says. "I was kind of taken aback. I said, 'Tell me why you think that way.'"

Marei had been using implanted biocompatible glass to repair deteriorated or damaged teeth and bone but wasn't happy with her results. After the Cairo workshop, Jain visited Marei's lab to learn more. "I had no serious understanding of the human body, let alone bone," he says. "But I found the whole idea of tissue engineering intellectually very exciting."

Jain had decades of experience developing sophisticated forms of glass for biomedical sensors, communications and microelectronics. In 2004—with funding from the National Science Foundation—he helped establish the International Materials Institute for New Functionality in Glass at Lehigh. The Cairo workshop was an introductory event for NSF International Materials Institute participants.

NSF was seeking to promote international research collaborations. Jain wanted to revitalize glass research and education, which was declining nationally due to glass's energy-intensive costs and to global competition. "I didn't want to see glass in this country go the way of steel," Jain says. "We needed more value-added glass products that require research and innovation."

Nano-macro porous bioactive glass samples made for *in vitro* tests. Other shapes and forms are fabricated for *in vivo* tests and practical applications (near left).

Illustrations (far left) by **Markos Kay**

RICH IN PORES

For hundreds of years, scientists had sought to make glass that lasts. "Like with windows," Jain says. "They last for centuries." Marei's challenge—and a key to future medical applications—was to create a biomedically active glass that goes away after it has served its purpose.

That purpose was to provide a "scaffold" that would help the body regenerate its own bone. It differs from conventional body part replacements, especially of hard tissues, which usually rely on long-lasting synthetic implants. "The body doesn't regenerate most organs by itself," Jain says. "But if you provide the right kind of microenvironment, it can."

Researchers had already established that glass can be made biocompatible, meaning the body will accept it and not reject it

Himanshu Jain is the director of the International Materials Institute for New Functionality in Glass. His research interests include introducing new functionality in glass through fundamentals; nano-macro porous glass for tissue engineering; light-induced phenomena in glass; and glasses for IR biosensors, photo- and nano-lithography, and photonics. He received his D.Eng.Sc. from Columbia University.

Upon exposure to body fluid, the nano-macro porous bioactive glass is covered quickly with proteins. It dissolves gradually, while minerals start depositing. This dynamic microenvironment activates the cells to start regenerating new tissue.

as a foreign substance. Jain's contributions have been to learn to control glass's biodegradation and to foster its ability to regenerate bone.

For glass to promote healthy bone growth and then disappear required it to do things it hadn't done before. "We started with the simple sense of how substances dissolve in liquid," Jain says. "If you have a solid crystal of sugar in coffee, it takes a long time to dissolve. If you have fine-grain sugar, it dissolves quickly."

The difference is that a grain of sugar has a proportionally much larger surface—the most reactive portion of a material—than does a large crystal. So Jain's group sought to make bioactive glass porous, with interconnected macropores measuring 100 to 200 microns (millionths of a meter) in diameter. The macropores would also allow space inside the glass for cells, nutrients and waste to move, and for blood vessels to form—key factors in regenerating bone, which is naturally porous.

But Jain and his colleagues envisioned making bioactive glass porous on not just one, but two levels—and the levels seemingly didn't go together. "We knew how to make large pores," Jain says. "The challenge was to introduce nanopores at the same time." Nanopores measuring about 10 nanometers—10,000 times smaller than macropores—would vastly expand the material's surface area and potentially offer a means of fine-tuning the glass's biodegradation.

The problem: "Small pores are unstable in the presence of big ones," Jain says. "We had to come up with ways to make sure both can coexist and remain in the glass when it's made." The key lay in phase separation, a condition in which—as with oil and vinegar in a salad dressing—two distinct materials with different properties exist at the same time in one substance. "Think of pores as another material," Jain says. "Our goal was to have a composite of glass and pores."

A team of Lehigh and international colleagues, including researchers from the Instituto Superior Técnico, in Lisbon, Portugal, and Alexandria University in Egypt, developed or refined two glass processes that successfully resulted in dual porosity—that is, pores at both macro and nano scales. One method is not far removed from traditional ways of making glass. Called melt quench, it entails mixing and melting oxides of calcium, phosphorus and silicon; casting as glass; heat-treating for desired phase separation; and then selectively leaching out appropriate phases to obtain multiporous glass. The other process, sol-gel, uses relatively low temperatures and forms a phase-separated gel which is then heat-treated to drive off the liquid.

Each technique presents a different balance of advantages and disadvantages. Dually porous, bioactive glass made with the melt quench method is stronger but less porous and somewhat inhomogeneous. Sol-gel glass is more readily fine-tuned at the nano scale, but the process is more time-consuming and expensive.

"This is all just the materials science," Jain says. "Getting it into patients is a very different matter."

THE 'BIO' IN BIOMATERIAL

Jain now realized the project needed a biologist. (To gain background, he himself had once taken a Lehigh cell biology course in which his daughter was a student. "She said, 'No way!' and I said, 'I promise I'll sit on the other end of the classroom,'" Jain says with a laugh.)

As with his initial conversation with Marei, Jain had another providential travel encounter. This time, he was flying to Japan for an international symposium on new materials science. Seated next to him was Matthias Falk, associate professor of biological sciences at Lehigh, who was traveling to Japan for an international microscopy congress. They looked familiar to each other, quickly discovered they were both from Lehigh and started to discuss their work.

"One aspect Himanshu explained was that they were having trouble detecting cells on the glass, which is not transparent," Falk says. "Neither light microscopy nor reflection microscopy worked very well. I said I thought we had a solution."

Falk's research on gap junctions, through which cells communicate with each other, often uses fluorescent microscopy, in which fluorescent dyes make cells stand out. Falk seeded samples of Jain's multiporous glass with human osteosarcoma cancer cells and mouse bone cells and found that using fluorescent microscopy vastly improved the visibility of cells on the material compared to the methods Jain had been using.

Overall, Falk found Jain's glass project exciting. "If an engineer can design a material that can go into the body, have cells bind to it, regenerate natural material and then degrade—that's amazing," he says.

Falk began investigating how well cells bind to multiporous bioactive glass. The results were better than expected. "Cells attach strongly to the material," Falk says. "They really seem to like it."

Bone cells on a multiporous bioactive glass have now been shown to grow deep into the scaffold and secrete proteins that help build new natural bone. What's more, cells for unknown reasons seem to prefer material with smaller nanopores to material with larger nanopores or no pores at all. That suggests engineers can modulate cell function or tissue regeneration rates by changing the nanoporosity of the scaffolding. "How do cells know whether a pore is five nanometers or 50?" Jain says. "We're trying to establish a fundamental understanding of how nanoscale morphology is important to cells."

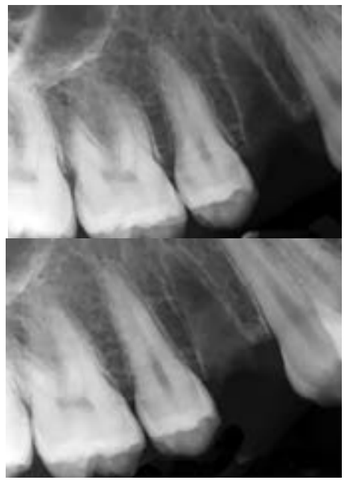
Pore size also affects how quickly the scaffolding material breaks down. Producing what's known as a tailored amorphous multiporous (TAMP) structure potentially allows many different applications in dissimilar parts of the body where the best results may depend on varying properties in the material.

Jain, Falk and their colleagues are now exploring additional biomedical applications for multiporous bioactive glass. The material may be useful for *in vitro* fertilization, potentially improving the development of embryos before they're implanted. Doctors at Lehigh Valley Health Network have shown interest in the material's potential to help heal burns and chronic wounds. Collaborators at the Central Glass and Ceramic Research Institute in Kolkata, India, have adapted the technology to make an injectable paste to repair osteoporotic vertebral compression fractures in elderly patients. The material could even be used as a vehicle for delivering continuously released medication.

"IF AN ENGINEER CAN DESIGN A MATERIAL THAT CAN GO INTO THE BODY, HAVE CELLS BIND TO IT, REGENERATE NATURAL MATERIAL AND THEN DEGRADE—THAT'S AMAZING."

Meanwhile, back in Egypt, Mona Marei has tested the material in goat and dog mandibles and under the skin in rabbits. She's now begun to test it further in ways she had dreamed back in 2004—rebuilding bone in humans receiving tooth implants or undergoing facial reconstruction. Preliminary results of a clinical trial on children started in her lab last year have been encouraging.

"She's pretty convinced this is promising and that multiporous bioactive glass is the right material for a number of applications in dentistry," Jain says. "Our work has come back to where it started, and this for me is hugely satisfying."



After extraction of the tooth, the empty socket (upper X-ray) is packed with nano-macro porous bioactive glass powder, which promotes the growth of new tissue (lower X-ray).

Image courtesy of **Mona Marei**

Real-world Impact

When a tooth is extracted, the surrounding alveolar bone that supports the teeth begins to degenerate. Alveolar bone support is essential to the successful placement of dental implants, and in some cases implants cannot be placed without a bone-grafting procedure.

Mona Marei's work with nano-macro porous bioactive glass in orthodontics has shown great promise. Hoping to utilize Lehigh bioactive glass to promote healing of the extraction socket while preserving the height and width of the bone, she and her team in the Faculty of Dentistry at Alexandria University have initiated a clinical trial of patients aged 9 to 16 years with malocclusion and good oral hygiene. Marei and her colleagues extract the maxillary and mandibular premolar teeth of each patient. They then use sterile saline to moisten TAMP powder to a desired consistency before inserting it into one empty socket and securely suturing it. They leave the contra lateral extraction socket unfilled as a control and follow up with patients clinically and radiographically after one week, two weeks, and one, two, three and six months post-surgery.

The study's preliminary findings show promising results of bone regeneration and are consistent with previous data from their animal studies. Of particular note are the differences in bone regeneration patterns between the treated and untreated extraction sockets and the "remarkable" growth of new blood vessels from existing blood vessels in the bioactive TAMP powder-filled socket.

"From my perspective, it is particularly exciting, in fact amazing, that our TAMP composition stimulates the regeneration of both hard and soft tissues as observed by Dr. Marei and her team," says Jain.

Matthias Falk received his Ph.D. from the University of Heidelberg, Germany. He was trained as a cell biologist and is interested in the processes related to protein biosynthesis, intracellular trafficking, the assembly of multi-protein complexes and how cells in multi-cellular organisms communicate with each other. Before coming to Lehigh, Falk worked at The Scripps Research Institute (TSRI) in La Jolla, California.

SPECIAL EDUCATION

MOVING YOUTH TOWARD SUCCESS

Lee Kern works with a team of researchers to learn how to best help students experiencing mental health and behavioral disorders.

High-school students experiencing severe mental health and behavioral disorders often drop out of school, have trouble getting jobs or wind up in jail, says Lee Kern, professor of special education. How best to intervene so that students' problems can be minimized?

That question was central to a large, five-year study led by Kern and conducted by researchers at Lehigh and six other institutions—Ohio University, the University of Missouri, the University of South Carolina, the University of Kansas, the University of Houston (TIMES) and Miami University of Ohio. With more than $10 million in funding from the U.S. Department of Education, they established the Center for Adolescent Research in Schools (CARS), working with more than 600 students at 54 high schools. Twelve of the schools were in Pennsylvania's Lehigh Valley and the surrounding region.

"Older students with emotional and behavioral problems have long been neglected," Kern says. "Very little research is conducted with this age group, so we lack information about effective interventions. Teachers are reluctant to provide supports because they expect adolescents to be independent. And the nature of most high schools—in which students have multiple teachers, none of whom usually gets to know them well—makes identification and service delivery difficult."

The CARS team developed and evaluated a range of interventions, including mentoring, to help reduce the difficulties that students with severe mental health and behavior disorders experience. They also developed a model for delivering services.

The study provided a rich data pool, allowing researchers to not only assess the effectiveness of various interventions but also the kinds of mental health services that students received, where and at what age they received them, and the link between the severity of their problems and the types of services provided. They're looking at whether interventions failed because they weren't implemented as designed and whether students' ethnicities, family incomes and school locations figure into who gets services.

"We're looking at the outcomes different ways," Kern says. Of great concern to the researchers, based on the findings, was that students with severe mental health and behavioral disorders weren't always getting the services they needed, such as interventions and classroom supports.

In launching the project, researchers asked school officials to refer students with the most intensive social, emotional and behavioral problems; they did not specify whether the students should be diagnosed as in need of special education. As a result, Kern says, about half of the students in the study had a special education diagnosis and half did not.

Except for lower academic performances among students with learning disabilities, researchers found that on every standardized measure there were no differences between those who had received special education diagnoses and those who had not.

"So if we're talking about depression, we have kids who are significantly depressed who are identified as having emotional and behavioral disorders, and they're guaranteed services by the school," she says. "We have another group of students, which is probably just as many, who are depressed but not guaranteed any kinds of services because they are not identified as having behavioral disorders."

Kern says the researchers see a need to screen all high-schoolers for social, emotional and behavioral problems because schools, through their special education identification systems, are just not picking up all the adolescents with significant needs.

Kern believes that all high-schoolers should be screened for social, emotional and behavioral problems. Doing so could help head off larger problems down the road, she says.

Illustrations by **Michelle Thompson**

Lee Kern's research interests include emotional and behavioral disorders, positive behavior support, school-based interventions and attention-deficit/hyperactivity disorder (ADHD). She received her Ph.D. from the University of South Florida.

If schools don't provide interventions, she says, "it's unlikely kids will get any kind of services for their mental health needs. Very few kids get community services. And when they do, they usually go once or twice, so they're not getting a sufficient dosage to really make a difference."

Such services need not be expensive to administer, especially when looking at cost-benefit ratio, she says. Most interventions can be group-delivered, providing effective ways to reduce students' anxiety and depression. "It's just that schools don't think they're responsible for providing them," Kern says. "Whether that's right or not, we know that if they don't provide them, students are not going to get them."

Schools also can reduce the stigma associated with mental health services by making programs available schoolwide, she says.

Using a mapping process, the researchers also found that school resources were not being used effectively. "For example, school staff spent a lot of time responding to crises, rather than putting preventative interventions in place," she says. "Also, trained school staff, including counselors, spent a lot of time on tasks such as scheduling that do not capitalize on their skills." Among interventions, a Check & Connect mentoring program proved valuable, regardless if students were paired with someone of the same gender and ethnicity. "That's a positive finding, that it doesn't matter who your mentor is," Kern says. "Just the mentoring process itself is really helpful to these students."

It's important for practical reasons too, since it's sometimes difficult to find mentors in the schools who match students in race and gender. In the project, mentors were mostly teachers, but also coaches and administrators who met with the students once a week and talked about schools and future plans, and sometimes, family and friendships. Mentors also reviewed dropout indicators such as grades, absences and tardiness. Both the students and mentors rated the relationships very highly.

The CARS team also found that students with severe emotional and behavioral problems reported a lower quality of life than other adolescents, a finding consistent with other research. While those who work with the troubled students tend to focus on reducing problem behaviors, the team is assessing whether there needs to be more focus on other indicators of quality of life. Do students feel safe at home? Do they feel they have friends? Do they participate in activities they find enjoyable?

By making support services available to all students, schools could help reduce the stigma associated with mental health issues.

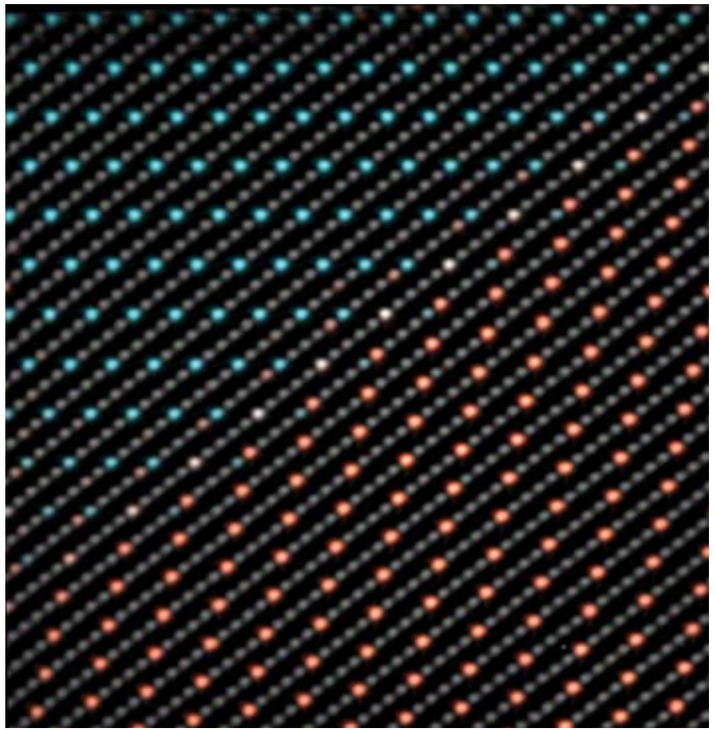
Given the students' high dropout rates and poor school outcomes, researchers were not surprised to find that students with severe emotional and behavioral problems were unhappy at school. However, interventions that can increase students' satisfaction with school are important, the data suggests. It's likely, researchers said, that students who feel better about school will do better academically and stay enrolled. The CARS team also found that high school girls with severe emotional and behavioral problems reported being less satisfied than high school boys with their families, themselves and life in general. Whether that's due to differences in development, gender expectations or the availability of interventions, the researchers see a need to carefully examine the appropriateness and effectiveness of interventions for adolescent girls.

Latino students also were found to be significantly less satisfied than black students with their lives, but further study is needed.

Findings have so far been published in the *Journal of Emotional and Behavioral Disorders*, *School Psychology Review*, *Journal of Clinical Child and Adolescent Psychology*, *Journal of Behavioral Education* and *Review of Educational Research*. More papers are pending.

The researchers have made recommendations to the U.S. Department of Education, including the possibility of funding schools that can be models for educators.

"Once we find schools that are doing good things, [we should] support them in doing those things, collect the data that they aren't able to collect, show that they have good outcomes and then these schools are much more visible," Kern says. "People can see, this is how you do it, this is the structure, this is how you allocate resources." ●



An atomic-resolution image of a twin boundary in nanocrystalline Ni-W (above). Twin boundaries are crucial to the understanding of anti-thermal behavior.

MATERIALS SCIENCE

UNCHARTED TERRITORY

Martin Harmer's research could fundamentally transform basic understanding of thermal processes, leading to revolutionary advances in the performance and applications of materials.

Martin Harmer seeks to understand a phenomenon about which very little is currently known: atoms that behave in a manner contrary to nature. Harmer's work has the potential to revolutionize scientists' basic understanding of thermal processes and inform the development of new materials that could withstand higher temperatures. A breakthrough in this area could lead to significant increases in engine efficiency, for example, saving billions of dollars in fuel costs.

The W.M. Keck Foundation, known for funding science and engineering projects with the potential to pioneer new territory in a field, has awarded Harmer a $1 million grant to discover and study the mechanisms that govern anti-thermal processes that appear to reverse nature. Harmer, the Alcoa Foundation Professor of Materials Science and Engineering, collaborates with Elizabeth Holm and Gregory S. Rohrer, both professors of materials science and engineering at Carnegie Mellon University, on the project, titled "Anti-thermal Behavior of Materials: Reversing the Trend of Nature."

The atoms in solids typically move exponentially faster with increasing temperature, obeying a classical law of physics. This motion fundamentally limits the properties and performance of materials. Turbine engine components, for example, start to weaken at higher temperatures, limiting the maximum operating temperature and efficiency of the engine.

A major challenge in condensed matter science is to combat this trend of nature in order to produce materials that are more efficient, resilient and enduring. Researchers at Lehigh, Carnegie Mellon and the Karlsruhe Institute of Technology have recently identified examples of several anti-thermal processes which actually become slower, or do not change at all, as the temperature increases. Anti-thermal behavior has been detected in isolated cases in metals, ceramics, semiconductors, polymers and biomaterials.

In experimental and atomistic simulation studies of nanograin metals, grains—microscopic crystals that form the metal—were found to grow exponentially faster than expected at room temperature.

In another experimental study—a collaboration that included investigators at Lehigh, Karlsruhe, and Aveiro University—the grains in a ceramic grew more slowly at higher temperatures, the opposite of expected behavior.

The researchers' goal is to study and discover the unknown atomic mechanisms that govern this intriguing type of anti-thermal behavior. They will then use this understanding to design new materials with enhanced thermal performance that have the ability, for example, to increase the operating temperature and efficiency of engines, or the service life of bulk nanograin solids.

With Keck funding, Harmer and his colleagues will apply a novel method for measuring grain boundary motion inside multigrain materials. The team will seek to understand the process by applying methods of atomistic computer simulation and utilizing Lehigh's atomic resolution electron microscopy instruments to directly image the atom movements associated with anti-thermal behavior. An imaging stage will be utilized to make *in-situ* observations of atom movements at operating temperatures.

Says Harmer: "This project will allow us to explore uncharted territory that could potentially uncover the secrets of nature's counterintuitive thermal behavior and pioneer new approaches to materials science." ●

Martin Harmer's research interests have focused on advancing the fundamental understanding of microstructure control, sintering, grain growth and transport behavior of inorganic materials for tailoring the material properties. Harmer received his Ph.D. and D.Sc. from the University of Leeds in England and was recently named a Distinguished Life Member of the American Ceramic Society (ACerS).

ECONOMICS

THE ECONOMICS OF OBESITY

With obesity rates on the rise, Chad Meyerhoefer examines the medical costs of a nationwide epidemic and how the U.S. might address it.

Obesity rates have more than doubled in the U.S. in the past 30 years. A significant risk factor for diabetes, cardiovascular disease and other clinically significant health problems, obesity accounts for almost 21 percent of U.S. healthcare costs. Chad Meyerhoefer, associate professor of economics, and a team of researchers have added new understanding to the obesity epidemic and its costs.

Quantifying how much obesity increases medical costs is difficult. Previous obesity studies were skewed because they failed to account for poverty and erroneous reporting, Meyerhoefer says. Obesity rates are higher among low-income populations, who tend to have less access to healthcare, for instance.

"If you don't address those issues, then you're going to significantly underestimate the cost," Meyerhoefer says.

Meyerhoefer and his colleagues—Lehigh doctoral student Adam Biener, John Cawley of Cornell University, and Mette Hammer and Neil Wintfeld of Novo Nordisk, Inc.—developed a methodology to correct existing models for those two factors using data from the Medical Expenditure Panel Survey, 2000-2010. They studied data involving adults with and without diabetes.

The team found that the greatest savings in medical costs occurred when morbidly obese individuals with diabetes lost between 5 and 10 percent of their body mass index.

Surprisingly, when the researchers compared medical costs associated with men who were in the low end of the obese range with men who were of normal weight, there was essentially no increase in cost, Meyerhoefer says.

Instead, the researchers found a nonlinear relationship between weight gain and medical costs.

"We thought we'd see an elevation in cost as people became overweight. You don't see that. Costs don't go up until you get into extreme obesity," he says.

The study found that a relatively small percent of the population, those with the highest BMI and classified as having class 3 obesity, generate most of the medical costs of obesity.

Meyerhoefer and his team also found that the medical costs of obesity in the United States are much higher—nearly $316 billion a year—than previous studies had shown. To put it in perspective, that's about the annual cost of Parts A and B of the Medicaid program combined. In addition, the study found the average cost to treat obese individuals has risen 14 percent since 2005.

Meyerhoefer says the study can be used by researchers, policy makers, health insurers, employers and government agencies to calculate the cost-effectiveness of interventions to prevent and treat obesity.

By encouraging employees to avoid weight gain, for example, companies can save money and write off some of the costs by implementing a workplace weight loss program through subsidies provided through the Affordable Care Act.

"Empirically, you don't see a lot of cost savings from weight loss because most people gradually gain weight over time. As a result, most of the potential savings are from avoided weight gain, rather than weight loss, per se," Meyerhoefer says.

The study, "Savings in Medical Expenditures Associated with Reductions in Body Mass Index Among U.S. Adults with Obesity, by Diabetes Status," was published in the journal *PharmacoEconomics* in 2014. Along with another study in the *Journal of Health Economics*, it has become one of the most cited on the topic. The American Heart Association and the Institute of Medicine are among those who have adopted the findings. ●

Key Findings

- The average inflation-adjusted annual medical care costs of adult obesity in the United States rose from $3,070 in 2005 to $3,508 in 2010—an increase of 14.3 percent.
- Adult obesity raises annual medical care costs in the U.S. by $315.8 billion (2010).
- Individuals with class 1 obesity (low risk) with a BMI of 30 do not have elevated healthcare costs, but costs rise rapidly with individuals with class 2 obesity (moderate risk) or class 3 obesity (high risk) with a BMI of 35 or greater.
- The estimated savings in annual medical care costs from a 5 percent reduction in weight is $2,137 for those with a starting BMI of 40; $528 for those with a starting BMI of 35; and $69 for those with a starting BMI of 30.
- The medical care costs for individuals with diabetes are greater than for those without diabetes at every unit of BMI, and, at high levels of BMI, this difference amounts to thousands of dollars per year.

Novo Nordisk provided financial support for this study.

Chad Meyerhoefer's research interests include the economics of health and nutrition, and much of his work involves the use of microeconometric methods to evaluate and inform public policy. He received his Ph.D. from Cornell University.

Fast Food, High Cost

According to Meyerhoefer's study, adult obesity raises annual medical care costs in the U.S. by $315.8 billion.

Photo by **Theo Anderson**

CHEMISTRY

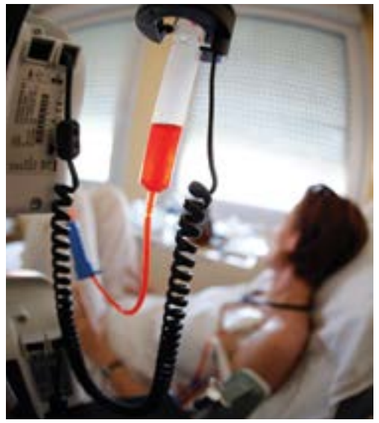
A FOCUSED ATTACK ON CANCER CELLS

Conventional chemotherapy attacks both good and bad cells. Damien Thévenin develops a system to deliver anti-cancer drugs exclusively to cancer cells based on the relative acidity of their environments.

The treatments for cancer, says Damien Thévenin, can sometimes seem worse than the disease itself.

Patients undergoing chemotherapy, he notes, suffer nausea, fatigue, loss of bone marrow and other side effects as the "chemo" kills good cells and bad alike.

Other therapies seek to target and kill cancer cells by employing antibodies that "recognize" receptors on the membrane of cancer cells and release drugs only inside those cells. But cancer cell membrane receptors come in many varieties, says Thévenin. Cancer cells from different tumors have different receptors, and even cancer cells in the same tumor can also have different receptors.



Conventional cancer treatments can have harsh side effects. pHLIP locates cancer cells and spares healthy ones.

Illustrations by **Antti Uotila**

"You have to know the kind of cancer a patient has and fit the targeting strategy to the cancer," says Thévenin, assistant professor of chemistry. "This requires a biopsy, a genomic analysis and drug targeting that is very specific to the type of cancer. All of this is labor-intensive and very expensive. In addition, while this strategy can be successful, it only works against very specific types of cancers."

In the past two decades, Thévenin and other scientists have turned their attention to pH. The extracellular environments of almost all cancers, Thévenin says, have a lower pH than the environments of healthy cells, making them more acidic and giving cancer drugs a broader, more general target to aim at.

Thévenin and his students are developing a unique targeting and delivery system that uses a peptide, or amino acid chain, to seek and destroy cancer cells. The peptide, called pHLIP for pH (Low) Insertion Peptide, is one of the transmembrane domains of a protein called bacteriorhodopsin, which is sensitive to light and is found in highly salty water. (pHLIP is pronounced like the word flip.)

In lab tests, pHLIP has shown the ability to deliver a potent anti-cancer drug to cancer sites based on their low pH and to release the drug in cancer and breast tumor cells. The drug is the FDA-approved Monomethyl Auristatin E (MMAE). The project has been funded by a grant from the National Institutes of Health/National Cancer Institute.

In an article published in 2015 in *Molecular Pharmaceutics*, a journal of the American Chemical Society, Thévenin's group reported that a conjugate, or pairing, of pHLIP and an auristatin anti-cancer drug inhibited more than 90 percent of cancer cell growth in two hours of incubation.

"These results," the group wrote, "indicate that pHLIP-based auristatin conjugates may have an enhanced therapeutic window as compared to that of free drug, providing a targeting mechanism to attenuate systemic toxicity."

The article by Thévenin's group, titled "Inhibition of Cancer Cell Proliferation and Breast Tumor Targeting of pHLIP-Monomethyl Auristatin E Conjugates," was authored by Kelly E. Burns, a Ph.D. candidate in chemistry; Matthew K. Robinson of the Fox Chase Cancer Center in Philadelphia; and Thévenin.

FOUR CRITICAL OBJECTIVES

To be effective, says Thévenin, drug targeting and delivery systems should meet four objectives:

1. The targeting system—in this case, pHLIP—must be able to locate cancer cells and spare healthy ones.

2. It must be able to deliver, or translocate, the drug into the targeted cell.

3. The drug attached to the targeting device must be delivered only to cancer cells and avoid harming healthy cells.

4. The drug should be relatively cell-impermeable, meaning it will not escape, or diffuse out of, the cancer cell after it has been infused into it.

The pHLIP-MMAE conjugate, says Thévenin, meets all four objectives.

First, pHLIP has demonstrated the ability to target tumors in mice based solely on the acidity of the tumor environment and not on a specific biomarker, or cell membrane receptor.

Second, the pH at which pHLIP folds

Damien Thévenin's research interests include biochemistry, membrane protein biophysics and drug delivery. He received his Ph.D. from the University of Delaware and performed his postdoctoral work at Yale University with Professor Donald Engelman.

and translocates MMAE into cancer cells corresponds to the pH of tumor environments. During translocation, the drug is released directly into the cell cytoplasm without requiring interactions with cell surface receptors or the formation of pores in cell membranes.

Third, pHLIP is capable of delivering into cells an array of molecules and peptides that would not be able to cross the cell membrane on their own otherwise.

"We have treated different types of cultured cells *in vitro*, including triple-negative breast cancer cells, with different amounts of pHLIP-MMAE at different pH levels," says Thévenin.

"The pHLIP–MMAE conjugates exhibit between an 11- and 144-fold higher antiproliferative effect at low pH than that at physiological pH and a pronounced pH-dependent cytotoxicity as compared to that of free drug."

In their paper, Thévenin's group reported that the pHLIP–MMAE conjugates "induce a potent cytotoxic [cell destruction] effect (more than 90 percent inhibition of cell growth) in a concentration- and pH-dependent manner after only two hours incubation without any apparent disruption of the plasma membrane.

"We are also the first group to show in mice that a pHLIP-drug conjugate is still going to the tumor site as expected. We have discovered that the cytotoxicity [cell destruction] depends on the pH and on the drug concentration."

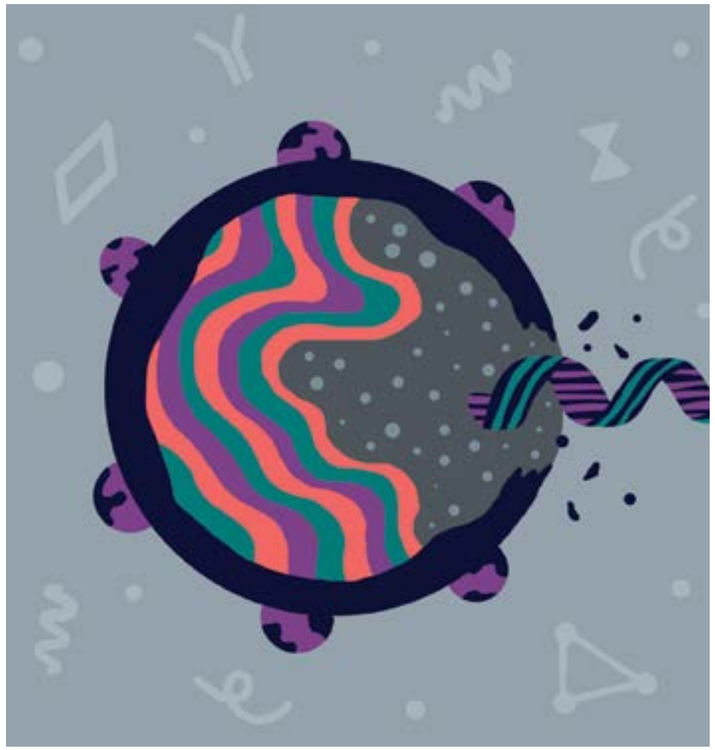
PLANS FOR THE FUTURE

Thévenin has been studying pHLIP since 2006, when he joined the lab of Donald M. Engelman, a Yale biophysicist, as a postdoctoral researcher. Engelman had previously discovered that pHLIP changes shape at a low pH and that this property could be used against cancers.

In Engelman's lab, Thévenin successfully demonstrated that pHLIP could deliver cell-impermeable drug molecules inside cells.

Today, Thévenin's group makes pHLIP in the lab. To do so, Burns links amino acids to each other using a process called solid-phase peptide synthesis and then joins MMAE and pHLIP with a disulfide bond. She is also currently synthesizing MMAE in a process that requires 19 steps.

Thévenin's group collaborates with researchers at the Fox Chase Cancer Center, who conduct *in vivo* experiments. Together, they recently showed that a pHLIP conjugate with an auristatin drug more potent than MMAE not only slows down tumor progression, but also prolongs survival of treated mice as compared to non-treated mice.



"THE PHLIP–MMAE CONJUGATES EXHIBIT BETWEEN AN 11- AND 144-FOLD HIGHER ANTIPROLIFERATIVE EFFECT AT LOW PH THAN THAT AT PHYSIOLOGICAL PH AND A PRONOUNCED PH-DEPENDENT CYTOTOXICITY AS COMPARED TO THAT OF FREE DRUG."

Thévenin has two other research projects that are related to cell membrane proteins and biophysics. In one, which is also funded by the National Cancer Institute, he seeks to understand how a specific family of membrane proteins (the receptor protein tyrosine phosphatases) assemble and influence cell signaling. In another, he is developing backscattering interferometry to study membrane proteins.

The pHLIP project has also been supported by a Faculty Innovation Grant (FIG) that Thévenin received with Marcos Pires, assistant professor of chemistry, and by a Class of 1968 Fellowship, which supports research by faculty members in the College of Arts and Sciences. ●

FINANCE

IMPACT OF THE JOBS ACT

The JOBS Act of 2012 was supposed to help make it easier for early-stage companies to go public. Years later, Kathleen Hanley questions whether the Act may have unintended consequences for capital formation.

Both Democrats and Republicans supported President Obama in signing the Jumpstart Our Business Startups (JOBS) Act, which aimed to give startup and growing companies improved abilities to raise funds.

When President Barack Obama signed the Jumpstart Our Business Startups (JOBS) Act into law in 2012, many in politics and business believed it would help American startups soar.

The bill contained provisions intended to make it easier for small and growing companies to go public, help them raise capital and ease their transition from young firms to budding business powerhouses. As written, the law provided young companies with important reporting exemptions with the SEC, gave them a pass on some of the more restrictive obligations of the Sarbanes-Oxley Act and more.

At a time of increasingly bitter partisanship in Washington, the JOBS Act was a true rarity—a bill supported by both Republicans and Democrats. When it became law, Obama called the bill a "game-changer" for the American economy, while Eric Cantor, then House Majority Leader, said it would allow business owners to "take risks, grow and create jobs."

With such broad-based support, the JOBS Act seemed all but certain to succeed. But nearly three years after the bill's passage, Kathleen Hanley, the Bolton-Perella Endowed Chair in Finance, began to wonder about its actual impact—and set out to determine whether it had succeeded as its backers claimed it would.

Hanley teamed with colleagues at the University of Virginia and Tulane University to perform an in-depth study of 312 initial public offerings (IPOs) for so-called Early-Growth Companies (EGCs) issued between April 2012 and April 2015. They sought to determine whether Title 1 of the Act was effective in reducing the measurable costs of going public.

Although the JOBS Act promised to help reduce the initial and ongoing costs of being a public company, Hanley and her colleagues found "no evidence" that the bill reduced the direct costs of an IPO issue—typically, expenses tied to accounting, legal or underwriting fees. Additionally, the team discovered an unintended consequence for companies that choose to pursue an IPO under the protections of an EGC; specifically, the IPOs they studied seemed to suffer "significantly" higher rates of underpricing, a trend they believe is tied directly to the legislation's more lax rules for transparency. "Overall, our results are consistent with a large body of literature that shows that investors value transparency and, in its absence, issuers are penalized by lower prices for their securities," the team wrote.

Even so, the team says there is still hope for the bill. Despite the financial difficulties the EGC status conveys, the team was surprised to see that most companies eligible for those protections continue to adopt them—a sign that these companies do believe there is benefit in the process, even if it does not show up in the measurable costs of issuance. For example, firms can now "test the waters" to communicate with investors before conducting an offering and thereby reduce the probability that an offer will be withdrawn. The ability for smaller companies to tailor their disclosure to meet their specific needs is another potentially valuable benefit of the Act that is difficult to quantify. The authors predict that, as time passes, investors are likely to become more familiar with the new regulations, and thus, issuing companies in the future may not face the same consequences as these early adopters. ●

Kathleen Weiss Hanley is the Bolton-Perella Endowed Chair in Finance and director of the Center for Financial Services. From 2011 to 2013, she was the deputy chief economist of the Securities and Exchange Commission and the deputy director in the Division of Economic and Risk Analysis. Hanley received her Ph.D. from the University of Florida.

ENCOURAGING MATERNAL ATTACHMENT

Susan Woodhouse examines maternal behavior and infant response to forge a path to more effective interventions for racially diverse and low-income families.

Susan Woodhouse challenges some long-held beliefs about maternal attachment.

Through a five-year, federally funded research project, Woodhouse, associate professor of counseling psychology, is investigating which aspects of mothers' caregiving for their babies best predict children's security of attachment, ability to regulate their emotions, and early indicators of mental and behavioral health. In an earlier study, Woodhouse found that in racially diverse and low-income families, a mother's sensitivity does not appear to be a key predictor of secure attachment.

Most prior research in this area has involved primarily white, middle-income families. Woodhouse instead studies low-income mothers of diverse racial and ethnic backgrounds. She found among them many mothers whose babies feel safe and secure, in spite of what might appear to be insensitive parenting styles.

"Clearly, there is a gap in our understanding of what parenting behaviors really make the most difference in promoting a secure attachment," says Woodhouse. A $2.1 million grant from the National Institute of Child Health and Human Development, one of the federal government's National Institutes of Health, supports her quest to find answers and close that gap.

The grant, titled "Caregiving, Attachment, and Regulation of Emotion," or CARE, allows Woodhouse to observe 200 primarily low-income women and their infants at 6 months and 12 months of age to determine what behaviors lead to a secure attachment, as well as the actions that detract from such attachment. In addition, Woodhouse examines other important child outcomes, such as early signs of behavioral problems as well as physiological indicators of how babies react to and recover from stress and how babies manage their emotions and focus their attention. All of these are important outcomes in terms of later school readiness and mental health.

"We hope to learn what Mom behaviors make the most difference in predicting baby outcomes," says Woodhouse, the study's principal investigator. "If we want interventions that work when there are limited resources, we want to focus on what matters most."

"There is a gap in our understanding of what parenting behaviors really make the most difference," Woodhouse says.

Susan Woodhouse is using a $2.1 million grant from the National Institute of Child Health and Human Development to investigate which behaviors among mothers can help foster a safe and secure attachment to their infants.

Illustrations by **Laurindo Feliciano**

Susan Woodhouse is an associate professor of counseling psychology whose research interests include attachment, emotion regulation, parenting, prevention and psychotherapy. She received her Ph.D. from the University of Maryland at College Park.

UNDERSTANDING INFANT SECURITY

Woodhouse began the study in March 2012 as a faculty member at Pennsylvania State University and continued when she arrived at Lehigh later that year. More than 100 mothers and babies have enrolled so far, and Woodhouse has begun to analyze the data she's already collected. She concentrates on the simple but powerful act of a mother holding her child "chest-to-chest" to calm the infant's crying.

"My new discovery is the key importance of chest-to-chest soothing when infants cry," says Woodhouse. "Even if a mother is making a lot of mistakes and being insensitive along the way, as long as she finally relents and comes through in the end by soothing the baby chest-to-chest, that baby will be secure. She doesn't even need to do it every time. As long as she does it at least 50 percent of the time, that baby will still be secure."

In fact, even if a mother does not hold her child chest-to-chest at least half of the time the child cries, her baby can still feel secure if the mother displays what Woodhouse calls "calm connectedness." For example, babies were secure if their mothers returned their gaze or if their mothers carried them while attending to household tasks.

CARE has also allowed Woodhouse to assess findings from her prior research that identify parent behaviors that negatively affect secure attachment. Frightening children in an attempt to stop them from crying, for example, proved ineffective. Woodhouse found that some year-old infants were unable to feel secure after their mothers had scared them by shouting or lifting them repeatedly into the air. Although the child stops crying, there are later negative consequences for the child in terms of disorganization of attachment, which is associated with later behavioral health problems.

THE IMPACT OF STRESS

Each participant must have a child 6 months of age or younger who is not yet crawling. Woodhouse and her team have been enrolling women at community events, housing projects, child-care centers and clinics. Team members distribute brochures to anyone who might qualify and explain that they're studying "how mothers and babies deal with everyday feelings and stress that are a normal part of raising healthy children." Researchers observe and test mothers and babies in their homes and in a lab-playroom, which offers a comfortable couch, age-appropriate toys and two cameras mounted near ceiling corners.

During the first two-hour visit, when the baby is 6 months old, researchers check heart rates and swab mouths for the hormone cortisol to assess stress levels of the mother and baby during normal tasks, such as strapping a child into a car seat.

The ability to adapt to stress and regulate emotions is key in later mental health and school readiness. By watching how babies' cortisol levels rise after a simple stressor and then how quickly this stress hormone returns to normal, Woodhouse can gauge whether a good mother-baby relationship buffers children from the negative effects of stress.

Because babies' heart-rate variability is an important marker of infant emotion regulation, electrocardiogram (EKG) wires are attached to the mother and child and tucked into a backpack or vest to avoid hampering movement during mother-baby interactions.

Researchers also observe behavior in the family home three times over two weeks by videotaping the mother and child for 30 minutes during everyday activities. When the baby is 12 months old, the mother brings him or her back to the lab for another two-hour testing and observation session. That's followed by two at-home observations, each 1.5 to 2 hours in duration, a week apart. CARE staffers are trained in how to videotape and rate the behaviors they observe.

Woodhouse says her work has opened her eyes to the "hidden strengths" of low-income mothers. "As we figure out what matters most for babies, we can develop interventions that will build on those existing strengths," she says.

"WE HOPE TO LEARN WHAT MOM BEHAVIORS MAKE THE MOST DIFFERENCE IN PREDICTING BABY OUTCOMES. IF WE WANT INTERVENTIONS THAT WORK WHEN THERE ARE LIMITED RESOURCES, WE WANT TO FOCUS ON WHAT MATTERS MOST."

After they complete the testing, participating mothers are offered social services, as well as parenting support through a program Woodhouse considers one of the most promising interventions available. The program, "Circle of Security," uses a video to stimulate learning and discussion about infant needs. By playing a game called "Name that Need," mothers learn whether a baby needs to be soothed or encouraged to explore. In addition, mothers are supported in exploring how to better meet their own babies' needs.

'THE RESULTS BELONG TO THE COMMUNITY'

Woodhouse participates in a community-research partnership called Parents and Children Together (PACT). As a PACT member, she receives guidance and suggestions from a PACT Community Advisory Board, which includes community leaders and grassroots community members, about how to best engage the community. It was the Community Advisory Board's idea, for example, to give mothers parenting support at the final visit.

"They wanted to make sure each mom would immediately get something positive to support her parenting, in addition to contributing to building knowledge about mothers and babies in the community," says Woodhouse, who regularly reports back to community members about her findings "so that the results belong to the community, not just to the scientific community."

Denise Sturnes, project coordinator and lab director, says she's seen mothers enter the study not knowing what to expect and later leave with a greater awareness of how to connect with their infants. "It's been rewarding for me to see the transformation," she says of mothers who learned that their children were not trying to bother or irritate them, but were instead in need of comfort and love.

Woodhouse says she understands that many other factors can influence a child's development, including behaviors of the father, grandparents and other guardians. However, mothers remain the primary caregivers of children around the world.

"For the first time, we are starting to see some of the hidden strengths that exist in low-income moms," Woodhouse says. "As we figure out what matters most for babies, we can develop interventions that will build on those existing strengths. We can help moms who are struggling look more like the successful moms within their own communities instead of trying to make them look like other moms from other places."

Kristin A. Buss, who directs PACT and is professor of psychology and director of graduate training at Penn State, considers Woodhouse's work "innovative."

"First, the work is innovative in the focus on specific aspects of mothers' behavior that help babies form secure attachment," says Buss. "The conceptual idea is that when mothers, regardless of cultural variations which have historically been viewed as maladaptive or less sensitive, engage in behaviors that help the baby calm, even if that behavior doesn't look pretty, it is effective. The second thing that sets CARE apart is that when families are done with the study, they enter an intervention phase."

Buss says the impact is not likely to happen overnight, but hopefully families in the study will see benefits from the lessons, and PACT members can help disseminate the findings in the community. Woodhouse anticipates completing the study by February 2017.

New Discoveries

Woodhouse and doctoral student Netta Admoni recently analyzed preliminary data from the CARE study regarding CARE heart-rate variability data, an index of parasympathetic nervous system activation, as mothers and babies move through a task similar to what happens if a mother interrupts playing with her baby to take a phone call. Mothers spend three minutes engaging in face-to-face play with the baby and then look away with a neutral face for two minutes before finally reengaging normally with the baby. Findings suggest that mothers who provide higher-quality caregiving have infants who seem more comfortable with their mothers disengaging for a couple of minutes. In contrast, mothers who provide lower-quality caregiving have infants who show physiological signs of stress when mothers look away and then show signs of greater stress, on a biological level, when their mothers reconnect with them. Woodhouse's lab is the first to identify different changes in babies' heart-rate variability depending on quality of care.

STRUCTURAL ENGINEERING

A MORE RESILIENT CIVIL INFRASTRUCTURE

Researchers in Lehigh's ATLSS Center work to fortify structures against natural disasters, protecting life and property.

While it may not garner as much attention as fighting terrorism or growing the economy, improving America's infrastructure—its roads, its bridges, and no less importantly, the resiliency of its built civil infrastructure —is one of the country's most pressing challenges.

Lehigh University's Advanced Technology for Large Structural Systems (ATLSS) Engineering Research Center has been conducting and hosting groundbreaking research on improving the resiliency of structures in earthquakes since it opened in 1986. In September 2015, Lehigh was awarded a highly competitive grant by the National Science Foundation (NSF) to establish an experimental facility associated with the Natural Hazards Engineering Research Infrastructure (NHERI) program. Led by James Ricles, the Bruce G. Johnston Professor of Structural Engineering and the ATLSS Deputy Director, and Richard Sause, the Joseph T. Stuart Professor of Structural Engineering and Director of ATLSS, the five-year, $5 million grant will enable ATLSS to expand its scope into fortifying structures against other natural disasters.

"The country's infrastructure has really deteriorated," says Ricles. "There's a push to develop resiliency, particularly in the aftermath of recent natural hazards such as Hurricane Sandy. There's a need to have structural systems and the community as a whole become more resilient to natural hazards."

The ATLSS Center contains some of the largest structural testing facilities in the world. Its equipment allows for hybrid seismic testing, where experimental simulations are combined with real-time numerical simulations to enable researchers to investigate the behavior of large-scale structural components during seismic events. The center was founded with financial support from the NSF and for a decade was part of the George E. Brown Jr. Network for Earthquake Engineering Simulation program, which supported innovation and education in earthquake engineering. Today it's a part of the NHERI program.

ATLSS researchers have been responsible for a number of breakthroughs in earthquake engineering, including braced frames with passive and semi-active dampers, and self-centering structures that absorb seismic loads. The ATLSS Center's large-scale reaction wall, strong floor and hydraulic actuators allow researchers to do real-time earthquake simulations on actual test specimens that are constructed in the Center.

"Let's imagine you have a building resting on the ground and an earthquake occurs," Ricles explains. "The building is going to be subjected to forces that develop as a result of the accelerations that are exerted on the inherent mass of the system. These forces are from the ground accelerations that develop as a result of the ground moving. Knowing the ground accelerations and inherent mass of the system, we can determine these forces, so we don't need to shake the ground and can fix the building to the laboratory strong floor and apply these forces directly to the building."

As engineering concepts for structural systems have improved, the failure of nonstructural components has become the weak link in structural resiliency, Ricles says.

"The reason a building may go offline includes structural damage," he says. "A building, however, may also be declared as unsuitable for occupancy if nonstructural systems in the structure are damaged. For example, if the sprinkler system no longer functions, then you can't occupy the building because of fire safety. If the elevators go out, there's no access for the physically handicapped. Cladding is, of course, an issue."

In September 2015, a team led by Paolo Bocchini, assistant professor of civil and environmental engineering, won a $2.2 million NSF grant "to establish and demonstrate a comprehensive framework that combines models of individual infrastructure systems with models of their interdependencies for the assessment of interdependent infrastructure system resilience for extreme events under uncertainty."

"The 'PRAISys' platform (Probabilistic Resilience Assessment of Interdependent Systems) will emphasize a probabilistic approach that permeates all aspects of the models, including the interdependencies," Bocchini says.

Lehigh will use the $5 million NSF grant to fund operation of the Center. Researchers from around the world will be able to submit proposals and won't have to pay to use the facility. They'll be looking to discover ways that buildings can remain online following natural disasters. ●

ATLSS Deputy Director James Ricles says that as engineering concepts for structural systems have improved, the failure of nonstructural components has become the weak link in structural resiliency.

Illustration by **Hvass & Hannibal**

James Ricles is the Bruce G. Johnston Professor of Structural Engineering, director of the NHERI Lehigh Experimental Facility and deputy director of the ATLSS Engineering Research Center. He received his Ph.D. from the University of California, Berkeley. **Paolo Bocchini** received his Ph.D. from the University of Bologna after completing a dual-advisor program at Columbia University, where he had been a visiting scholar.

ANTHROPOLOGY

THE CHANGING FACE OF MARRIAGE IN MALI

Polygyny, a seemingly outdated vestige of rural life, has evolved into an institution compatible with modern living in urban Mali. Bruce Whitehouse examines how marriage is understood and practiced in West Africa—and the potential consequences of its changing meaning.

Whitehouse has learned that both men and women are wary of monogamy, but for different reasons.

Photography by **Katie Orlinsky**

During a wedding ceremony in Bamako, the capital city of the West African nation of Mali, couples pledge their commitment to one another in front of family and friends. Brides wear white dresses, and ceremonies are often followed by elaborate celebrations with food and dancing. At first glance, the practice of marriage in Bamako appears similar to that of many Western cultures.

A check box on the required paperwork for a legally binding civil ceremony, however, draws a distinction.

Malian law requires couples to commit to either monogamy or polygyny when they marry. Checking the box for polygyny—a form of plural marriage in which a man is allowed more than one wife—does not require a man to take another wife at any point, but it leaves the option available. If a couple commits to monogamy, they are legally bound to that type of union unless both parties agree to legally change the agreement.

Fewer than one in five couples in the capital city of Bamako check the monogamy box, says Bruce Whitehouse, associate professor of anthropology. Monogamy, says Whitehouse, has taken on something of a bad name in Bamako.

A MATTER OF TRUST

Whitehouse, who first traveled to Mali as a Peace Corps volunteer, spent 10 months conducting Fulbright-funded field research on marriage and polygyny in Bamako. He interviewed individuals and led focus-group discussions, asking Malians to share their views and experiences with marriage. He sought to figure out how marriage is understood and practiced in an urban demographic and its impact on larger Malian society.

Whitehouse learned from his interviews that it wasn't just men who didn't want to check the box for monogamy—women were wary of it as well, although for different reasons.

Men avoid checking the monogamy box in order to hold the threat of polygyny over their wives, says Whitehouse. And though marriage provides the social respectability that Malian women seek, many believe their husbands will be unfaithful, regardless of which box they've checked during the civil ceremony. They don't trust the state to uphold the contract of monogamy, so the type of commitment made during the ceremony becomes somewhat inconsequential.

"One inference that I can draw is that there's this really high degree of mistrust between men and women before they get married, and it doesn't necessarily end after they get married. Marriages are perceived as being more brittle than they used to be, and much more oriented toward material gain," says Whitehouse.

THE ECONOMICS OF MARRIAGE

For a woman in West Africa, says Whitehouse, the number one route to economic security is through marriage.

Women have always had some economic autonomy within marriage, but a husband is expected to provide housing and food for his wife and children, says Whitehouse. In a climate of economic uncertainty in which modern urban households face high unemployment rates and skyrocketing food and housing costs, women are driven to approach their relationships strategically—far from the Western ideal of love, trust and exclusivity within marriage.

"For a woman, it's through her relationships with a man or sometimes multiple men that she winds up providing for her economic needs," says Whitehouse. "Anecdotal evidence suggests that women are taking multiple partners before marriage and possibly during marriage because they want to secure their economic future. And they're coming more and more to see marriage as primarily an economic transaction."

This mindset, says Whitehouse, is causing a great deal of friction between young men and women.

"Women see men as being inherently unfaithful and inveterate liars and manipulators," he explains. "And the young women are saying, 'Well, if they're going to treat us that way, we might as well maximize our return and play these multiple partners against each other.' When you're married, you can divorce that husband and move in with somebody else if he's going to be a better provider for you. I don't think this is that widespread yet, but the fact that we're seeing it at all in this fairly conservative society is very significant."

New Perspectives

"Marriages are perceived as being more brittle than they used to be, and much more oriented toward material gain," says Whitehouse.

Bruce Whitehouse's research interests include globalization, the state, migration, medical anthropology, transnationalism and Islam. He received his Ph.D. from Brown University.

'A VERY MODERN INSTITUTION'

The urban version of polygyny, Whitehouse discovered, differs from its rural counterpart. During his time in the Peace Corps, Whitehouse lived with a polygynous family in a rural community.

"None of the adults in that family had even a primary school education," says Whitehouse. "It was easy for me to associate polygyny with that context. But you go into the urban setting, and you've got these more elite, educated, modern families, and polygyny is not only on the table, but it seems to be adapting. ... It turns out to be, in some senses, a very modern institution, or at least compatible with modern life."

While rural polygyny can create a sense of unity, with multiple wives living in the same household and raising their children as siblings, a new phenomenon of urban polygyny sees each co-wife and her children living separately and maintaining a deliberate distance from the other co-wives and their children. This arrangement, says Whitehouse, allows wives to maintain the illusion that their union adheres to certain modern norms.

"The love angle is still important and people aspire to that, but it turns out not to be achievable for a lot of them in their daily lives," he explains. "So they wind up falling back on strategies that they hope will at least provide them with some kind of security."

Regardless of intent or approach, marriage is an obligation in Mali, says Whitehouse. Changes to the meaning and practice of the institution affect the entire society.

"It's not a question of if, it's when you're going to get married, and how much of your life you're going to stay married," he says. "[Aside from that certainty], we're seeing that almost everything else connected to marriage is changing in West Africa. I think this is going to put a great deal of stress—already has put a great deal of stress—on relations between men and women, parents and children. I think it's going to have very far-reaching consequences." ●

Whitehouse says "almost everything ... connected to marriage is changing in West Africa." And as a result of the tumult, he fears potential long-term complications for family life in the region.

Instability in Mali

In early 2012, strengthened by arms from the 2011 civil war in Libya, rebels and Islamist militants gained control of northern Mali, upsetting the country's relative stability. The nation then experienced a military coup in March of that year, and Islamist rebel groups capitalized on the chaos. A French-led offensive intervened, but remaining militant groups have since attacked Malian soldiers and United Nations peacekeepers. More recently, an attack on a luxury hotel in Bamako in November 2015 targeted civilians. Twenty-two people were killed.

Whitehouse's blog, bridgesfrombamako.com, provides insight into a nation roiled by unrest and corruption. He writes about the experiences of friends and acquaintances living in Mali.

"That's how I like to handle some of these big sweeping issues as an anthropologist—to look at it from the lens of particular individuals who are grappling with it in their own lives," he says.

Whitehouse's expertise is frequently sought by the U.S. government and the governments of other nations, journalists and non-governmental agencies working in the region. He recently coordinated a special issue of the journal *African Security* examining the big picture of state sovereignty in Mali and throughout northwest Africa.

"Journalists want to know what might happen next," says Whitehouse. "I don't know what might happen next. I don't think I'm a pessimist. I try to be hopeful for the future, but I also try to be a realist. ... Under the surface there's a lot that's wrong, and those problems that had accumulated during the period before the coup, most of them still haven't been addressed. So I try to draw attention to those problems. They have to do with really basic things like the rule of law, corruption."

MUSIC

A REQUIEM BY AND FOR CHILDREN

Steven Sametz's 'A Child's Requiem' honors the children and adults killed during the shooting at Sandy Hook Elementary School in 2012.

Steven Sametz says ***A Child's Requiem*** represents a "collision between the adult world and the world of innocence."

March 5, 2015 marked the premiere of Lehigh composer Steven Sametz's oratorio, *A Child's Requiem*, written to honor the 20 children and six adults who were killed during the shooting at Sandy Hook Elementary School in 2012. At the first performance of the piece, held at the University of Connecticut's Jorgensen Center for the Performing Arts, the university's Symphony Orchestra and Concert Choir joined the Chorus Angelicus Children's Choir, soprano Janani Sridhar and tenor Gregory Zavracky under the direction of Jamie Spillane.

Sametz, the Ronald J. Ulrich Professor of Music and director of Lehigh University Choral Arts, wrote *A Child's Requiem* with a commission he received in 2013 from the University of Connecticut when he won the 10th Raymond and Beverly Sackler Music Composition Prize. The prize carried an award of $25,000.

In an interview conducted by Silagh White, director of arts engagement and community cultural affairs at Lehigh, and Andrew Cassano, administrative director of the university's Zoellner Arts Center, Sametz described *A Child's Requiem* as "a response to a child's loss and grief."

The Sandy Hook Elementary School shooting occurred on Dec. 14, 2012, in Newtown, Conn., and was the deadliest mass shooting at a high school or grade school in U.S. history. Sametz, a native of Westport, Conn., said *A Child's Requiem* "revolves around a libretto, much of which was written by children."

"I HOPE TO OFFER THIS PIECE AS A GIFT TO THE TOWN OF NEWTOWN AS THEY HEAL FROM THEIR TRAGIC LOSS."

"It's paired with lines from [the American poets Ralph Waldo] Emerson and [Emily] Dickinson and H.D. [Hilda Doolittle, who was born in Bethlehem]. It's kind of a collision between the adult world and the world of innocence.

"I hope to offer this piece as a gift to the town of Newtown as they heal from their tragic loss."

Sametz, who is also the artistic director for the Princeton Singers, an elite singing group, has received commissions from the National Endowment for the Arts, the Connecticut Council on the Arts and the Santa Fe Music Festival. He has also composed music for Chanticleer, the Dale Warland Singers, the Philadelphia Singers, the Pro Arte Chamber Choir, the Santa Fe Desert Chorale, the Connecticut Choral Artists and the King of Thailand.

His recent guest-conducting invitations include appearances with the Taipei Philharmonic Foundation, the Berkshire Music Festival, the New York Chamber Symphony and the Netherlands Radio Choir.

The Lehigh Valley premiere of the oratorio included 300 musicians: the 65 student musicians of the Lehigh University Choir and the 160-member Lehigh Choral Union, which comprise part of Lehigh Choral Arts, as well as the Princeton Singers, Princeton Girlchoir, an orchestra, soprano Tami Petty and tenor David Vanderwal. ●

Steven Sametz is the founding director of The Lehigh University Choral Composer Forum, a summer course of study designed to mentor emerging choral composers. He serves as the national advisor on composition for the American Choral Directors Association. In 2014, Sametz conducted his choral symphony, *Carmina amoris*, with more than 200 Lehigh singers, soloists and orchestra at Carnegie Hall. He holds a D.M.A. from the University of Wisconsin-Madison.

MANAGEMENT

BEYOND 'BLANKET TRUTHS'

Corinne Post strives to better understand the circumstances in which women thrive as leaders—and what makes them more successful than men.

U.S. Senate Majority Leader Harry Reid beside a screen showing a clock counting down to a government shutdown, at a news conference in Washington in 2013.

In the fall of 2013, the U.S. government, held hostage by a venomous and deadlocked Congress, just barely averted a crippling default on its debt—an event that could have caused a crisis nowomt just on Wall Street, but throughout the entire world economy. The nation—and the world—had a handful of women to thank.

Lawmakers had for weeks been locked in a historic budget showdown that ultimately saw almost the entire federal government shut down. Nearly a million federal workers were sent home. Vital services were eliminated. And the cost to the U.S. economy counted? According to some estimates, it ran in the billions.

Even despite the massive costs, however, the political fighting raged. As the standoff dragged into mid-October, Republicans and Democrats remained far from an agreement on the central issue of the shutdown—President Obama's Affordable Care Act—and it seemed increasingly likely that the shutdown would linger on. The debt default, and all its frightening impacts, loomed as a real possibility.

That's when a bipartisan coalition of women from the U.S. Senate stepped up to end the crisis. Maine Republication Susan Collins kick-started the effort, and quickly found allies in Republican colleagues Lisa Murkowski of Alaska and Kelly Ayotte of New Hampshire, as well as Democratic senators Barbara Mikulski, Amy Klobuchar, Jeanne Shaheen and Heide Heitkamp.

The women held wildly different political views, but they also realized the nation, at that moment, needed a great deal less partisanship and a whole lot more leadership. Within short order, Collins and her team colleagues garnered enough support from their male colleagues to bring the shutdown to an end.

"I don't think it's a coincidence that women were so heavily involved in trying to end this stalemate," Collins would tell The New York Times shortly thereafter. "Although we span the ideological spectrum, we are used to working together in a collaborative way."

Added Sen. John McCain of Arizona: "Leadership, I must fully admit, was provided primarily from women in the Senate."

Perhaps not surprisingly, the media was quick to seize on the story, with Time magazine covering Collins' effort under a headline that read, "Women Are the Only Adults Left in Washington."

For Corinne Post, the 2013 government shutdown—not only the way the women helped solve it, but also the way that effort was portrayed in the media—served as timely motivation to continue work focused on women leaders in the workplace. Post, an associate professor of management at Lehigh, has long been studying issues surrounding workplace diversity, and has a particular interest in investigating how diversity can best be leveraged to enhance innovation and performance within corporations and other organizations.

Looking back on the shutdown today, Post says she recalls feeling as though the media coverage didn't quite ring true.

And there was one basic reason why: It was all just far too simplistic.

"As a researcher, I'm always skeptical about blanket truths," Post said. "It's unlikely that women are always better leaders. My question was, in what type of contexts would they be more likely to make a positive difference? Are there certain qualities and characteristics that make women better leaders?"

> "IT'S UNLIKELY THAT WOMEN ARE ALWAYS BETTER LEADERS. MY QUESTION WAS, IN WHAT TYPE OF CONTEXTS WOULD THEY BE MORE LIKELY TO MAKE A POSITIVE DIFFERENCE?"

It's a question that Post had been exploring for years before the shutdown. In one particularly revealing study, she examined 82 teams, representing more than 800 people, who worked at 29 leading research and development companies. The

Rising to the Challenge

Sen. Susan Collins was a key figure in the movement to end the government shutdown in 2013—and she was backed by a coalition of several other female senators as well.

Corinne Post holds the Scott Hartz '68 Term Professorship and her research interests include diversity management; performance and innovation; gender, racial and ethnic differences in individual work experiences; career trajectories; work-family conflict; and women on boards of directors. She received her Ph.D. from Rutgers University.

data were collected in 2008 and 2010 and supported by part of a $265,000 National Science Foundation grant.

The idea of the study was not to come to the final answer as to which sex is more adept at leadership—such an answer, Post says, very likely does not exist—but rather to pinpoint the strengths unique to each, as well as some the organizational circumstances in which each are more likely to thrive—or fail. Her study helped her do precisely that.

According to her findings, which were published in the Journal of Organizational Behavior, women appear to excel in the unique and important management task of unifying large, diverse and complex teams—teams that consist of individuals from different departments with diverse specialties, and teams whose members are spread out over a large geographic area. Such teams are notoriously difficult to manage, simply because workers in them don't necessarily understand each other, or the work each respectively contributes.

Post found that women proved themselves to be adept in leading teams to bridge the sometimes wide gaps—in function, and in culture—between team members. Most likely, she says, that's because women tend to be more aware of potential relationship problems and possibilities than men—and more willing and able to repair those relationships, too.

Supporting this hunch, Post found that the more complex teams she studied that were managed by women had greater cohesion and more positive, beneficial and constructive interactions than similarly complex teams that were managed by men. The individuals who reported to those women leaders, Post says, felt that they "had a voice."

"There appear to be some key differences between men and women in the context of how they relate to others," Post says. "Men will generally think independently, while women will think more interdependently. This makes them more likely to see success leading functionally diverse teams—those where the different groups inside of that team don't necessarily understand each other, or trust each other, or even speak the same language, or even teams that simply are located in different places geographically."

Moving forward, Post plans on continuing her work into the unique leadership styles and skills of women and men, with the goal of unearthing additional specific situations in which one sex or the other may be more effective, generally speaking, when it comes to organizational success. Prompted by the aversion of a political and budget crisis on the senate floor, she is also turning her attention to understanding the potential role of female leadership styles in preventing and mitigating organizational crises.

"I'm interested in trying to unravel this a bit more," she says. "Really, what are the qualities that women leaders bring to the workplace? I don't see this work as being about elevating women. It's about pulling out their unique – and sometimes invisible – behaviors and understanding how they might deliver better outcomes." ●

Post's work shows that women are more likely than men to be successful when leading large, diverse and complex teams.

Women on Boards

Post's work about women team leaders ties into related research on women on corporate boards, which, popular culture claims, universally boosts firms' performance.

But this notion doesn't jive with the extensive body of research that shows mixed evidence about the advantage, for firms' bottom line, of female directors in the boardroom. Post and Kris Byron of Syracuse University gathered 140 studies linking women on boards and firm performance. The studies were divided into two groups: One set was examined for accounting returns, profitability, or how well the company used assets to generate earnings; the other for performance as defined by the market or shareholders.

Post and Byron found female board representation to be positively related to profitability. Moreover, that relationship is more positive in countries with stronger shareholder protections, perhaps because shareholder protections motivate boards to use the different knowledge, experience, and values that each member brings to the board. (Without such a strong motivation, the voices of female directors, when they are in the numerical minority, sometimes are not heard or discounted.)

The analysis also revealed that while there is little relationship between female board representation and market performance, the relationship is positive in countries with greater gender parity and negative in countries with low gender parity. Additionally, Post and Byron found that female board representation is positively related to boards' two primary responsibilities—monitoring and strategy involvement.

AFRICANA STUDIES

A SCHOLAR'S CRITICAL PLAYLIST

From hip-hop to mass incarceration, James Peterson seeks to spark meaningful discussion about diversity among a wider audience.

Peterson says *Hip-Hop Headphones* "tries to define what hip-hop culture is."

Illustration by **Vincent Skyers**

You need to reach a lot of people to bring about understanding and change. James Braxton Peterson wants to reach as many as possible.

Peterson has long been interested in media and public writing. As host of "The Remix," a podcast on Philadelphia NPR affiliate WHYY, he engages issues at the intersection of race, politics and popular culture. He is an MSNBC contributor and has also appeared on Al-Jazeera, CNN, HLN, Fox News and other networks. His writing has appeared in the *Huffington Post*, *The Guardian*, *Reuters* and *The Daily Beast*.

But now, he says: "It's time for me to reach an even broader audience."

With his first book, *The Hip-Hop Underground and African American Culture*, Peterson explored the concepts that lie at the intersections of African American literature and underground hip-hop, a culture he describes as "a bit more politically and socially conscious." His second book, *In Media Res*, examined a range of societal issues through an edited collection of creative work by scholars, activists and artists.

Peterson, associate professor of English, calls his most recent project, *Hip-Hop Headphones: A Scholar's Critical Playlist*, his most personal. Expected in May 2016 and billed as "a crash course in hip-hop culture," the book is intended for use by educators teaching courses on hip-hop culture as well as their students.

For years, schools and other educational entities have asked Peterson for help in implementing hip-hop culture in classrooms as an educational tool. He hopes the book can provide similar assistance.

"[*Hip-Hop Headphones*] tries to define what hip-hop culture is. It includes a lot of me thinking about this concept of critical listening: What are the educational advantages to listening to music critically, to thinking about social justice issues in the music and the culture? How do we cultivate those skills in the classroom space?" Peterson explains. This book, he says, is also his most accessible to date.

Along those lines, Peterson has been working with For Beginners, a graphic non-fiction series, on an illustrated book about mass incarceration in the U.S. prison system. *Prison Industrial Complex for Beginners*, also expected in 2016, will help readers understand and think more systematically about the fundamental concepts of mass incarceration. Visual artist John Jennings, who illustrated the cover of Peterson's first book, is creating visual renderings of the book's concepts.

"It's a book that you should be able to use in high schools, that prisoners should be able to read to get a better sense of the system they're caught in," says Peterson. "It should be very accessible to average readers."

Ultimately, Peterson wants to help society thoughtfully and effectively navigate issues of diversity and inclusion, which have moved to the forefront of public discourse both nationally and at Lehigh.

"I was hired at Lehigh to do a lot of different things," he says. "I hope I can be part of the solution of figuring out how we get where we need to be as a 21st-century, hopefully global, institution." ●

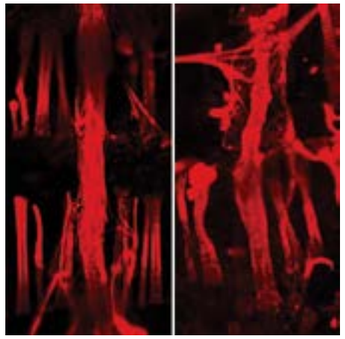
James Braxton Peterson is director of Africana Studies at Lehigh. He is the founder of Hip Hop Scholars, LLC, an association of hip-hop generational scholars dedicated to researching and developing the cultural and educational potential of hip-hop, urban, and youth cultures. He received his Ph.D. from the University of Pennsylvania.

A HEART-HEALTHY LASER

Chao Zhou has received a $500,000 grant from the National Institute of Biomedical Imaging and Bioengineering to continue his work exploring the use of light as a possible alternative stimulator for artificial pacemakers.

As electrical systems go, the human heart is one of nature's most durable. Every minute, your heart beats about 80 times; every hour, nearly 5,000 times. By the time you are 70, you will have recorded about 3 billion heartbeats.

Each of those heartbeats is a marvel of coordination between the heart's four chambers—the right and left atria, and the right and left ventricles. As the atria fill with blood, an electrical signal is generated that causes both to contract and push blood into the ventricles. The ventricles then contract and push blood through the pulmonary and aortic valves and out to the rest of your body. The ventricles then relax, the atria fill again with blood, and the cycle repeats.



Zhou's group has also used optical coherence microscopy to study the influence of the circadian rhythm gene on the fruit fly heart.

Illustrations by **Nicolle R. Fuller**

If injury or disease disrupts your heart's electrical system, you can be fitted with a battery-powered pacemaker that signals the cardiac tissue, helping your heart regain its regular rhythm. Electric pacemakers are used today by an estimated 3 million people around the world.

Pacemakers have helped scientists learn more about the heart's physiology and its disorders, says Chao Zhou, but they have their limits. They must be surgically implanted. They are not specific to heart tissues and can cause unwanted contractions in other areas of the chest. They produce inhomogeneous areas of depolarization and can also generate toxic gases, alter pH levels and cause tissue damage.

Zhou, assistant professor of electrical and computer engineering, and his colleagues have taken the first step toward developing a laser pacemaker that could one day stimulate the human heart noninvasively with light signals.

The researchers have built a microscope that paces the tiny heart of the common fruit fly without touching it, while simultaneously controlling its heart function, monitoring its performance and taking high-resolution images of it at the microscale.

The system uses two optical technologies—optical coherence tomography (OCT) and optogenetics—to generate pulsed blue light signals that pace the fruit fly's heart during the three stages of its life: larva, pupa and adult.

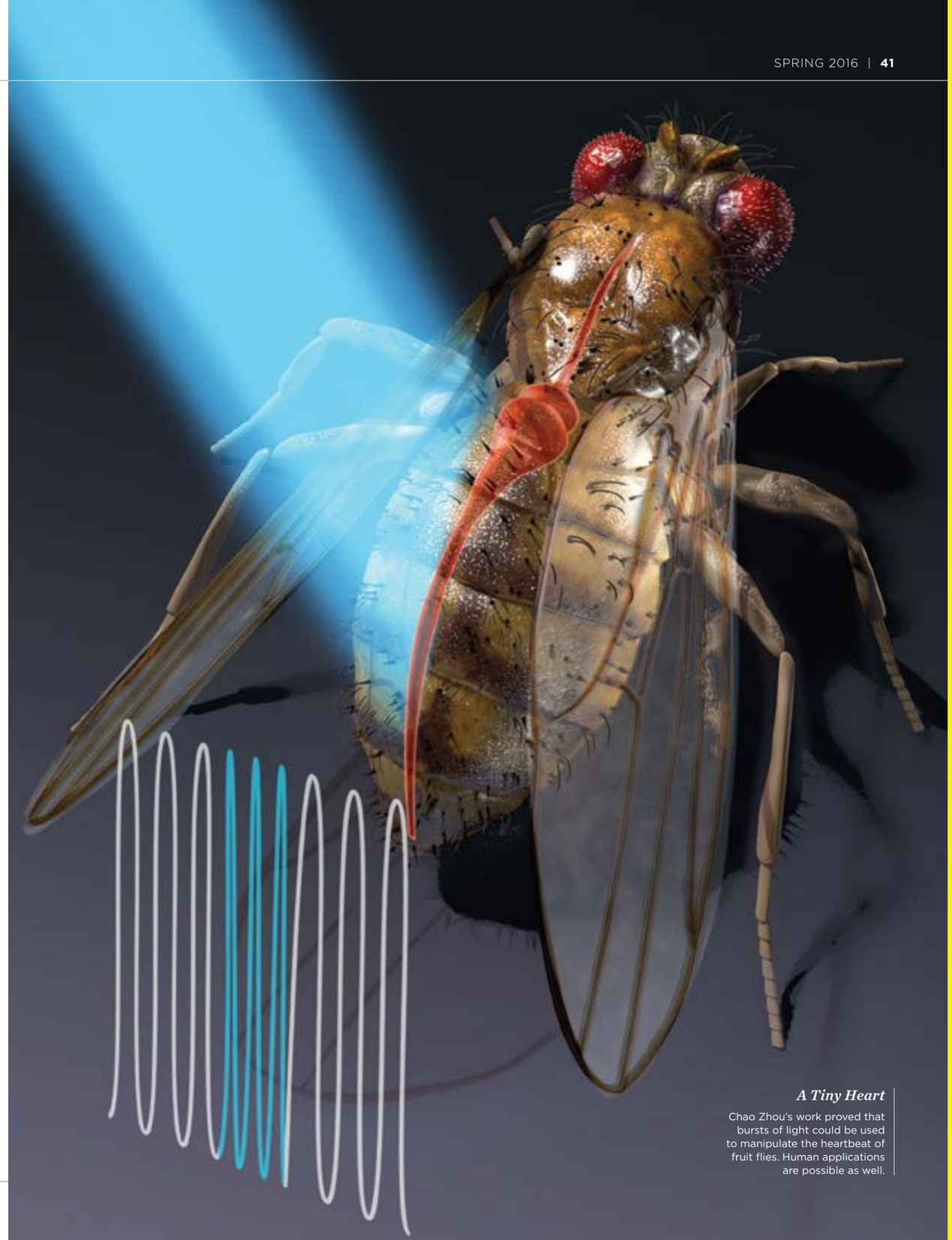
The group reported its results recently in *Science Advances,* a journal published by *Science* magazine. Their article, titled "Optogenetic pacing in *Drosophila melanogaster*," was written by Aneesh Alex, a former postdoctoral research scientist at Lehigh, and co-authored by Zhou and by Airong Li and Rudolph E. Tanzi, both of the Genetics and Aging Research Unit of Harvard Medical School's Department of Neurology. The project has been funded by the National Institutes of Health (NIH).

Optogenetics uses light to control and study the activities of living cells that have been genetically modified with a light-sensitive protein. OCT combines light waves, usually from the near-infrared portion of the electromagnetic spectrum, with interferometry to capture microscale images from deep within biological tissue and other media that scatter optical signals.

Optogenetics was invented by researchers at Stanford University a decade ago to study nerve cells. In 2010, says Zhou, two other groups published articles about the use of optogenetics to pace the heart of the zebrafish. At that time, Zhou, a postdoctoral researcher at the Massachusetts Institute of Technology, was using OCT to study fruit flies in collaboration with researchers from Harvard Medical School.

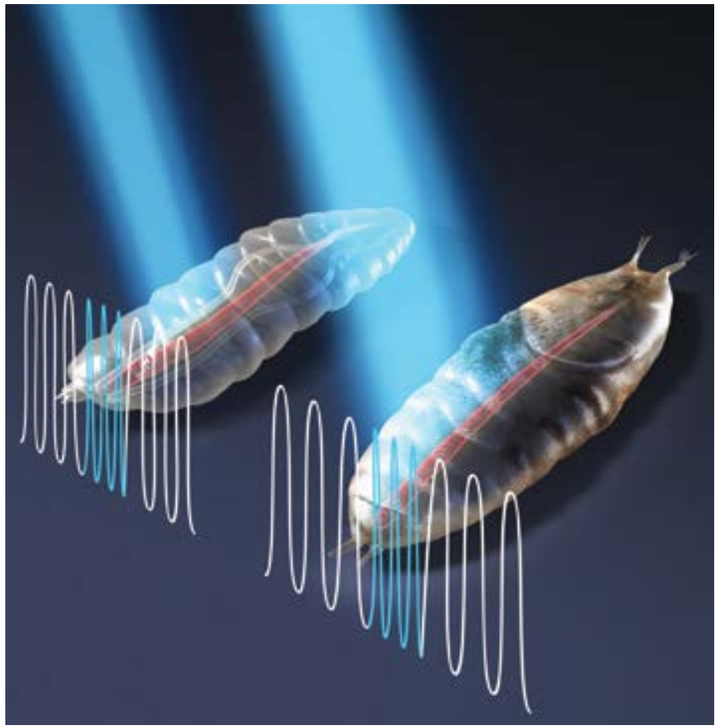
"NIH had awarded me a grant to improve OCT technology to enable the molecular imaging of cell features," says Zhou. "I came up with a new idea, which was to use optogenetics to stimulate heart pacing and OCT to monitor heart function.

Chao Zhou's research interests include biomedical optics, optical coherence tomography (OCT), optical coherence microscopy (OCM), diffuse optical spectroscopy/imaging and laser speckle imaging. He received his Ph.D. from the University of Pennsylvania and served as a postdoctoral associate at the Massachusetts Institute of Technology.



A Tiny Heart

Chao Zhou's work proved that bursts of light could be used to manipulate the heartbeat of fruit flies. Human applications are possible as well.



Optogenetic pacing can be performed at different developmental stages of the fruit fly.

"We found that we could shine a light to control the heart rhythm and then use OCT to confirm that the heart was beating and to see how it was beating. We used OCT to see the fly's heartbeat in real time."

The fruit fly, known scientifically as *Drosophila melanogaster*, offers several advantages for optical study, says Zhou. First, biologists have obtained the complete genome sequence for the fruit fly and developed many ways to modify the genome. Second, despite differences in scale and complexity between humans and fruit flies, Zhou says, the genomes of the two members of the animal kingdom are surprisingly similar.

"For human beings and fruit flies," says Zhou, "70 to 80 percent of the genome is the same. You can easily test a human gene type in the fruit fly and then in a mouse."

The heart of a typical adult fruit fly lies about 200 microns below the fly's outer tissue surface. It varies in size between 10 and 20 microns when contracting and about 100 microns when dilating. And the heart beats 300 to 400 times per minute.

"It is possible to observe the heartbeat of an intact fly with near-infrared OCT technology," says Zhou. "And because the fruit fly heart is so small, we need a very sophisticated imaging technique with a high resolution that works very quickly. Otherwise, the image we get is very blurry."

To begin their experiments, Zhou and his group bred a genetically altered strain of fruit flies by inserting a light-sensitive protein (taken from algae) into their cardiac cells. Then they anesthetized a fly, taped its wings to a glass microscope slide and shined a low-power, 16-milliwatt blue laser at its heart. When the researchers changed the frequency of the laser, they observed a corresponding change in the heart rate of the fly. When the laser pulsed 10 times per second, for example, the heart rate accelerated to 10 beats per second, in perfect synchronicity with the laser.

To monitor the fruit fly's response to the laser, Zhou and his group developed an optical coherence microscopy (OCM) system that enables nondestructive imaging in real time at microscale resolution. Using OCM, the researchers were able to monitor and analyze the structure and function of the fly heart at the larva, pupa and adult stages.

"OCT is like ultrasound, which sends high-frequency sound waves into tissue and then measures the reflection," says Zhou.

"OCT is similar. It uses near-infrared light instead of sound. The light has a shorter wavelength than the sound waves, which gives us much finer resolution, at the microscale. As the light is reflected from different depths of tissue, the delay in the reflecting of the light signal tells you how deep the signal has penetrated into tissue. From this, we can generate a cross section of a sample from beneath the surface of the tissue."

The use of optical coherence microscopy, the researchers wrote in *Science Advances*, allowed the group to "quantitatively determine cardiac physiological parameters, such as refractory period [recovery time] and contraction time, of the *Drosophila* heart at different stages of its life cycle."

After the group concluded its experiment, the fly continued its normal development.

"One of the key advantages of our system is that it is completely noninvasive," says Zhou. "We can do experiments over and over again on the same specimen.

"If you sacrifice animals during experiments, you obviously cannot use them again. This makes it difficult, if not impossible, to study the developmental stages of the same animal. With noninvasive optical stimulation and imaging, however, you can see how the same fly heart grows and develops."

During the course of their three-year study of the fruit fly, Zhou and his collaborators have observed that the fly's heart slows down in the early pupal stage, stops beating for about a day, and then resumes beating and restores its normal heart rate of 300 to 400 beats per minute in the late pupal and adult stages.

"We were the first group to observe this dynamic change in the fly heart rate," says Zhou. "Nothing in the literature showed this. It is difficult to detect it without the noninvasive imaging tools we have."

Zhou's group has also used optical coherence microscopy to study the influence of the circadian rhythm gene on the fruit fly heart. Circadian rhythms refer to oscillations in an organism's physical, mental and behavioral processes, including levels of hormones expressed. These rhythms result from environmental cues. They often follow a 24-hour cycle, and they vary from day to night.

In a paper published in September by *PLOS ONE* (the Public Library of Science), Zhou and his collaborators from Harvard Medical School, joined by researchers from Zhengzhou University in China, reported that the circadian clock gene plays a major role in the development of the structure and function of the fruit fly heart.

Their study, the researchers said, was one of the first to be conducted in a whole animal *in vivo* that explored the role that circadian clock genes play in heart development and function.

In the *PLOS ONE* article, Zhou's group reported that expression levels of one of the fruit fly's circadian clock genes, cryptochrome (dCry), increase significantly during the fly's pupal and adult stages. Reductions in those levels, they wrote, "resulted in a slower heart rate, a reduced cardiac activity period, a smaller heart chamber size, pupal lethality and disrupted posterior segmentation.

"Collectively, our studies provided novel evidence that the circadian clock gene … plays an essential role in heart morphogenesis and function."

Zhou, who recently received a second grant from the NIH's National Institute of Biomedical Imaging and Bioengineering to explore different pacing strategies using OCM, says it will take many years before optical pacemakers can be used in humans.

"Our initial goal was not to develop optogenetic pacing for humans," he says. "That day is very far off. Instead, we wanted to do this in small animals in order to verify and refine the effectiveness of using near-infrared light signals to stimulate and image heart muscle cells. Also, we wanted to find out how different genes affect heart development. To learn this, we first needed to develop a good research tool.

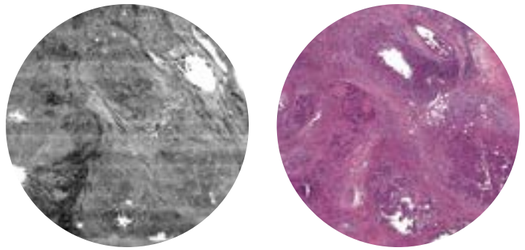
"With bigger animals come challenges. How do you insert light-sensitive proteins? How do you do near-infrared simulation? An optical fiber or LED would need to be implanted, which is invasive. Also, near-infrared light waves will scatter, but without being completely lost. You would have to guide this light to the region where you want it in order to do optical pacing."

ZHOU BELIEVES HIS WORK WITH OCT AND OCM OFFERS A POWERFUL RESEARCH PLATFORM TO STUDY FUNDAMENTAL MECHANISMS OF HEART DISEASES.

Improving the ability to do noninvasive pacing with optical signals, however, can also help advance the development of novel medical treatments, says Zhou.

"For example, if a person is born with a congenital defect in his heart, can we shine a light on his heart, when he is in his early developmental stages, to help correct the defect? Can we use therapeutic tools to correct human diseases?

"We don't know the answer to these questions yet. We're still at the hypothesis stage, but the technology now exists to make it possible to think about them."



Above: Side-by-side comparison of OCT image (left) and histology (right) of invasive ductal carcinoma, a common form of breast cancer. OCT was done in minutes; histology takes several days.

Shedding New Light on Biopsies

Physicians often take biopsies to make clinical diagnoses. Tissue samples removed from the patient are placed in wax, cut into very thin slices, stained and examined under a microscope. This process is labor-intensive and takes time, leaving worried patients waiting for days or sometimes weeks for results. During surgery, removed tissue samples are sent for similar histological evaluations. Some patients must return for a second surgery if doctors discover that a portion of a tumor remains after the original surgery.

"It's a clinical practice, but it's not ideal," says Zhou.

He and his team think there's another way: the optical biopsy. Optical coherence tomography (OCT) and optical coherence microscopy (OCM) have the potential to change the face of cancer detection and evaluation. Conceptually similar to ultrasound but using near-infrared light instead of sound, optical biopsies can reduce or even eliminate the need for tissue excision and processing by providing in situ 3-D structural and functional images of tissue microstructure with a cellular resolution close to that of histology. With OCT and OCM, results can be obtained within minutes.

Zhou and his colleagues conducted a study in which three pathologists blindly read their images of human kidney samples. They then compared the diagnoses, which were remarkably accurate: over 80 to 90 percent.

"We send the light in, detect the reflected light, and we figure out where the reflected light is coming from. That gives us depth information with micron-scale accuracy. … Once you know from a single point what the reflectivity of different depths [of tissue] is, then you can move your light beam along the tissue surface and get a cross-sectional image of the tissue. Then you move the beam over a square and you get an entire 3-D picture of the sample," explains Zhou.

Right now, optical biopsies face practical limitations. Depth, for example, is a challenge. So far, OCT and OCM work only with some superficial tumors such as skin cancers. In cases of breast cancer, an imaging probe might aid during surgery to identify areas of potential concern and possibly help reduce the need for a second surgery. For now, Zhou is working on how they might improve the surgical procedures using this technique.

"We're pretty optimistic that with further development, we can make this real-time optical biopsy possible, and that can hopefully change the clinical practice," says Zhou.

EARTH & ENVIRONMENTAL SCIENCES

AN ENIGMA IN MONGOLIA

Seismologist Anne Meltzer and an international team of researchers study the Hangay region of Mongolia in an effort to gain better understanding of the generation of large earthquakes.

Near the geographic center of Asia, north of China and Tibet and south of Russia, the Hangay and trans-Hovsgol mountain ranges cover about 425,000 square kilometers (164,000 square miles) of Mongolia and look out over an arid and mostly treeless steppe.

Occupying half of this region and embedded in its center, the Hangay Dome rises to heights of 4,000 meters (13,000 feet)—about 1,500 meters higher than the surrounding topography.

High topography in continental interiors is unusual, says Anne Meltzer, and this makes the Hangay a unique opportunity for scientists who study the processes that shape the earth's surface.

Meltzer, professor of earth and environmental sciences, leads an international team of two dozen researchers who have spent six years studying the Hangay region with a National Science Foundation grant. The team has expertise in geomorphology, geochronology, thermochronology, paleoaltimetry, biogeography, petrology and geochemistry, and includes scientists from the Mongolian Academy of Sciences.

Researchers install a broadband seismic station at the Hangay Dome in central Mongolia. A family of "station keepers" watches over the security of the seismic station during the two-year recording period.

In addition to exploring the earth's geologic history, says Meltzer, the team hopes to shed light on the connections among continental deformation, the development of topography and global climate.

"A high topography influences the circulation of the atmosphere," she says. "The region of Mongolia influences the movement of air masses and storms on a global scale with far-reaching impacts on weather and climate. Also, in the early 1900s, there were four magnitude-8 earthquakes on faults that pass on either side of the Hangay. Large magnitude earthquakes are rare within continents. Starting in 2005, there were swarms of smaller earthquakes around Ulaanbaatar, the capital of Mongolia, where most of the country's population, government, and business is located.

"Our work sheds light on the processes and structures that generate large earthquakes. The Mongolians take a keen interest in this."

In her work, Meltzer buries seismometers at strategic sites in the Hangay region. The instruments can detect earthquakes equal to or larger than magnitude 5 anywhere in the world. The instruments recorded the devastating earthquake in Nepal in April 2015, as well as the recent nuclear test in North Korea in 2016. The instruments are sensitive enough to also pick up the footsteps of a passing goat. The elastic waves generated by earthquakes propagate through the earth, says Meltzer, and by imaging them it is possible to open a window into the subsurface of the earth, from near the surface to deep into the interior. One puzzle that intrigues Meltzer and her colleagues is the dramatic difference between the height of the Hangay Dome and the elevation of the surrounding landscape. The relatively high topography of the Dome, she says, is a feature more commonly found near the edges of continents, where the thick, rigid tectonic plates making up the earth's outer layer collide.

"We know," says Meltzer, "the plates are in motion at the earth's surface, colliding to form mountains and subducting [sliding beneath each other] to form volcanic regions. Generally the interior regions of continents do not deform and have elevations closer to sea level. But in the Hangay we see high topography, and the question is why."

The researchers have examined several factors that might answer that question.

"The continental crust of the Hangay Dome looks to be thicker than the average continental crust," says Meltzer. "This helps support the topography. If you look deeper inside, the lithospheric plate [the crust and rigid part of the upper mantle] appears anomalously thin, and the deeper, warmer part of the mantle is closer to the surface. This could account for the relative height of the Hangay Dome."

The team has concluded that the high topography is a function of several processes. Early plate collisions, says Meltzer, thickened the crust, producing a state of gravitational equilibrium between the earth's crust and mantle that allows the crust to "float" at a high elevation.

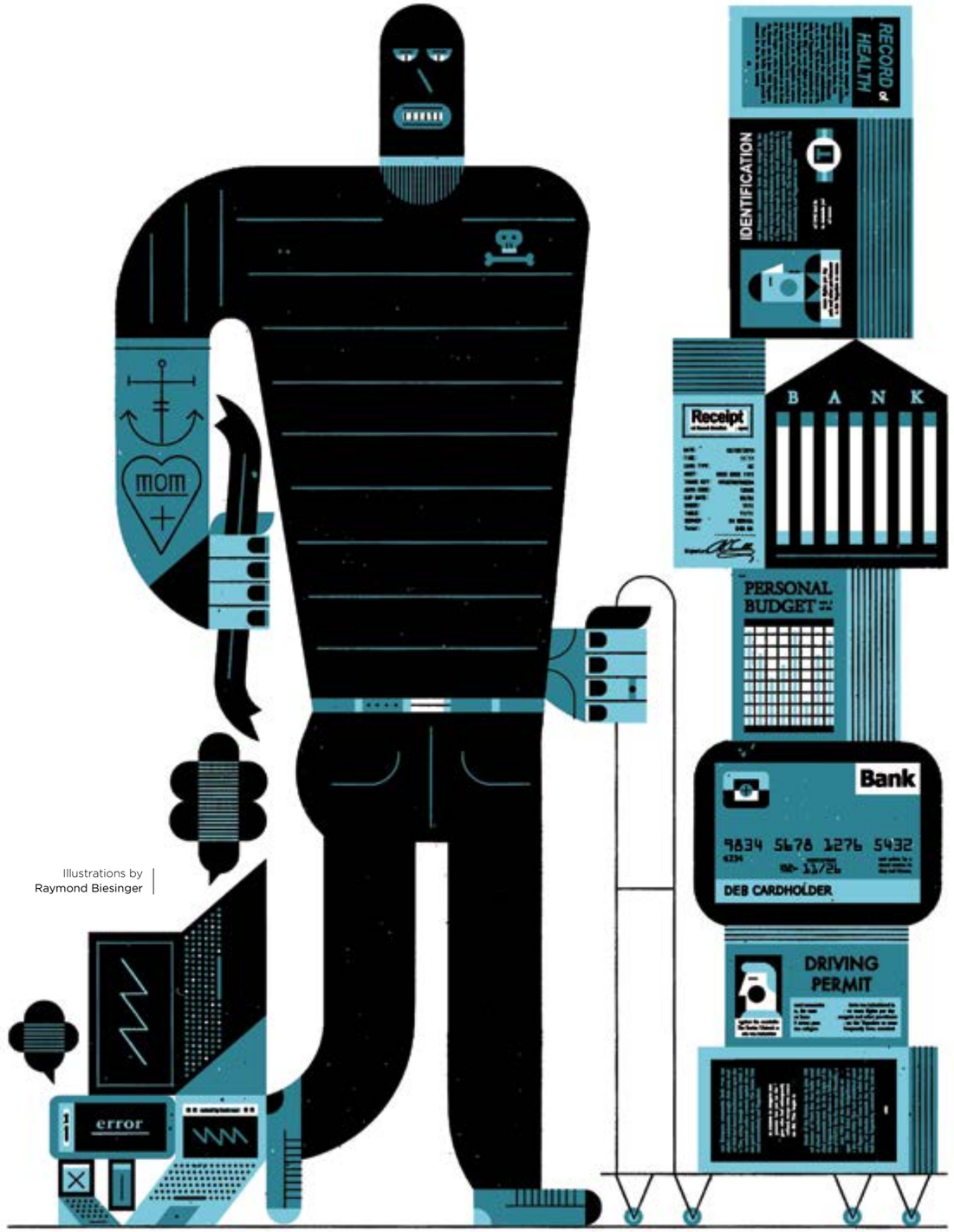
"It's like an iceberg," says Meltzer. "We see the tip of the iceberg but not the larger mass below the water. With the Hangay, we see a high mountain, but underneath is a root of low-density material propping it up. Its relative thickness makes the crust more buoyant and therefore capable of supporting a high topography like that of the Hangay in the interior of a continent."

A second process, says Meltzer, could be a dynamic flow of material inside the mantle that generates high topography.

Meltzer is looking to start a new research project in Indonesia. "The relative motion of the Indian, Australian, and Eurasian plates provides an opportunity to study the transition from plate subduction to continental collision."

The country is at considerable risk from seismic hazards. "We hope to get undergraduates involved from Lehigh and Indonesia. One outcome from this research would be a better understanding of the seismic hazards and how to mitigate the risk of these hazards." ●

Anne Meltzer is the first Francis J. Trembley Chair in Earth and Environmental Sciences. She studies earthquakes and the structure of the earth through naturally and artificially generated seismic waves. Meltzer has conducted research in Pakistan, Tibet, Mongolia, North and South America, and the Caribbean. She is a former chair of the board of directors of the Independent Research Institutions for Seismology (IRIS) and received her Ph.D. from Rice University.



Illustrations by
Raymond Biesinger

‘CAN WE TRUST THE SYSTEMS?’

Unfortunately, the answer is: sometimes yes, but sometimes no. At Lehigh, researchers across numerous disciplines are working to thwart hackers and data thieves, with the ultimate goal of creating a world of trustworthy computing.

You’re feeling sick and can’t get to a doctor, so you post a question about your symptoms on an online health forum. In doing so, you’ve left a digital footprint.

You’re hungry and in an unfamiliar neighborhood, so you use your smartphone to search for restaurants. Another footprint.

You frequent a particular online vendor, so you store your credit card information in your account to expedite checkout. Yet another footprint.

Regardless of how you’ve used your computer or mobile device, when you enter information into a website, search engine or social media platform, you’ve left a digital breadcrumb of sorts that can potentially be seen or tracked by others.

“We have left so many footprints on the Internet, and we have no idea what type of information we have left,” says Ting Wang, assistant professor of computer science and engineering. “[And] if someone wants to dig in, they can find out.”

There’s no shortage of digging going on, either. When former National Security Agency subcontractor Edward Snowden leaked classified information in 2013 about the NSA’s surveillance activity, he triggered a global conversation about privacy in an age where most everything, including our personal data, is digitized.

“Privacy, whether it’s abused by attackers or whether it’s abused by our own government, is a very big concern,” says Daniel Lopresti, professor and chair of computer science and engineering and director of Lehigh’s Data X Initiative. “So privacy and security go together hand in hand, and the bigger rubric is trustworthy computing—can we trust the systems?”

Today, individuals with malicious intent operate from anywhere in the world, attempting to access and manipulate software, networks, physical systems and the data stored within each of them. The protection of personal information has become a critical issue, and Lehigh researchers are working to strengthen our systems and bolster user trust in a variety of ways.

DEMONSTRATING THE PROBLEM

The ultimate goal in privacy research, says Wang, is to raise people’s level of concern by making them aware of the risk. In one area of his systems-based work, Wang and his team use data mining and machine learning tools to understand and quantify privacy risk.

Many online systems request basic personal information, such as age, sex and ZIP code, but allow users to operate under pseudonyms or avatars, providing a sense of privacy. In not providing a full name, people assume they can’t be identified.

“Many think this is effective protection,” says Wang. “[But] there are attacks that can break the protection and reveal some sensitive information about people.”

Even without immediate access to names, an attacker can use what’s known as a “linking attack,” connecting one particular dataset with public datasets such as voter registration lists. Correlating the datasets can reveal user identities. In fact, says Wang, 98 percent of United States citizens can be uniquely identified by just three attributes: ZIP code, age and gender. In the case of medical information, correlating data can reveal such private details as an individual’s disease or other health affliction.

In a recent paper currently under submission, Wang and colleagues Shouling

Ji, Qinchen Gu and Raheem Beyah, all of the Georgia Institute of Technology, demonstrate the vulnerabilities within online health forums. They introduce in their study a new online health data de-anonymization (DA) framework, which they call De-Health. De-Health identifies a candidate set for each anonymized user in a forum and then de-anonymizes each user to a user in its candidate set. Applying De-Health to user-

Daniel Lopresti directs Data X, Lehigh’s university-wide strategic initiative in the area of computing and data analytics. His research examines fundamental algorithmic and systems-related questions in pattern recognition, bioinformatics and security. Lopresti received his Ph.D. from Princeton University.

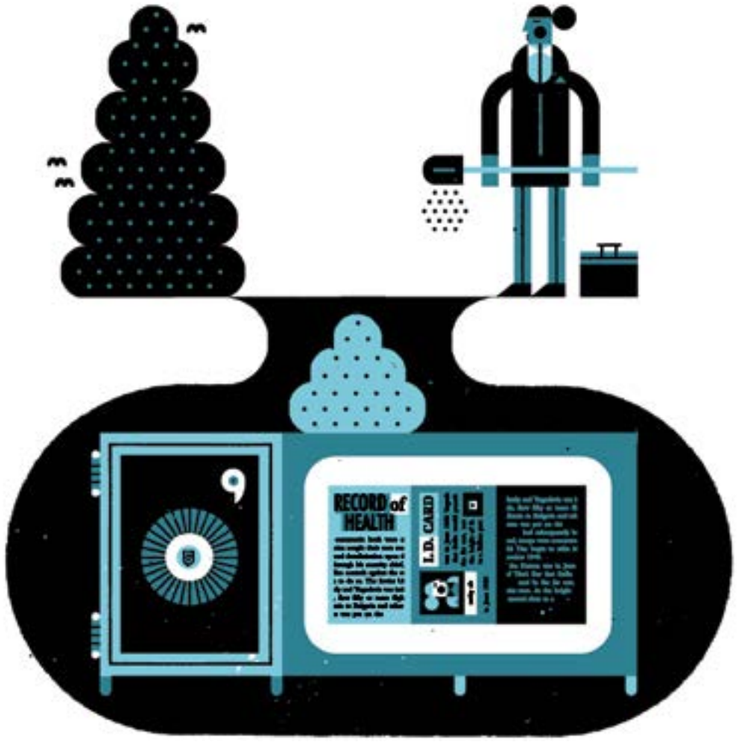
Ting Wang directs the DataPower Lab (DPL) at Lehigh. He is the recipient of a major innovation award for “Big Data Analytics for Cybersecurity” from IBM and received his Ph.D. from Georgia Institute of Technology.

generated datasets from popular forums WebMD and HealthBoards, the researchers linked hundreds of anonymized users to real-world people and their personal information including full names, health information, birthdates and phone numbers.

Wang and his colleagues hope De-Health will help researchers and policymakers improve the anonymization techniques and privacy policies utilized on websites like these.

Beyond exploring risk, Wang focuses on building technical tools that can help people understand the potential privacy leakage, or privacy price, of the things they do and say online. He also investigates protection mechanisms that will help individuals control who has access to their information. There's a balance, he says, in the amount of information shared and the service or results received.

"There's no free lunch with privacy," says Wang. "Companies need information to do personalized service. Everyone understands that. But no one understands [if] the information is too much, if it reveals too much about themselves. … Society lacks an understanding of how the system of data use works."



HIDING INFORMATION

Even when users are aware of the risks, sensitive information still finds its way onto the Internet. Mooi Choo Chuah, professor of computer science and engineering, studies ways to protect that data and defend it from network-based attacks.

"Every time you have new changes in an operating system, you tend to have some vulnerability, and the minute the attackers know that there is such vulnerability, they will launch an attack," says Chuah.

Chuah's research includes mobile computing, mobile healthcare, disruption-tolerant network design and network security. Another focus involves the design of data mining techniques over encrypted data. Encryption is particularly useful in the healthcare sector. In clinics and hospitals, data mining of patients' data allows for more effective, personalized treatment, but unencrypted data stored on computers are subjected to sensitive information leakage when such systems are breached. Thus, it makes more sense for the data to stay encrypted until it is accessed by applications.

In terms of individual patient service, Chuah has designed a protocol in which the data of a patient with diabetes, for example, can be encrypted such that only his or her primary care physician and endocrinologists who specialize in diabetes at affiliate hospitals can open it. This attribute-based encryption, which allows only individuals with defined characteristics to open the data, enables patients to determine who can see their information.

Chuah's encryption design also enables healthcare providers to learn how to better serve a particular type of patient without risking the safety of patient data. Information about that type of patient, accessed through an information-sharing coalition with other hospitals, can allow for improved service, says Chuah. When encrypted using Chuah's design, sensitive data can be shared and explored for patterns, but only those authorized users with the appropriate keys can view the actual data. This allows for data mining without the risk of information leakage.

"[It's] the safest way [to perform data mining]," says Chuah. "You can outsource your computation to a public cloud like Amazon, but they have no idea what your data is because it's in encrypted form."

DISGUISING INFORMATION FLOW

Data is not the only thing that can divulge information about users. The way it flows reveals quite a bit as well.

Suppose, for example, you log in to your bank account. The data in and associated with that account is encrypted, but the fact that you have an account with that particular bank is not a secret.

"That is sensitive information," says Parv Venkitasubramaniam, associate professor of electrical and computer engineering. "Nobody has a right to know which bank you bank with. [Privacy is essential because] any information flow and any communication in cyberspace cannot be without an element of sensitive information. … What we are looking at is even if the information is encrypted, there's still something that's being leaked implicitly."

Even if someone isn't able to read a message shared between two individuals, they can still know that two people are communicating, and the timing of how the message is sent tells a story all its own. That, says Venkitasubramaniam, is a violation of privacy as well. His solution is to change how the information flows.

One focus of Venkitasubramaniam's research is user anonymity in wireless networks. He seeks to understand how to prevent information leakage through transmission timing. Venkitasubramaniam uses the analogy of sending a letter via the postal system to explain the concept: When one person sends a letter to another, they print the recipient's name and address and their own name and address on the envelope. The message itself is hidden, but the sender, recipient and postmark are obvious to an observer. Similarly, in a wireless network, transmission timing can reveal information about the sender and receiver as well as the routes of information flow.

> "EVERY TIME YOU HAVE NEW CHANGES IN AN OPERATING SYSTEM, YOU TEND TO HAVE SOME VULNERABILITY, AND THE MINUTE THE ATTACKERS KNOW THAT THERE IS SUCH VULNERABILITY, THEY WILL LAUNCH AN ATTACK."

To disguise the journey of the letter, the sender might put the envelope inside another envelope and place that one inside yet another envelope, addressing each envelope to a different recipient. Each recipient will in turn mail the letter to the next, unaware of the start or end points of the communication, and eventually the letter will reach its intended recipient. This method provides information flow security, but it comes at a cost: time. The same is true with electronic transmission in a wireless network, so Venkitasubramaniam's work also involves understanding a fundamental trade-off: the price paid for information flow security in terms of increased delay, network bandwidth consumption and additional use of resources.

Venkitasubramaniam's graduate research focused on communication and signal processing methodologies, a more mathematical approach. Information flow security is a good match, he says, because it involves changing the protocol, and protocol changes affect the performance metrics of a network. His current research is primarily theoretical. He and his team attempt to drive an algorithm, changing control variables to understand how to best achieve the desired network performance while minimizing information retrieval from transmission timing.

When it comes to privacy, Venkitasubramaniam says, it all depends on the expectations of individuals, who tend to operate on a scale.

"On the one end, you have people who share every moment of their lives on social media, and then you have those who are nonexistent on social media," he says. "You have to develop a system that caters to all of them. In that sense, the way we try to address this challenge is by having some sort of fluid metric for privacy and claim that, depending on where you stand on the scale, this is the kind of performance you can expect from the network."

DENYING ACCESS

The problem of security doesn't arise only when communicating online. Personal data is at risk even in brick-and-mortar stores.

When customers in Target retail stores swiped their credit and debit cards at the height of the 2013 holiday shopping season, they were unaware that their confidential customer data would fall into the hands of thieves. Millions of Target shoppers were affected by this large-scale breach, and the company later revealed that the personal information of millions more had also been stolen. The company lost millions of dollars in addition to the trust of many customers.

Yinzhi Cao, assistant professor of computer science and engineering, thinks a defensive measure against this kind of attack can be the credit card itself.

Cao and his colleagues, Xiang Pan and Yan Chen, both of Northwestern University, developed SafePay, "a system that transforms disposable credit card information to electrical current and drives a magnetic card chip to simulate the behavior of a physical magnetic card." SafePay is a low-cost, user-friendly solution that would be compatible with existing card readers while preventing information leakage through fake magnetic card readers or skimming devices.

SafePay utilizes a bank server application, a mobile banking application and a magnetic card chip. The user downloads and executes the mobile banking app, which communicates with the bank server. During transactions, the bank server provides the mobile app with disposable credit card numbers, which expire after a limited time or even just one use. In the absence of wireless Internet access, the mobile app can collect and store several disposable card numbers for future use.

Once it has a card number, the mobile app generates an audio file in wave format and plays the file to generate electrical current, which connects with the magnetic card chip via an audio jack or Bluetooth. The magnetic card chip functions just as a magnetic card stripe on a traditional credit card would, making it fully compatible with existing card readers.

Test results show that SafePay can be used successfully in all tested real-world scenarios. The team, whose work was supported by funding from Qatar National Research Fund and the National Science Foundation, envisions banks distributing the SafePay device to users in an effort to safeguard account information. Their

Mooi Choo Chuah directs Lehigh's WiNS Laboratory. Her research interests include building robust mobile data systems, assistive technologies and future Internet systems. Chuah was recently elevated to IEEE Fellow. She received her Ph.D. from the University of California, San Diego.

Parv Venkitasubramaniam's research interests are in developing theoretical foundations for privacy and security in cyber and cyber-physical systems. He is a recipient of the NSF's CAREER Award and received his Ph.D. from Cornell University.

paper, "SafePay: Protecting against Credit Card Forgery with Existing Magnetic Card Readers," won the best paper award of the Institute of Electrical and Electronics Engineers (IEEE) Conference on Communications and Network Security (CNS) in 2015.

RECOGNIZING ATTACKS

In 2013, a man in New Jersey using an illegal GPS jamming device to hide his location from his employer inadvertently interfered with the satellite-based tracking system used by air traffic controllers at Newark Liberty International Airport. The relatively inexpensive jamming device confused the airport's radar, which sends out a signal that bounces off an airplane to determine its location.

This type of attack, though in this case unintentional, prevents air traffic control from receiving signals from airplanes. However disruptive, it's easy to recognize—when nothing works, it's obvious that something is wrong.

Rick Blum, the Robert W. Wieseman Professor of Electrical Engineering and professor of electrical and computer engineering, examines far more sophisticated attacks on sensor systems and networks. Through funding by the U.S. Army Research Office, Blum works to develop the fundamental theory of cyberattacks on sensors employing digital communications while advancing the state-of-the-art design and analysis approaches for estimation algorithms under attack.

Sensors, which can be as complicated as radar and as simple as a thermostat, collect and respond to data. Like anything connected to a wireless network, sensors can be compromised. An attacker can, for example, employ a spoofing attack to slightly modify the data going into a sensor without being detected. In the case of an airplane, someone might tamper with the delay of the radar signal returning to air traffic control. In another type of attack, known as a man-in-the-middle attack, an attacker can modify the data coming out of a sensor, either by physically taking it over or by intercepting communications.

The first step in protection, says Blum, is to make sure the signals received are what you'd expect.

"The signal coming from this airplane has got to look like the signal I sent, but delayed," he explains. "If it looks really different, then somebody did something. … [But] with sophisticated attacks, you really have to be more sophisticated."

Devices called "bad data detectors" can serve as a level of defense, determining whether or not the data looks the way it should. Still, some bad data can pass through the detectors. Consistency here is key.

"The data that one sensor is getting should be consistent with the data the other sensor is getting," says Blum. "If it's not, you can see it by looking at it. It's really good to have lots of sensors because they can't attack them all. You have to look at things that are going on in different places and think, 'Are they consistent?' We have mathematical models for what the sensor data should look like, and we can sort of say, 'Okay, that's really way too different.'"

With enough data and time samples at each sensor, Blum and his team can determine which sensors have been attacked. They also conducted mathematical analyses to determine what to do with data that has been compromised—whether it's safe to use to make an estimation or if it should be discarded.

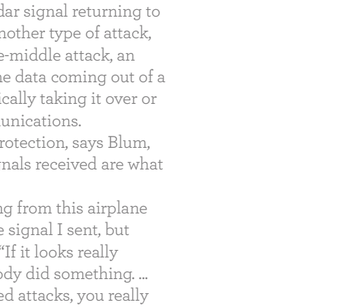
The risk of sensor attacks increases with the rise of the "Internet of Things," the network of physical objects that collect and exchange data via computational elements.

"The Internet of Things says that we're going to have sensors all over the place—in our homes, in our cars," says Blum. "We have to figure out how to protect it."

DEFENDING CYBER-PHYSICAL SYSTEMS

As connections between cyber systems and physical systems continue to develop, much more than information can be threatened. When linked by communication networks, critical infrastructure—of which our trust is essential—is at risk as well.

Take the U.S. electrical power grid, for example. Advanced electricity systems, or "smart grids," help make our use of energy more technically and economically efficient as well as more environmentally friendly. In the past, says Chuah, a large-scale power outage would occur because of a local substation disturbance known only by the local control center. Because power lines are interconnected and the stations didn't communicate, other stations didn't receive warning and couldn't prepare ahead of time. Smart grids help prevent that.



"You can collect data regarding the current and the voltage going through all these transmission lines, and that data can be sent to remote power centers to provide a more global view to look at the health of the power systems," says Chuah. "But, unfortunately, any time you put smart meters on a network—especially over a wireless network—it's bound to be compromised."

An attack on the smart grid targets more than data—it targets the system itself. A malicious user with access to the system might embed a virus within it or access sensitive customer information, but attackers might also inject false data into the power grid system, prompting incorrect and potentially devastating control decisions.

Blum directs Lehigh's Integrated Networks for Electricity (INE) cluster, a team of engineers, mathematicians and economists dedicated to research and education on advanced electricity networks. Nine cluster members compose a Lehigh team that has partnered with four other universities—the University of Arkansas, the University of Arkansas at Little Rock, Carnegie Mellon University and Florida International University—and has received a $12.2 million grant from the U.S. Department of Energy to develop and test new technologies to modernize and protect the U.S. electrical power grid. Participating Lehigh cluster members are Blum, who serves as the team's principal investigator; Chuah; Venkitasubramaniam; Liang Cheng, associate professor of computer science and engineering; Boris Defourny, assistant professor of industrial and systems engineering; Shalinee Kishore, associate professor of electrical and computer engineering; Alberto Lamadrid, assistant professor of economics in the College of Business and Economics; Wenxin Liu, assistant professor of electrical and computer engineering; and Larry Snyder, associate professor of industrial and systems engineering.

The Lehigh team will develop and test algorithms to protect core power grid controls and operations, incorporate security and privacy protection into grid components and services, protect communications infrastructure and implement security testing and validation to evaluate the efficacy of the measures they implement.

MAKING NO ASSUMPTIONS

Lopresti, whose research has included electronic voter systems and biometric security, emphasizes vigilance in both research and practice.

The problem of hackers and other data thieves, he says, isn't going away—which means researchers at Lehigh and elsewhere will need to continue their work to throw up new cyber roadblocks.

"Security researchers don't typically build something and sit back and claim that it's secure," he says. "That's pretty rare. Sometimes you can claim security if you create mathematical models and then within that mathematical framework prove it's secure, but then those models have to be implemented, and invariably that's where the problems arise. It's not that the math is wrong—the math is right—but you put it out in the real world and there are 50 other ways it can be broken."

Biometrics, Lopresti notes, were once considered the final solution for user authentication. But, as he's proved in some of his research, even if a security measure appears to work, it might have some serious flaws.

And so the work continues.

"If the systems in use aren't trustworthy, people won't use them," he says. "If you've ever been in an elevator and it shakes, it's like, 'I'm using the stairs from now on.' That's exactly what we're talking about. It's very, very much like that." ●

Yinzhi Cao's research focuses on the security and privacy of the web, smartphones and machine learning. He received his Ph.D. from Northwestern University.

Rick S. Blum is the director of Lehigh's Integrated Networks for Electricity cluster, the Energy Systems Engineering Institute and the Signal Processing and Communication Research Lab. Blum is a Fellow of the IEEE, an IEEE distinguished lecturer and an IEEE Third Millennium Medal winner. He received his Ph.D. from the University of Pennsylvania.

POLITICAL SCIENCE

ACTIONS SPEAK LOUDER THAN WORDS

In her new book, Nandini Deo explores the inner dynamics of both the women's movement in India and the Hindu nationalist movement to illustrate the key elements of effective social mobilization.

When it comes to mobilizing social change, people are motivated by action rather than ideology, says Nandini Deo.

As part of her doctoral research on the women's movement in India, Deo, associate professor of political science, set out to learn about how women's organizations there were lobbying the government. But when she got to India, the lack of existing infrastructure for the groups to use in interacting with those in power caught her attention. Many of the goals of the women's movement involve government policy and resources, Deo thought, so why wasn't there any organized lobbying effort?

Thinking it would be useful to demonstrate alternative approaches to influencing politics, Deo decided to also examine the Hindu nationalist movement, which has existed for about as long as the women's movement but has had a different historical trajectory. Deo's five years of fieldwork resulted in a book, *Mobilizing Religion and Gender in India*, which was published in November 2015. In it, Deo employs a historical comparative approach to examine the successes and shortcomings of Hindu nationalism and the Indian women's movement, both of which have experienced periods of power and irrelevance.

Indian female police attempt to stop members of the National Federation of Indian Women (NFIW) during a protest against the increasing violence against women in the country.

CHANGING TIMES, SHIFTING POWER

The women's movement in India was powerful in the 1950s but has since declined in influence. The movement initially provided services such as girls' education and economic activities, but with growing trust in the state's handling of those concerns, turned its focus instead to policy issues. However, in the 1970s, leaders of the movement realized the government was not addressing women's needs. The controversial 1975-1977 state of emergency declared by Prime Minister Indira Gandhi, which allowed the prime minster to rule by decree, further diminished trust. As a result, the women's movement distanced itself from political parties and the state as a whole.

"Today [the women's movement] doesn't have a particularly powerful influence on most political parties, and because a lot of these groups are competing with one another for funding from large foundations and bilateral aid agencies, they also often find it difficult to work together," says Deo.

Conversely, in the 1950s, when the women's movement held power, the Hindu nationalist movement held very little. Having been implicated in the assassination of Mahatma Gandhi, Hindu nationalists were treated as outsiders in mainstream politics. Determined to earn the respect of the public, the group turned its attention to providing healthcare and education. Decades later, these efforts paid off.

"There are a lot of people who have interactions with [the Hindu nationalist] movement that they see as beneficial to them, even though the movement itself has goals that are pretty problematic for most Indians," explains Deo. "So even though they don't really agree with the ideology of the movement, their interactions with the individual activists are often positive. I argue that that's partly why they've been

Nandini Deo's research interests include comparative politics, South Asian politics, civil society, social movements and foreign aid. Deo received her Ph.D. from Yale University. In her teaching she explores student-centered, project-based, contemplative and collaborative techniques.

Women for Women

Sampat Pal Devi, the founder of the Gulabi Gang. The Gulabi Gang, or "the pink gang" as translated from Hindi, is a women's movement whose members take justice into their own hands.

able to come back into the mainstream of Indian politics."

In fact, the Hindu nationalists won a significant majority in a 2014 election.

"They did much better than anyone was expecting, and I think part of the reason they were able to do that is because they have this sort of constant presence in Indian communities," says Deo. "Even though sometimes among the elite in the party there can seem like there are problems and infighting, that grassroots effort is very strong and is able to keep people connected to the movement."

Ultimately, says Deo, when it comes to mobilizing support for a movement, actions speak louder than words.

"People want to feel like the person who's asking them to show up to a protest or a rally is someone who they can trust, somebody that they feel isn't just using them," she says. "I think that only comes from having lots and lots of interactions with somebody."

News of the victory of Bharatiya Janata party (BJP) prime-ministerial candidate Narendra Modi. Modi led his Hindu nationalist party to a historic landslide victory.

Extending the Conversation

In her book Deo also explores another challenge that Hindu nationalism and the women's movement present to traditional Indian society—new perspectives on the division of private and public. While Hindu nationalists work to infuse public life with religion, which many consider private, the women's movement seeks to take matters long held as private—domestic abuse, a family's unequal treatment of daughters versus sons—and make them public concerns.

An extended conversation about how feminists think about religion and the question of private and public boundaries will be featured in an international, interdisciplinary conference on post-secular feminism at Lehigh in March 2016. Deo serves on the conference committee and will participate in a panel discussion. The conference, "Feminisms Beyond the Secular: Emerging Epistemologies and Politics in the 21st Century," will include scholars from several different countries.

BROADER APPLICATION

Deo believes the lessons from her research can be applied broadly and might also serve as a means to understanding world politics.

"In some of the politics that we see sort of playing out in other parts of the world, in North Africa, in the Mideast, we see support for relatively right-wing religious parties," says Deo. "A lot of the reason why they get the support they do is because they are community activists. They provide services that people see as demonstrating that these people genuinely care about them, especially in the context of states that are not being very effective in providing the basics of education and healthcare and so on. I think that kind of appeal is very powerful.

"The big picture story that I tried to tell in the book is that it's not the ideas of the activists that shape whether people support them or not. It's what they're doing day to day," she says.

Deo's next steps involve India's 2013 Companies Act, a provision of which requires all Indian businesses over a certain size to donate at least 2 percent of their annual profits to charity. This corporate social responsibility provision allows businesses to choose the charity that will receive their donation. Deo is exploring how companies choose their recipients and how social movements take advantage of the opportunities presented by the Act.

The Companies Act has the benefit of involving Indian companies, Deo says, so groups receiving funds won't be accused of being a puppet of the West, a charge often made against women's organizations.

In summer 2015, Deo and four Lehigh undergraduate students conducted fieldwork in India, interviewing individuals at some of the biggest companies in India to learn how they are responding to the Act.

"Because it's new money and these companies are developing new relationships, it seems like a really important time where if you can become a partner with some of these companies, you could assure yourself of long-term, sustained funding," says Deo. This approach, she says, might be particularly helpful to the women's movement. ●

SCHOOL PSYCHOLOGY

HOW DOES ADHD CHALLENGE STUDENTS?

George DuPaul conducts three separate studies that span students' educational stages from preschool through college.

Can a web-based training program help parents of 3- to 5-year-olds with attention-deficit/hyperactivity disorder (ADHD) learn strategies to ease their child's transition to kindergarten? How do college students with ADHD fare educationally and socially year to year? Among teens with ADHD, how effective is a particular school-based treatment program in helping them succeed?

George DuPaul, professor of school psychology, and fellow researchers are conducting three separate studies into the chronic neurodevelopmental disorder that affects individuals through adulthood. The research, which focuses on different age groups, spans students' educational stages—from preschool through college.

"We're really interested in how ADHD challenges these individuals," says DuPaul, a co-principal investigator on each project. "And what can we do to support them to be successful?"

To help preschoolers with ADHD, DuPaul and Lee Kern, professor of special education, developed Project PEAK (Promoting Engagement with ADHD Pre-Kindergartners), a training program parents can take in face-to-face sessions or online. The study is funded with a $1.2 million Institute of Education Sciences grant.

Parents learn what to expect over the course of their child's development as well as strategies to help their child change his or her behaviors, such as by setting routines and relying more on praise and positive reinforcement than punishment.

"Our hypothesis, and we're not alone in this, is that the earlier we can identify students with ADHD and work with them, the better the outcome," DuPaul says.

On the college level, DuPaul's research centers on how ADHD affects students' educational and social functioning. Project TRAC (Trajectories Related to ADHD in College) is funded with a $3 million National Institute of Mental Health grant.

DuPaul and researchers from the University of North Carolina-Greensboro and the University of Rhode Island are following students at six colleges over four years. Preliminary findings are sobering: Students with ADHD have lower grade point averages than students who do not have the disorder, struggle socially and engage in riskier sexual behavior, he says.

Both the ADHD and control samples have students who are doing well and students who are struggling. The researchers expect to compare the year-to-year progress of students in both groups. "Do they grow further and further apart?" he asks. "Or do kids with ADHD get better over time as they learn the environment and get support services?"

In the BEST (Bridges to Educational Success for Teens) project, DuPaul and researchers from Ohio University are conducting a first-of-its-kind intervention program for high school students. The study is funded with a $3 million grant from the Institute of Education Sciences.

The researchers are tracking 96 students with ADHD who receive training in organizational and interpersonal skills and other areas. By monitoring the students, DuPaul says, researchers will be able to spot any red flags so that students can be connected to services, if needed.

"What we're trying to do is give them skills that are lifelong, to self-regulate," he says. "And that's critical, because it cuts to the heart of the disorder." ●

George DuPaul's research interests include the assessment and treatment of individuals with attention-deficit/hyperactivity disorder (ADHD) and related behavior disorders. He received his Ph.D. from the University of Rhode Island.

‘THE MOST HUMAN EXPERIENCE’

Kashi Johnson leads students on a transformative journey of self-discovery via hip-hop theatre, empowering them to find their voice and speak their truth.

“If they’re willing to follow me, I’ll introduce them to the transformational power of hip-hop and the exciting ways it can inspire them to celebrate who they are,” says Kashi Johnson ’93 of the students in her course, “Act Like You Know: Hip-Hop Theatre.”

Now leading her eighth cohort of students, Johnson, associate professor of theatre, steps beyond lectures on the history of hip hop and immerses students in rich, dynamic experiences where they write and perform their own original work within the hip-hop aesthetic. A recent semester included four master teaching artists who, during individual weeklong residences, taught students about the founding elements of hip-hop: the DJ, breakdancing, the MC and graffiti art. But the most inspiring element of the four-credit course is perhaps the final show, where students become a performance ensemble and share their newfound appreciation of hip-hop in a showcase of dramatic skits, rhymes, choreography and spoken word poetry.

“Empowering my students to find their voice and speak their truth is really what it’s about for me,” says Johnson. “Hip-hop is the perfect performance vehicle because it demands that the person on stage or on the mic believes in their talent and abilities and is fearless in their self-expression.”

The class’s final exam, a live show performed for a large invited audience, is, as Johnson described in a 2013 TEDx talk, “a rite of passage, a definitive moment for students to declare who they are.”

Once they do, says Johnson, they never turn back.

Andrew Lustig ’10, now a professional performance artist, calls “Act Like You Know” “the most human experience.”

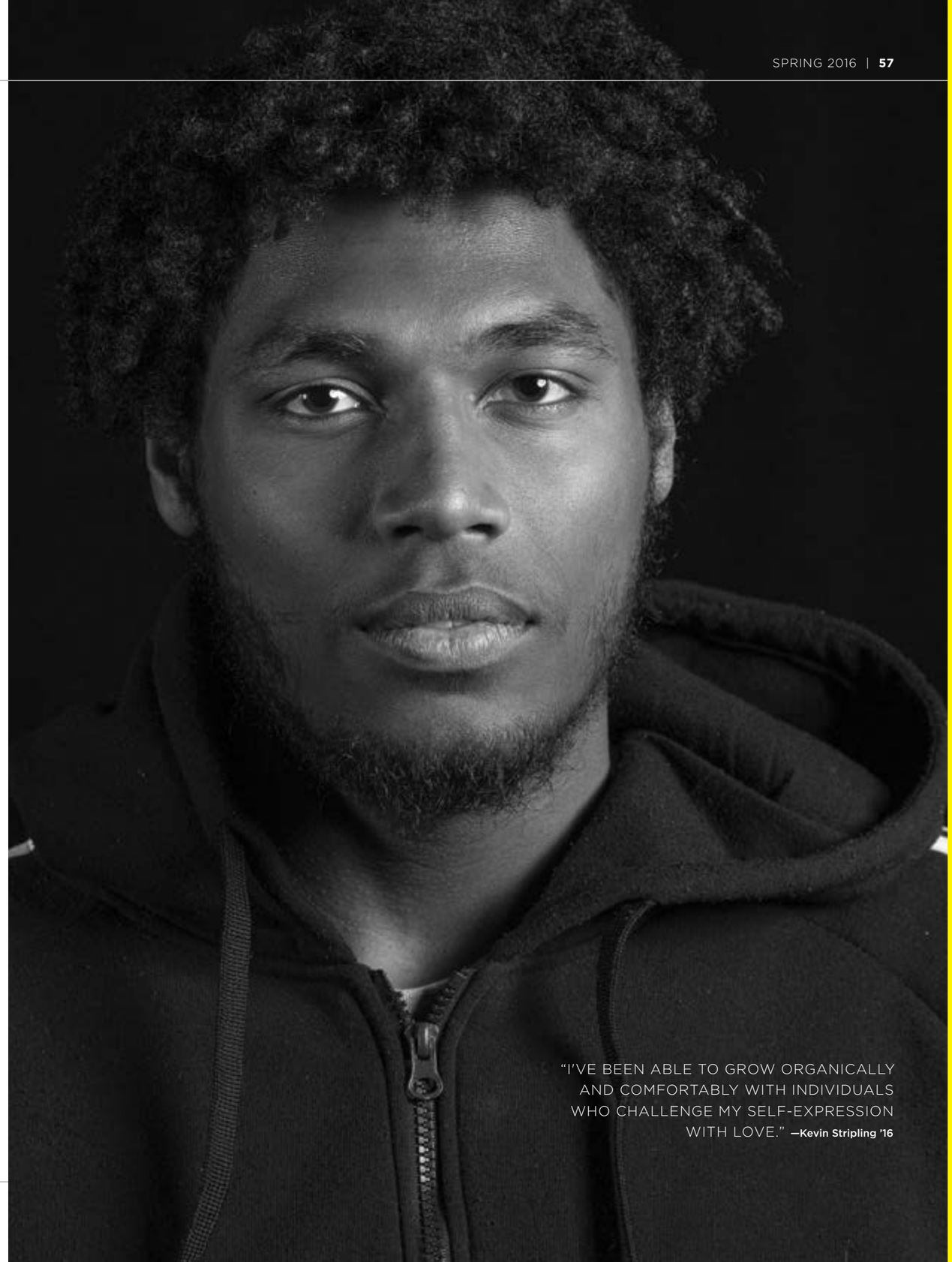
Johnson’s course, says Lustig, presents hip-hop as not only an art form, but also as history connected to important social and economic issues and racial relations in the United States. “It’s performance, yes, and it’s art, yes, but it’s also so deeply connected to people’s lives and to the world that we live in,” he explains. “All of a sudden, [hip-hop] became both an artistic pursuit and an intellectual pursuit and a pursuit of social change and of social justice.”

Johnson recently partnered with fellow Lehigh alum Daphnie Sicre ’98, an instructor at Borough of Manhattan Community College, to write a chapter in a forthcoming anthology from Routledge Publishing titled *Black Acting Methods: Critical Approaches*. The chapter, “#UnyieldingTruth: Employing Culturally Relevant Pedagogy,” documents “Act Like You Know.” Johnson is also exploring how she might collect data to track student experiences in the course.

“I’m excited about the possibilities,” says Johnson. “This class feeds into this generation’s desire to tell their stories in their way. They’re going to use their phones, laptops and social media to tell their story. This course is going to polish them up, expose them to quality performance techniques and empower them to not just put nonsense out there, but something of substance, something they can truly hang their hat on and be proud of.” ●

“[Kashi] finds the talent in each person and both literally and figuratively puts that talent on stage,” says Helena Cheng ’14, now a high school science teacher. “Knowing Kashi and having had her class has completely affected who I am as a person and professional. As she did, I don’t allow myself to lower standards for students or accept excuses.”

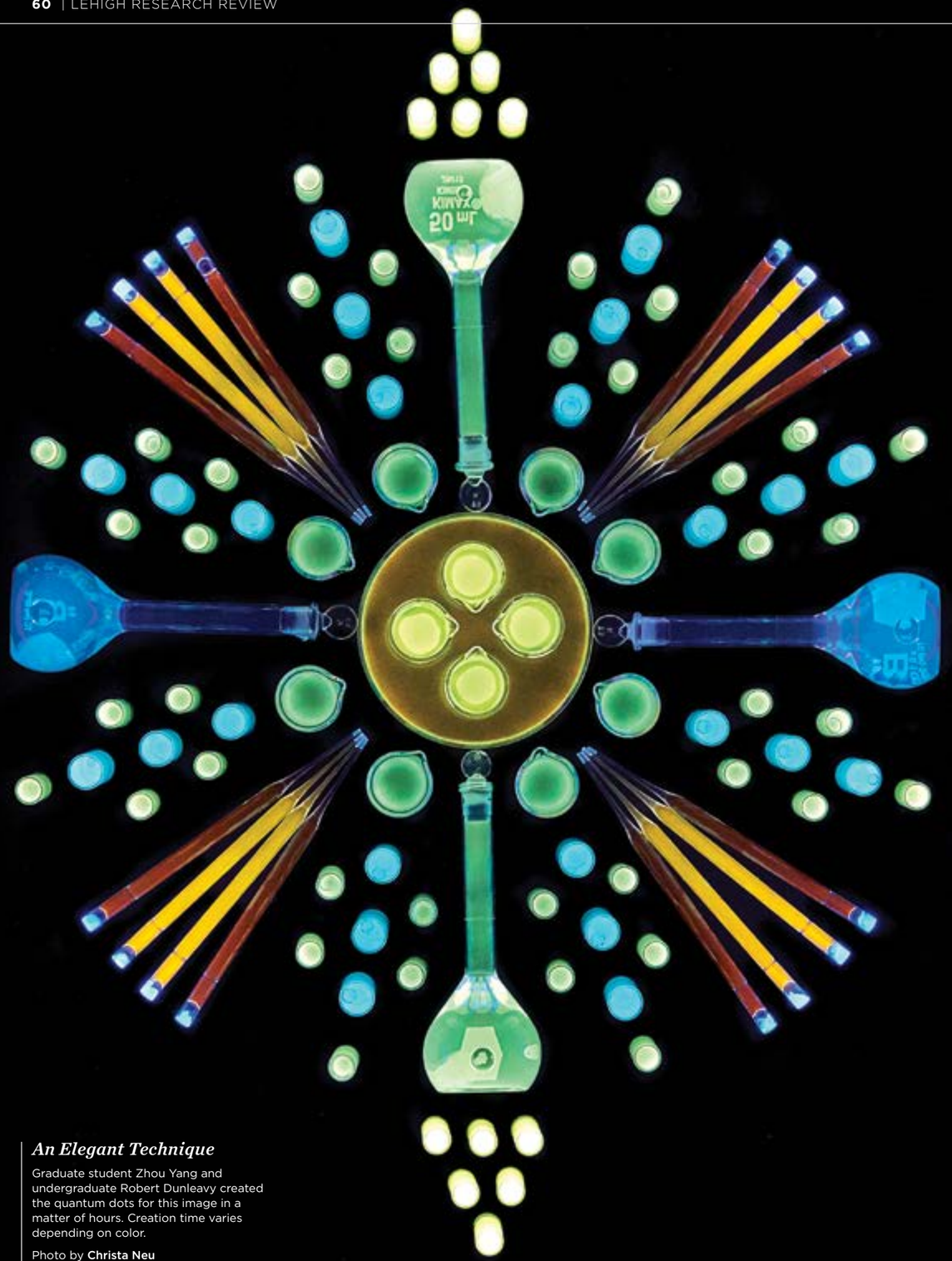
Photography by **Christa Neu**



“I’VE BEEN ABLE TO GROW ORGANICALLY AND COMFORTABLY WITH INDIVIDUALS WHO CHALLENGE MY SELF-EXPRESSION WITH LOVE.” **—Kevin Stripling ’16**

Kashi Johnson is an actress, director, poet and associate professor of theatre. She teaches courses in acting, African American drama and hip-hop theatre, and she regularly leads spoken word workshops in the Lehigh Valley. A Lehigh graduate, Johnson received an M.F.A. in acting from the University of Pittsburgh.

"WHEN YOU ARE ACTING OUT OF THE ACTUAL SELF, TELLING THINGS FROM THE HEART WITH TRUE FEELING AND EMOTION, YOUR VOICE GETS STRONGER AND YOUR PERFORMANCE BECOMES MORE POWERFUL."**—Amber Tang '16**



An Elegant Technique

Graduate student Zhou Yang and undergraduate Robert Dunleavy created the quantum dots for this image in a matter of hours. Creation time varies depending on color.

Photo by **Christa Neu**

BIOMANUFACTURING

QUANTUM DOTS BY NATURE

Quantum dots are used in transistors, solar cells, LEDs, lasers and medical imaging. Current industrial production processes are time-consuming and environmentally unfriendly. Three Lehigh researchers have found a better, more natural approach.

Conventional production techniques for QDs currently cost $1,000-$10,000 per gram. The biomanufacturing technique costs about $1-$10 per gram.

The bacterial strain *Stenotrophomonas maltophilia* (right)

Lehigh researchers have successfully demonstrated the first precisely controlled, biological way to manufacture quantum dots. This one-step method starts with engineered bacterial cells in a simple, aqueous solution and ends with functional semiconducting nanoparticles, all without resorting to high temperatures and toxic chemicals.

Born of an ideal collaboration among three Lehigh faculty researchers, this elegant technique has great potential for green manufacturing of quantum dots (QDs), which are used in transistors, solar cells, LEDs, lasers and medical imaging. Current industrial processes to produce them are messy, requiring toxic solvents, heat and high pressure.

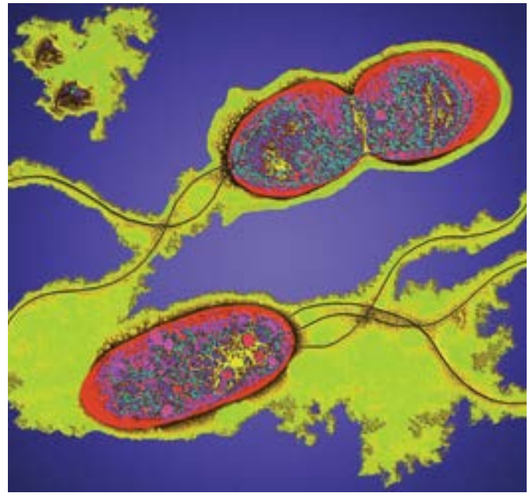
Bryan Berger, associate professor of chemical and biomolecular engineering and bioengineering, wondered in 2012 whether the bacterial strain *Stenotrophomonas maltophilia* could be manipulated to generate QDs on command, since it had previously been known to exhibit heavy metal resistance.

Berger teamed up with colleagues Steve McIntosh, associate professor of chemical and biomolecular engineering and member of Lehigh's Class of '61; Chris Kiely, the Harold B. Chambers Senior Professor of Materials Science and Engineering; Robert Skibbens, professor of biological sciences; and Ivan Korendovych, assistant professor of chemistry at Syracuse University. Together they won a $2 million grant in 2013 from NSF's Division of Emerging Frontiers in Research and Innovation (EFRI) to prove the production of cadmium sulfide QDs using an engineered form of *Stenotrophomonas*. They tailored the bacteria to grow nanocrystalline metal sulfides including QDs, building on earlier research, which was funded by Lehigh's Faculty Innovation Grant (FIG) and Collaborative Research Opportunity Grant (CORE) programs.

"The beauty of a biological approach is that it cuts down on the production needs, environmental burden and production time quite a lot," says Berger. Industrial processes take many hours to grow the nanocrystals, which then need to undergo additional processing and purifying steps. On the other hand, biosynthesis takes minutes to hours maximum to make the full range of quantum dot sizes (about 2 to 3 nanometers) in a continuous, environmentally friendly process at ambient conditions in water that needs no post-processing steps to harvest the final, water-soluble product. Because bacterial cells are much larger than the nanocrystals, researchers simply use a centrifuge to pull the cells away from the QDs in the solution.

More recently, the researchers have branched into creating lead sulfide QDs and are working on oxide-based materials, widening the range of QD practical applications. Their underlying technique allows them to control the particle size to fractions of a nanometer, an essential function, since particle size determines the QD's optical and electronic properties.

Cell-based growth needs only basic equipment in a typical biochemistry wet lab setting. Using a process called directed evolution, researchers altered the bacteria so they would selectively produce quantum dots. Housed in a beaker containing water, cadmium and sulfur precursors, and minimum levels of carbon and nitrogen, the cells forgo most normal biological functions. They build quantum dots by sequestering metal ions from their environment,



Bryan Berger's research is focused on problems at the interface of biophysics and engineering. He and his team work extensively with clinicians and biomedical scientists. Berger received his Ph.D. in chemical engineering from the University of Delaware and is a recipient of the NSF Faculty Early Career Development Award (CAREER). **Steve McIntosh** pursues research areas that are interdisciplinary in nature and encompass the fields of catalysis, (cont'd)

generating a reactive sulfur source and controlling the resultant structure to form a crystal.

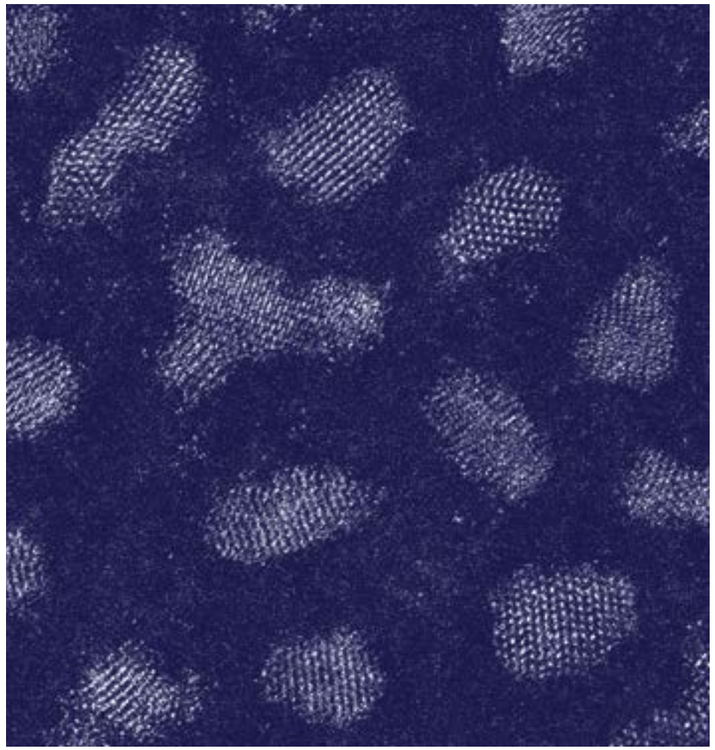
Perfecting the methodology to structurally analyze individual nanoparticles required a highly sophisticated Scanning Transmission Electron Microscope (STEM). Lehigh's Electron Microscopy and Nanofabrication Facility was able to provide a $4.5 million state-of-the-art instrument that allowed the researchers to examine the structure and composition of each QD, which is only composed of tens to hundreds of atoms.

"Even with this new microscope, we're pushing the limits of what can be done," says Kiely. The instrument scans an ultra-fine electron beam across a field of QDs. The atoms block the electrons in the beam, producing a kind of shadow image on a fluorescent screen, akin to the way an object blocking light produces a shadow on the wall. A digital camera records the highly magnified atomic resolution image of the nanocrystal for analysis.

An early challenge for the team was figuring out how to separate QDs from the biological material that surrounded and obscured them. "It was a learning process to clean off the organic residues. Once you get rid of that, you begin to see the true structure of the material," says Kiely. "It took many, many months of frustration for our dedicated team of students (Zhou Yang, Leah Spangler, Chris Curran, Robert Dunleavy and Li Lu) to figure out exactly how to do this. Now that we have a much better understanding, we're starting to accelerate our progress of new materials discovery."

"THE BEAUTY OF A BIOLOGICAL APPROACH IS THAT IT CUTS DOWN ON THE PRODUCTION NEEDS, ENVIRONMENTAL BURDEN AND PRODUCTION TIME QUITE A LOT."

The researchers' work was featured on the cover of the July 2015 issue of *Green Chemistry*. The article suggests that because a single enzyme in the bacteria is responsible for QD generation, the current cell-based model could be scrapped entirely in the future. QDs could be generated with the same enzyme synthesized from yeast or some other easily manipulated bacteria, says Berger. "We have fairly strong evidence for a cell-free process. It's more cost-effective to use just a purified enzyme," he says. The team is pursuing an extracellular approach and is poised to scale up its laboratory success into a future manufacturing enterprise.



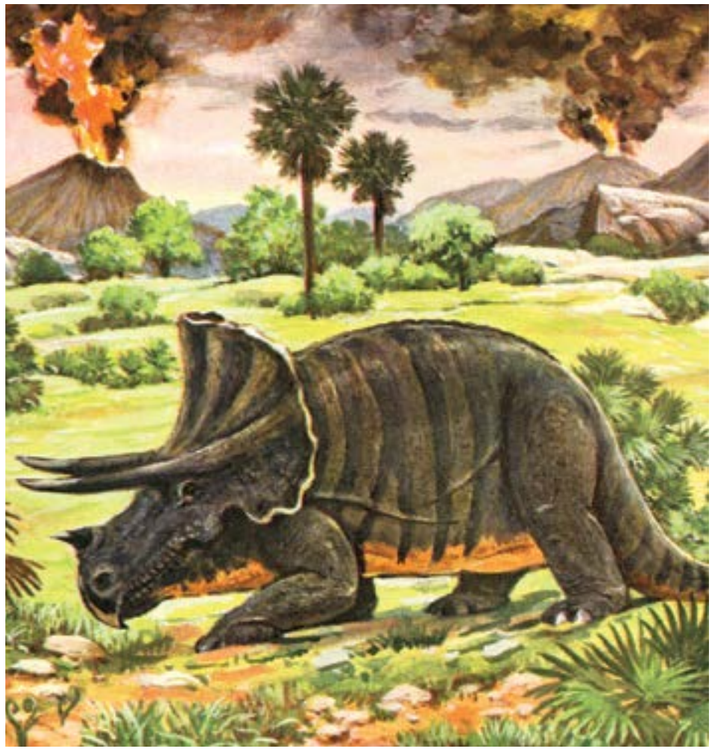
A high resolution electron micrograph of cadmium sulphide quantum dots formed by biomineralization.

The researchers hope to establish a manufacturing company that makes inexpensive QDs in an eco-friendly manner. Conventional manufacturing costs $1,000 to $10,000 per gram. A biomanufacturing technique could potentially slash the price by at least a factor of 10, and the team estimates yields on the order of grams per liter from each batch culture, says McIntosh.

Taking a long view, the three colleagues hope that their method could lead to a plethora of future QD applications, such as greener manufacturing of methanol, an eco-friendly fuel that could be used for cars, heating appliances and electricity generation. Water purification and metal recycling are two other possible uses for this technology, because the enzyme makes QDs by isolating heavy metals from water.

"We also want to create many different types of functional materials and make large-scale functional materials as well as individual quantum dots," says McIntosh. He imagines developing a process by which quantum dots arrange themselves into macrostructures, the way nature grows a mollusk shell out of individual inorganic nanoparticles. "If we someday get to macroscale, if we're able to make more of the material and control how it's structured while maintaining its core functionality, we could potentially get a solar cell to assemble itself with quantum dots. That would be incredible." ●

Chris Kiely applies advanced analytical electron microscopy techniques in the arenas of catalysis and nanotechnology. He serves as director of Lehigh's Electron Microscopy and Nanofabrication Facility. Kiely received his Ph.D. from Bristol University.



MECHANICAL ENGINEERING

THE ART OF PALEO-ENGINEERING

Brandon Krick inspires new engineering techniques with a 3-D wear model developed for a study of Triceratops teeth.

The National Science Foundation (NSF) recently awarded Krick and Natasha Vermaak, assistant professor of mechanical engineering and mechanics, a new grant that applies the wear model created for dinosaur teeth to develop composite materials for applications involving sliding wear.

The three-horned dinosaur called the Triceratops might have been more complex than we thought. In fact, Triceratops' teeth were far more intricate than those of any reptile or mammal living today.

Brandon Krick, assistant professor of mechanical engineering at Lehigh, and Gregory Erickson, professor of anatomy and vertebrate paleobiology at Florida State University, joined a multi-university team of engineers and paleontologists to determine that the Triceratops developed teeth that could finely slice through dense material, giving them a richer and more varied diet than modern-day reptiles.

The team outlined the findings of their NSF-funded study in the journal *Science Advances*.

Today, reptilian teeth are constructed to be used mostly for seizing food and then crushing it. The teeth do not occlude, or come together, like those of mammals. In essence, they can't chew. The teeth of most herbivorous mammals self wear with use to create complex file surfaces for mincing plants.

Several years ago, Erickson suspected dinosaurs' teeth had some unique properties, but the technology to really discover what they were capable of did not exist.

Enter Krick, a few years later. Krick specializes in tribology, the science of how surfaces of materials interact while in motion. Erickson and Krick, accompanied by scientists at the University of Florida, the University of Pennsylvania and the American Museum of Natural History, got started.

To get a look at their interior, Erickson cut into Triceratops teeth from museum specimens collected around North America. He discovered that Triceratops' teeth were made of five layers of tissue. In contrast, herbivorous horse and bison teeth, once considered the most complex ever to evolve, have four layers of tissue. Crocodiles and other reptiles have just two.

"Each of those tissues does something," Erickson says. "They're not just there for looks."

Erickson sent samples of the tissue to Krick to determine what each did and how they worked in concert to allow these animals to slice plants. Krick was able to mimic how plants moved across the teeth by scratching the teeth and measuring the tissue wear rates.

Krick and his team of engineers, including Lehigh graduate student Mark Sidebottom, found that the material properties of the teeth were remarkably preserved in 66-million-year-old teeth.

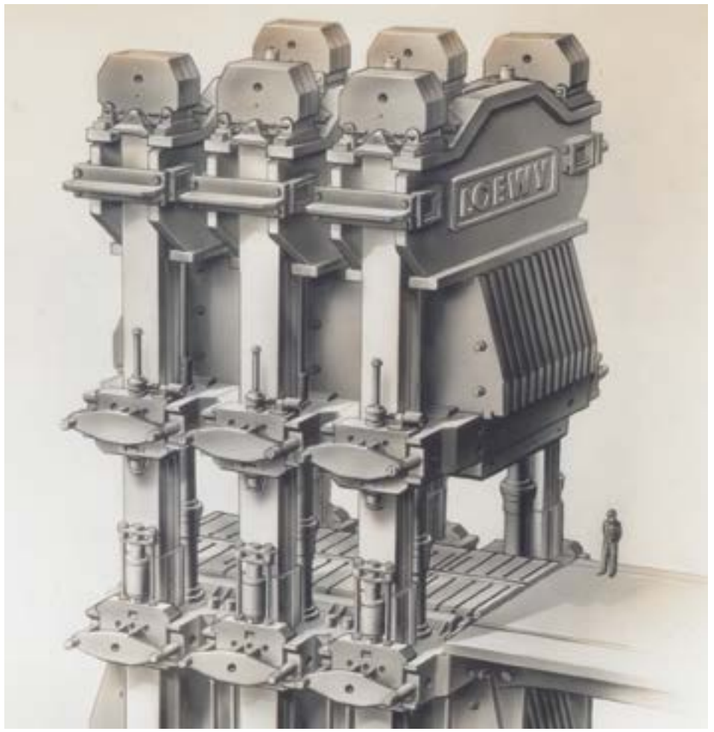
"If you took these dinosaurs' teeth and put them in a cow, for example, they would work," Erickson says.

The team developed a sophisticated three-dimensional model to show how each tissue wore with use in a strategic manner to create a complex surface with a fuller (a recessed area in the middle, much like those seen in fighting knives and swords) on each tooth. This served to reduce friction during biting and promote efficient feeding.

The wear model is inspiring new engineering techniques that can be used for industrial and commercial applications.

"Paleontologists challenged us with an interesting engineering problem, and now we have a wear model that can be used to design material systems with optimized wear properties and surface features for many applications," Krick says. ●

Brandon Krick's research interests are at the intersection of mechanical engineering, materials science and surface physics. He earned his Ph.D. from the University of Florida.



MATERIALS SCIENCE IN MANUFACTURING

A GLOBAL COLLABORATION

The Institute for Metal Forming's new name honors the Loewy Family Foundation, whose generous support has allowed it to foster collaborative research on an international scale.

The Loewy Visiting Professorship has brought to Lehigh noted researchers from around the world.

Founded in 1970, Lehigh's Institute for Metal Forming (IMF) has long educated students in the principles and applications of metal-forming technology, supported graduate research, and helped industry solve problems in metal forming.

Since he was appointed IMF director in 1997, Wojciech Misiolek has had a specific vision for its future: international collaboration.

"I immediately recognized that we needed to work with the best in the field, both in the U.S. and abroad," says Misiolek, the Loewy Chair in Materials Forming and Processing. "We have sought to build a network of collaborative projects, which would mainly benefit Lehigh's graduate programs."

Misiolek's global vision has become reality through the support of the Loewy Family Foundation. Established in 1966, the foundation honors the legacy of brothers Erwin and Ludwig Loewy, who fled Nazi Germany just before World War II and later revolutionized large metal parts manufacturing in England and the United States. It ranks support for higher education among its top priorities.

Loewy Family Foundation support has enabled Misiolek and IMF graduate students to gain valuable research and teaching experiences through exchanges with research institutions in Australia, Austria, Brazil, Colombia, Germany, New Zealand, Norway and Poland.

The Loewy Visiting Professor position, established in 1999, has brought to Lehigh noted researchers with unique expertise.

"OVER THE YEARS WE HAVE HAD THE REMARKABLE PRIVILEGE TO HOST TRULY OUTSTANDING SCIENTISTS FROM AROUND THE WORLD."

This year, the IMF has brought three visiting professors to Lehigh: 2015-16 Loewy Visiting Professor Alejandro Toro of the National University of Colombia, Henry Valberg of the Norwegian University of Science and Technology, and André Luiz Costa of the Federal University of Sergipe, Brazil.

"Over the years we have had the remarkable privilege to host truly outstanding scientists from around the world," says Misiolek.

On April 29, 2016, the IMF will become the Loewy Institute in recognition of the continued support of the foundation. The work of Erwin and Ludwig Loewy in England and America revolutionized airplane manufacturing through the design and construction of enormous forging and extrusion presses that changed the way fighter planes were built in war time. Later, it made way for the development of the commercial airline industry and breaking of the sound barrier.

Today, the institute that soon will bear the Loewy name continues research on materials such as aluminum, copper and magnesium alloys, and on—believe it or not—snake skin. Misiolek, Toro, and Hisham Abdel-Aal of Drexel University have joined forces to analyze the characteristics of the skin of the albino python and boa constrictor.

"We want to learn how nature created this skin, because we know it works so well," says Misiolek. "If we learn that, we may be able to mimic that—not copy it, but apply the same concepts to designing new material applications." ●

Wojciech Misiolek conducts interdisciplinary research in materials processing and process engineering. He received his Ph.D. from AGH University of Science and Technology in Kraków, Poland.

NEH GRANT

ENGAGE & INTERACT

Lehigh's Africana Studies program has been awarded a $500,000 challenge grant from the National Endowment for the Humanities. The three-to-one matching grant, announced in December 2015, will require Lehigh to raise $1.5 million over the next five years.

"OUR COMMITMENT HAS ALWAYS BEEN TO BE PUBLIC FACING IN OUR PROGRAMS—TO ENGAGE AND INTERACT WITH OUR LOCAL SCHOOLS, CHURCHES AND COMMUNITY ORGANIZATIONS IN A DELIBERATE EFFORT TO CREATE PROGRAMS, DEVELOP NEW INITIATIVES AND BUILD KNOWLEDGE TOGETHER."

—JAMES PETERSON

Principal Investigators

James Peterson, *director of Africana Studies and associate professor of English*

Monica Miller, *assistant professor of religion studies*

Susan Kart, *assistant professor of art, architecture and design*

In 2011, Lehigh selected Africana Studies as its first academic "cluster," bringing together faculty from English; history; religion studies; theatre; art, architecture and design; and journalism. The program has since developed powerful and socially relevant public programming, including a four-day conference in February 2015 that explored the life and legacy of Malcolm X.

The NEH funds will be used to create an endowment to expand the Africana Studies program at Lehigh, including enhancing curriculum, increasing public humanities initiatives and strengthening the program's community partnerships to further explore public concerns and social justice issues related to race, politics, gender, religion and other areas. New initiatives will see faculty and students moving further into the public sphere, joining with local residents and other community partners in forums, town halls and public meetings to deliberate on local concerns that they can address together.