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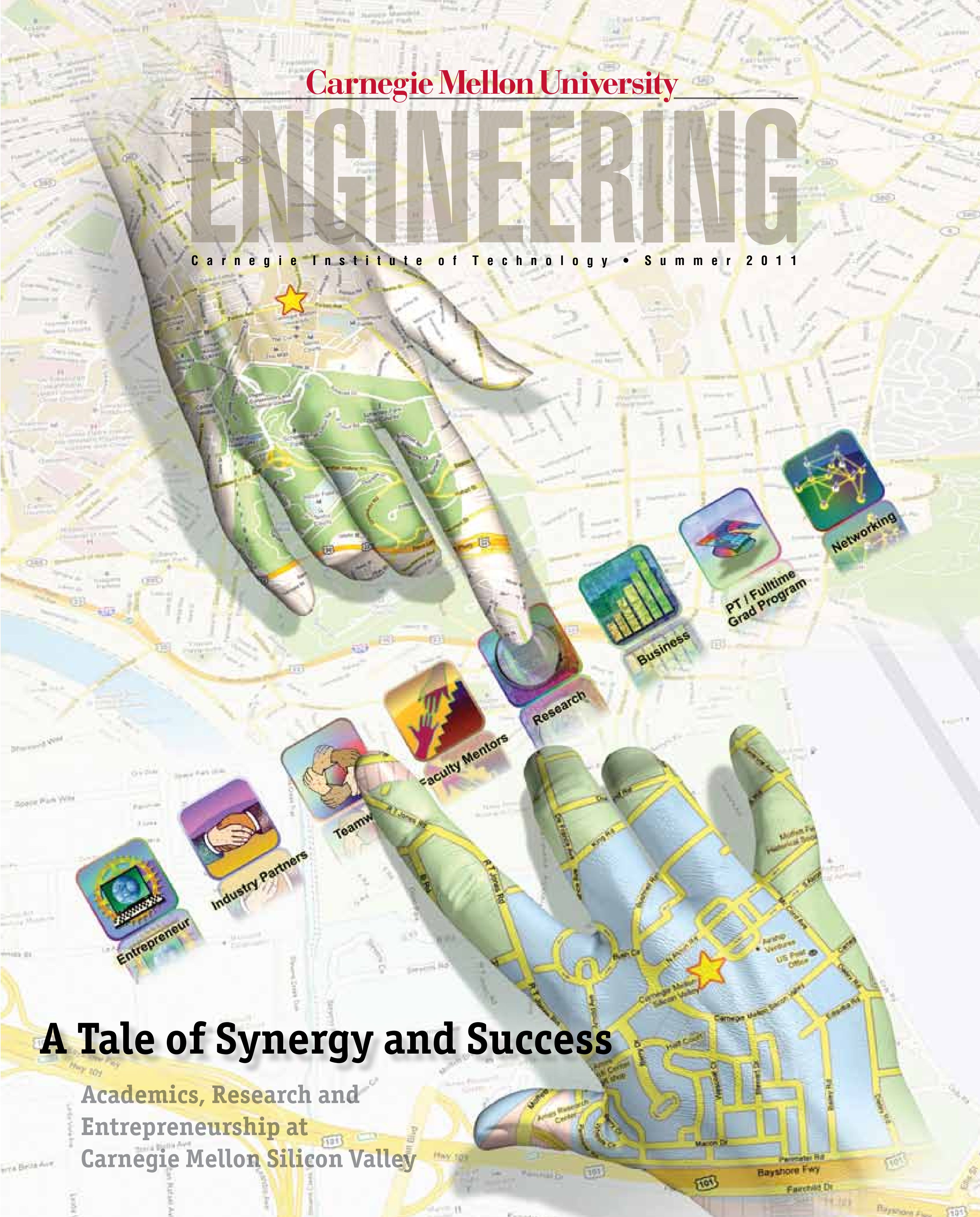
Carnegie Institute of Technology • Summer 2011



A Tale of Synergy and Success

Academics, Research and Entrepreneurship at Carnegie Mellon Silicon Valley

In the Aftermath of the Fukushima Daiichi Accident • Controlling Nanomaterials • Student Activities Enhance Academics

CIT Night at the Casino

There's nothing like good food and a few hands of Texas Hold'em to bring people together. And that's precisely what happened at Casino Night, an on-campus student event that was sponsored by CIT's newly formed Community Building Committee (CBC).

The CBC is a student-run organization whose goal is to foster a sense of community throughout the College of Engineering. "We want students from different majors to mingle, so they feel comfortable with each other and the faculty," says CBC member Sophie Grodsinsky, a sophomore in Civil and Environmental Engineering. The CBC thought that a Casino Night would lure students away from their books, and the committee was right.

On March 19, approximately 500 students strolled through the University Center to try their luck at games of chance. Other drawing cards were international food tastings and activities. To emphasize CIT's diverse community, the Dean's Office with the help of various student engineering organizations set up tables that offered foods and games representing the locations where CIT has activities: Rwanda, Greece, Portugal, India, Japan, Silicon Valley and Pittsburgh. Reports indicate that the guava juice and pierogi were amazing.

Just as exciting were the prizes that were given away. In the casino games, students won entry tickets for pick-a-prize raffles that were held at the end of the night. A coffee pot and a couple sets of computer speakers were the most coveted prizes. The spirit of community took root when groups of students pooled their tickets together in an effort to win speakers for their dorms.

"The night was a total success," concludes Grodsinsky. "People had a blast and that's what we were going for."

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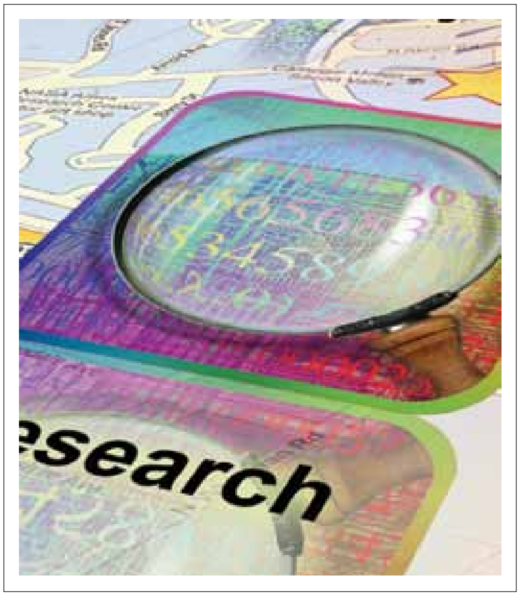
Grain boundaries reveal how materials behave/p.14



Feature/4-9

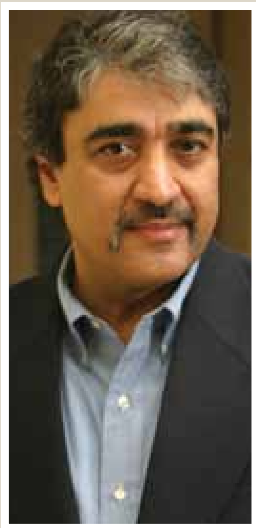
A Tale of Synergy and Success

Three years ago Carnegie Mellon University set out to fully integrate the Silicon Valley campus with Pittsburgh. We accomplished that and more.

Cover and feature illustrations by
JEAN FRANÇOIS PODEVIN

What's in your toothpaste?/p.10

Innovative infant products/p. 24



Three years ago the College of Engineering set out to integrate Carnegie Mellon Silicon Valley with the main university in Pittsburgh. The California campus had excellent graduate programs in software engineering and management. Local high-tech companies sent their employees to the school because of its problem-solving culture. The campus had a great reputation, and it is located in perhaps the most innovative place in the world. Yet something was missing, namely a strong sense of connection to Pittsburgh.

We asked ourselves, "How do we foster productive interaction between the two campuses? How do we steer a great enterprise, Carnegie Mellon Silicon Valley, to the next level?" The answers focus squarely on our strengths – academics, research and spirit of entrepreneurship. In this magazine we examine the role these factors play in extending the reach of the Silicon Valley campus and Carnegie Mellon as a whole.

Another area in which CIT is widening Carnegie Mellon's influence is in the area of energy. We intend to position the university as well as Western Pennsylvania as a major hub for enabling and managing the transition to a sustainable energy future. We will do this through a "systems" level approach – one that taps into the interconnections between technologies, economies and people. CIT will contribute much through educating engineers, policymakers and the general public. We contend that sharing the results of our research is critical if we are to instigate intelligent public discourse on energy.

There is a great deal of misinformation surrounding the production of power, regardless of its generation source: renewables, fossil fuels, nuclear, etc. The public's need for straightforward information on these matters has become sorely evident in the aftermath of the Fukushima nuclear accident. Dr. Aris Candris (E, '74, '78), the CEO of Westinghouse Electric Company, gives his perspective on what happened in Japan and the future of nuclear power (see page 18).

Providing the world with safe, clean reliable energy will require innovations in technology and conservation. As we move ahead in these areas, we will keep you apprised of our efforts.

Sincerely,
Dean Pradeep K. Khosla

Carnegie Mellon University
ENGINEERING

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Announcements

On the Horizon: **CIT Programs in India and Rwanda**

Broadening our reputation as a global thought leader, the College of Engineering is developing academic programs in India and Rwanda.

Partnering with the Shiv Nadar Foundation in India, Carnegie Mellon University (CMU) will offer undergraduate programs in mechanical and electrical and computer engineering to Indian students. Selected students will spend two years studying in India and two years in Pittsburgh. This endeavor builds off an existing partnership between the two institutions that provides graduate-level education in advanced software engineering.

Shiv Nadar, the foundation's chairman, stated, "Global education has always been the big dream for Indian students. Each year, more than 40,000 Indian students head overseas in search of global exposure. This alliance with Carnegie Mellon University will now offer Indian students the chance to access the education architecture of a highly renowned, world-class institution right here in India."

In Rwanda, CMU is partnering with the government to develop a Center of Excellence in Kigali, which will deliver first-class graduate education. CMU will be the first U.S. research institution in Africa offering degrees with an in-country presence. Striving to become the technology hub for East Africa, Rwanda is investing heavily in infrastructure and capacity building in the critical areas of ICT and engineering. We will offer master's programs in information technology and electrical and computer engineering.

Students in these global programs are required to meet Carnegie Mellon's rigorous academic standards. Classes for both programs are projected to start in 2012.

Professors Release Book Focusing on the **"Science of Product Emotions"**

In their latest book, "*Built to Love*," CMU Professors Jonathan Cagan (MechE) and Peter Boatwright contend that if companies want to energize the marketplace, their products and services must make customers feel better. Emotions and subsequently customer loyalties rise when consumers love a product, so products should be built to evoke emotions from the start.

Cagan and Boatwright, who have worked with Fortune 100 companies to niche firms, demonstrate in this book how emotions impact sales. They analyze the emotions that are relevant in product development and explain how to apply this information to develop highly valued products that excite people.

Networking
Teamwork
Business
Entrepreneur
Faculty Mentors
Industry Partners
PT / Fulltime
Grad Program
Research
Carnegie Mellon
Silicon Valley
Hwy 101
Bayshore Fwy
Fairchild Dr

A Tale of Synergy and Success

"Three years ago Carnegie Mellon University set out to fully integrate the Silicon Valley campus with Pittsburgh. We accomplished that and more.

Let's look at the facts. Silicon Valley is one of the world's top R&D centers, and nearly one third of all U.S. venture capital activities occur here. Some of the most influential high tech companies on the planet are sited in the region, and roughly 5,000 Carnegie Mellon alumni work in the San Francisco Bay Area. Carnegie Mellon belongs here, and that's why we've renewed our commitment to make Carnegie Mellon Silicon Valley an enterprise that garners global recognition.

In 2008, the College of Engineering, under the leadership of Dean Pradeep K. Khosla, ramped up efforts to expand the graduate education and research currently underway at the Silicon Valley campus. A tally of our efforts reveals we are succeeding. A Ph.D. program in electrical and computer engineering is in full swing. Thriving bicoastal programs integrate Pittsburgh's academic offerings with California's professional opportunities. Relationships with West Coast industry have broadened. Enhanced collaborations with all levels of government and the nonprofit sector are afoot. Our research volume has increased 54%.

The key to this success? It's the inextricable link between the school's academic and research initiatives and the entrepreneurial culture of Silicon Valley says Martin Griss, the campus's director. In his mind, it's a synergetic relationship. Students enroll in the Silicon Valley campus to obtain a world-class education and gain networking opportunities. Faculty members have entrepreneurial experience and contacts—everybody knows somebody. These combined factors enhance our reputation and attract students. However, Griss traces the campus's recent growth directly to the expansion of full-time graduate programs and the onset of new research, a priority given by President Jared Cohon when he visited the campus in 2008.

When the Silicon Valley campus was founded in 2002, its degree programs were part-time so that working professionals could pursue an advanced education. In consultation with industry, the faculty developed a curriculum and pedagogical approach tailored to the needs of working professionals. However, part-time students, already stretched by work, school and family commitments, were limited in their time and resources and unable to participate in the intellectual culture essential for growing research. Griss, who has been at the campus practically since its inception, believed that "if the campus was to grow into a vibrant research community, it had to offer full-time graduate programs." He was right. In the fall of 2008, 10 full-time students enrolled and "an avalanche started," says Griss.

Partnering with the Silicon Valley campus, the Information Networking Institute (INI), based at the main campus, launched a bicoastal offering of their Master of Science in Information Technology (MSIT) programs, which included tracks in mobility, information security and software management. A major strength of bicoastal programs is that students get a great education in two very different environments. The addition of the INI students led to more on-campus energy, as students from multiple programs studied and worked together. Student projects escalated.

"Students started doing research,

Martin Griss, Campus Director

which was part of our strategy," says Griss. Expanded research generates opportunities for faculty and students to work with local companies. "This is how mobility got started," says Griss. After the CyLab Mobility Research Center was founded, discussions about creating a Ph.D. program began. Talks ensued with the Electrical and Computer Engineering Department in Pittsburgh, and soon the first two Ph.D. students arrived at Carnegie Mellon Silicon Valley. Today there are 24.

Going over the numbers, Griss calculates, "We now have 18 to 20 full-time students in the software engineering programs. There are the bicoastal programs with the Information Networking Institute, and those bring 26 to 28 students in. Add 24 Ph.D.s, and now we're up to approximately 70 full-time students." This number is projected to climb because in fall 2011, the campus is rolling out a new degree that focuses on entrepreneurship. Finally, rounding out the student body are approximately 115 part-time students.

Educating the Entrepreneurially Inclined

Enrollment at the California campus is solid. Students want to immerse themselves into the Silicon Valley environment, and the school's evolving curriculum addresses their interests. Ray Bareiss, Director of Education, explains that when the campus was founded, the initial student body consisted of engineers engaged in "traditional, high-ceremony" software engineering, as practiced at aerospace companies. Large teams and projects were standard. However, driven by student demand, the focus evolved quickly to more of what might be considered the "Silicon Valley-style of engineering." Bareiss says, "Today's students are involved in smaller projects that are completed in a short time frame and call for *agile methods*. The majority of our students are focused on product development and many have entrepreneurial ambitions, and we are responding to it."

Carnegie Mellon's focus on agility sets us apart from other universities in the area. Developing and releasing new apps into the marketplace takes weeks or months, not years, and this "rapid development of technology aligns with our style of teaching," says Bareiss. He explains that unlike traditional software development, an agile approach stresses customer involvement and communication. In Silicon Valley, agile practices are standard.

Griss says, "We've been able to expand our educational offerings to address more of the segments we encounter in Silicon Valley, including large-scale companies, internet companies, startups, entrepreneurs."

> The majority of our students are focused on product development and many have entrepreneurial ambitions, and we are responding to it."

A key point in the faculty's pedagogical approach is to teach both students and companies how to work with customers and their values. Bareiss's colleague Professor Patricia Collins explains, "We help companies develop a customer-oriented approach to requirements." Citing the ongoing relationship between Carnegie Mellon and Samsung as an example, she says, "They came to us with a problem. We did user studies to understand the project's requirements. We looked at their end users' needs and at Samsung's." Through collaboration the project produced results to everybody's satisfaction. Even better, "because of our strong customer orientation, we have placed students at Samsung," says Collins.

Bareiss and the faculty agree that their approach to education is pioneering. Besides the emphasis on agile product development, Bareiss says, "our whole curriculum is learning by doing. We are team based, project oriented, and faculty serve as coaches. We

Ray Bareiss

Patricia Collins

don't use the traditional lecture/test model. We've made graduate study more like professional work. The education that students receive here seamlessly transfers to the work environment. Other schools have isolated project courses that promote such transfer, but we're unique in that we've implemented this approach across our entire curriculum."

Another aspect of the Silicon Valley programs that translates to the real world is the emphasis on global education that is facilitated by distance learning. Here again, Carnegie Mellon is changing the face of traditional education. Professor Stuart Evans utilizes distance learning to teach innovation and entrepreneurship to students worldwide. He exposes students to the latest academic thinking, and venture capitalists and entrepreneurs participate in his classes. In line with Carnegie Mellon Silicon Valley's educational philosophy, these geographically distributed classes stress team-building, communication with external communities, and the faculty serve in an advisory capacity.

"To give you an example, I had a class that was sponsored by Emirates Airlines based in Dubai," says Evans. The class consisted of four student teams and Swiss executives who served as mentors. "I led discussions from my home study with students across the U.S., our mentors in Switzerland and a client in Dubai. I regularly got questions from students around the world. That's amazing." Equally impressive is that new companies arise from these classes. "Out of my high-tech venturing class, we had two companies result," says Evans, "Teaching students how to craft startups in a credible, academically rigorous way is an impetus for the full-time master's in software management that's launching this fall."

The new one-year, full-time program evolved from the part-time M.S. software management program, in which faculty discovered students who made the leap from working in larger corporations to starting their own companies. "In our part-time software management product development concentration, five out of eight teams have pursued entrepreneurial ideas. We give them the combination of confidence, tools and education to make the change," says Bareiss.

The full-time version of the M.S. software management program covers product development, enterprise innovation and entrepreneurship. According to Bareiss, it targets both mid-career professionals and recent graduates. At the onset of the program, students will attend a workshop where they generate ideas for a venture. They'll form teams, and over the course of the year they'll expand and refine their ideas.

"Ventures will move from a gleam in the eye and head toward the development of a product. The students will develop processes to make things happen. They'll learn about managing teams. They'll look at business models and develop business plans. They will think about intellectual property," says Bareiss. "At the end of the year, some will actively launch their ventures, while others will see this as a stepping stone to different career possibilities."

Students who don't form startups will still have the knowledge to "fill a space that is greatly underdeveloped in the business world," says Evans. When startups gain traction and start to scale, they need people with particular skills. "You need strong, technical people who have managerial capabilities. We develop people who may not be the founders of a company, but can fit in and scale a company to the next stage of its development," explains Evans.

"The founding of a company requires one set of skills. The scaling of a company requires another. Startups usually go through four or five morphs and recalibrations in their early days. But once companies get a niche, a competitive edge, a different type of innovator is needed. These business-savvy people can put their ideas into practice and create a sustainable business that generates liquidity for investors. That is what the Silicon Valley model is all about," says Evans.

The master's degrees awarded at

Jason Lohn

Stuart Evans

the Silicon Valley, unlike the Ph.Ds, are professional degrees that impart technical, business and organizational skills. Research is not required, but often students seek to deepen their technical knowledge by engaging in graduate assistantships. Patricia Collins explains, "The assistantships provide financial aid and the opportunity to participate in research projects. Students get to write and publish papers. This is exciting for them and for us, the faculty."

Research opportunities along with supportive and productive relationships with the faculty attract students who will play a pivotal role in advancing the software industry. Evans says, "We're seeing it is not the professors who create the companies in the Silicon Valley. It is their research students. They take their research interests and generate businesses around them."

Research Makes It All Go Round

A direct outcome of expanded academic programs at Carnegie Mellon Silicon Valley is the increase in research. Research funding here has tripled since 2008, with the U.S. Government being the primary source: NASA, NSF, DARPA and the Army. Industrial sponsors are growing as well.

Signs of new activities are evident. Recently, the campus's original research facility, the Innovations Laboratory underwent renovations. Upgrades were made to the lab's electrical, data networking and heating and cooling systems in an effort to support a variety of research purposes says Jason Lohn, the lab's director. He categorizes the campus's research into a number of areas: NASA-sponsored work, wireless and security, machine learning and language technology, mobility, ubiquitous computing and disaster management. Because of CMU's interdisciplinary culture, campus size and equipment costs, outfitting one lab that is shared by all the research groups is a smart approach for now. "We are like a startup in nature—we make do with fewer resources but we provide a supportive environment," says Lohn.

"The goal is to make the lab a resource for everyone, whether they're doing wireless or smart phone work," says Lohn. The lab promotes a cross fertilization of ideas by bringing together people with different technical backgrounds.

The lab provides faculty and students a place to work, but it is by no means their only option. Collaborative research with NASA is robust. "Our relationship with NASA is another distinguishing feature about Carnegie Mellon," says Griss. The campus is located in NASA Ames Research Park, and there is a longstanding working relationship between CMU and NASA. At one time, half of the faculty taught master's classes while the other half was NASA contract research staff who worked in the areas of high-dependability computing, robotics and space-related activities. Today these lines of demarcation blur as NASA personnel become more involved with academic programs.

"Teaching students how to craft startups in a credible, academically rigorous way is an impetus for the full-time master's in software management that's launching this fall."

This heightened collaboration is proving to be of great value, especially in the emerging field of disaster management. The Silicon Valley campus is the home of the Disaster Management Initiative (DMI), which is a consortium of researchers, public organizations, private corporations and others who aim to build better technical solutions for disaster management and provide humanitarian aid. Many government agencies and relief organizations seek to develop high-level teams to respond during massive disasters like Haiti or Katrina, and "by working with these agencies, we can enhance our outreach and leverage our research," says Griss. At Moffett Field, NASA has an elaborate training facility for the emergency services community. CMU researchers have access to collapsed structures, a rubble yard and a hazardous materials yard where they can test new robots under field conditions. "Our collaboration with NASA has been valuable in providing access to research and other opportunities," states Griss.

"Disaster management is a growing area for us," he continues. While CMU is still trying to determine the best ways to work with government and public entities, everyone involved is motivated to make it work. "The DMI especially makes sense here [in California]. This area is called the Disneyland of disasters—we have wildfires, earthquakes, you name it," he says.

Another reason the DMI works for Carnegie Mellon is that is plays off our strengths in mobility and security research. In disaster ravaged areas, communications often get knocked out, yet relaying accurate, secure information is critical for rescue purposes and for assessing damage to critical infrastructure like water or natural gas lines. Mobile systems are vital in disaster response but they have many other applications.

Worldwide mobile systems are becoming the chief mechanism for accessing the internet. Capitalizing on the need for this technology, Carnegie Mellon CyLab established the Mobility Research Center at the California campus. Here is where you'll find CMU faculty and students exploring agile software engineering, human-computer interaction, sensor-enabled environments, networking, security, robotics, etc.

CMU's mobility work has caught the attention of Silicon Valley companies, such as Ericsson, Nokia, Samsung, Panasonic, Motorola and others, all of which interact with the campus. "We have become part of the community and we connect with companies. Students want to be part of this, and that's why we nurture corporate relationships," says Griss. This emphasis on relationships has helped Carnegie Mellon Silicon Valley to establish a unique partnership with Institut Telecom, a consortium of European higher education and research institutes involved in telecommunications and mobility research. With a goal of fostering joint innovation between California and Europe, the partnership encourages collaboration between Carnegie Mellon and the companies associated with Institut Telecom. This venture is ripe with potential. The European organization has 5,400 students, 650 professors and it spins off 65 startups a year. Reflecting on the Institut Telecom, Griss says, "We [CMU Silicon Valley] always want to have a startup in the wings. But we don't want to be merely an incubator. We want to add education, mentoring and research to our entrepreneurship."

"At Carnegie Mellon Silicon Valley it's all about synergy," says Griss. "Education draws from research, and in turn, both foster entrepreneurship. Our environment feeds this flow, and things flow quickly here."

BY **SHERRY STOKES**

CAN NANOTECH BE MADE CO-FRIENDLY FROM THE START?

How research and a new Ph.D. program aim to avoid "the path of DDT"

BY MIKE VARGO

On a shelf in Greg Lowry's office in Civil and Environmental Engineering (CEE) are several tubes of a South Korean toothpaste. The printing on each box is in Korean characters, except for the block letters that say NANO SILVER. "Silver nanoparticles are anti-microbial," Lowry explains. "Maybe they're in there to attack the microbes that cause bad breath. But when you rinse your mouth, where do those particles go? Down the drain, and then where, and what do they do?"

Lowry's colleague, CEE professor Jeanne VanBriesen, notes that it's now possible to deodorize from head to foot with nanotech. "You can buy socks that have nanosilver embedded in the fibers to make your feet stink less," she says. "But every time you wash the socks, some particles wash away. Again, is there an environmental concern?"

Greg Lowry

Jeanne VanBriesen

The question looms larger as engineered nanoparticles of many kinds are coming to be used in products from fuel additives to medicines and electronics. What we want to avoid, says VanBriesen, is "going down the path of DDT or CFCs [the gases found to deplete the earth's ozone layer]. Only after those materials were in wide use did we begin to look at the consequences." That approach led to massive recalls and costly rework.

Carnegie Mellon is part of a unique effort to steer nanomaterials on a smarter path. The university is one of six in the U.S. housing research hubs of CEINT—the federally funded Center for the Environmental Implications of NanoTechnology—and one of two, along with Howard University, recently chosen to expand their CEINTs by piloting a first-of-a-kind Ph.D. program in the subject.

VanBriesen, head of the new doctoral program, says one goal is to seed the world of nanotech R&D with "engineers trained to think about the long-term impacts of what they are designing." Also, some of the Ph.D. students will major in engineering and public policy, and their mission will be "to bring scientific literacy to policy making in this field," says Lowry, the director of CEINT@Carnegie Mellon.

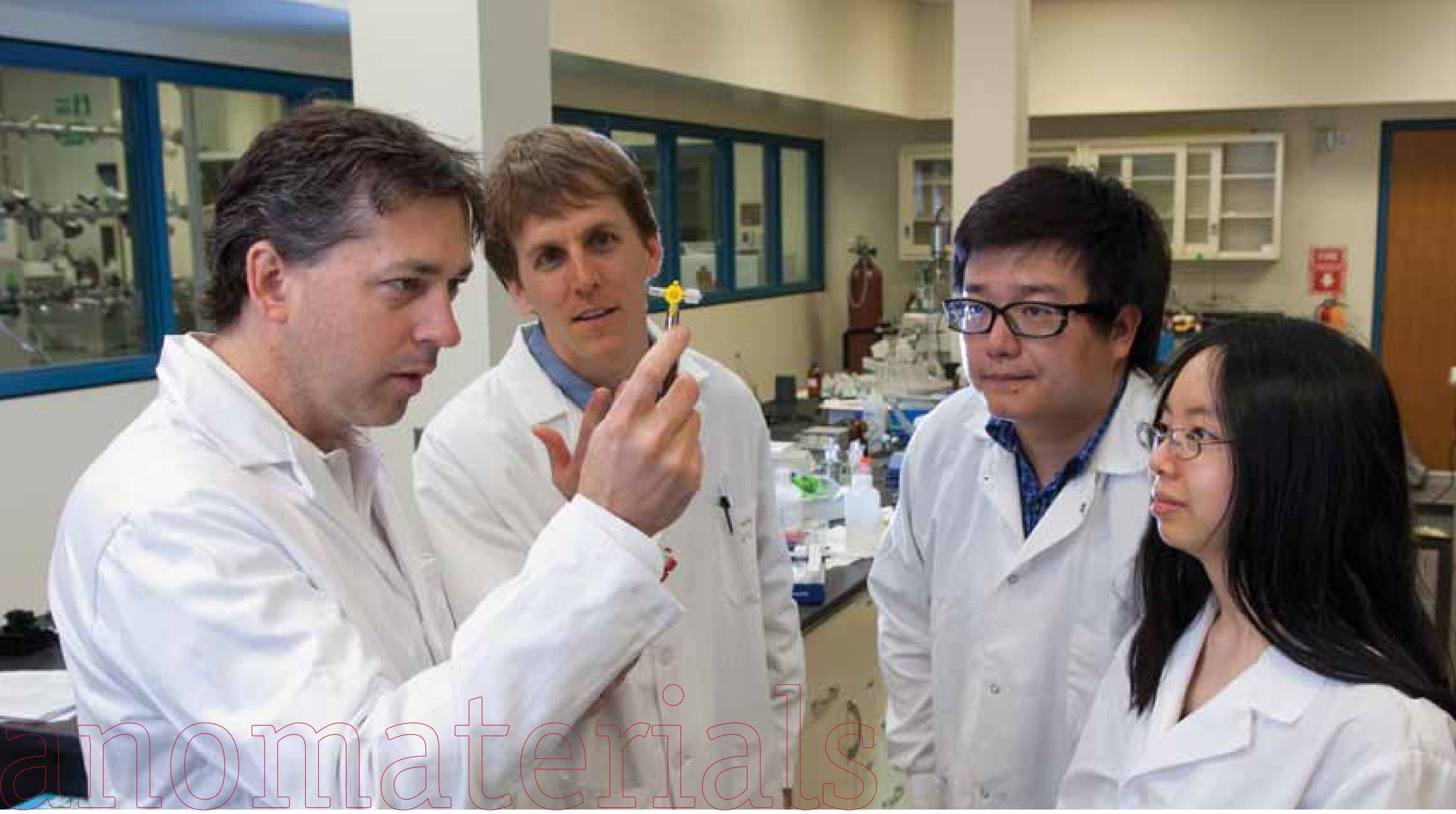
New Properties, New Risks

Nanoparticles are chunks of matter with dimensions of about 1 to 100 nanometers, much closer to the size range of individual atoms than to, say, grains of table salt. At that scale, factors such as quantum forces and surface effects can produce properties that a material doesn't have in other configurations.

For example, VanBriesen says, "We know that carbon has different properties depending on its structure. It can be a diamond, or graphite, or coal. Now we can engineer carbon nanotubes"—atoms bound together in long, hollow cylinders—"which are different from all of these and have unusual properties like very high tensile strength and conductivity." The nanotubes are being embedded in resins to make light, tough bicycle parts and other sporting gear; future uses could range from larger structural shapes like auto body parts to super-thin membrane filters and "paper batteries."

To strive for complex and highly targeted effects, nanoparticles may be made of multiple materials or have coatings. Some are being tested in medicine to deliver drugs where they're needed within the body, while scientists are trying to get others to selectively penetrate and kill tumor cells.

However, new properties could bring new hazards. Particles tiny enough to cross bio-barriers might get into unwanted places once they leave the body, and even nanomaterials used



to protect the environment have the risk of backfiring. Cerium oxide is a very potent combustion catalyst in nano-form. It's being added to diesel fuels in Europe to burn the fuel more efficiently and cut emissions, and "the EPA is considering mandating its use in the U.S.," Greg Lowry says. "We'd be putting a lot of that nanomaterial into the environment and it's redox-active. It has the potential to interact with organisms."

Learning to Wrangle the Unknowns

The work of assessing and managing nano-risks is not only complex but inherently interdisciplinary. Carnegie Mellon's new Ph.D. program is being created with a five-year, $3.15 million IGERT grant from the National Science Foundation. IGERT (Integrative Graduate Education and Research Traineeship) funds are meant expressly for "preparing people to solve tough problems that can only be addressed at the interfaces of disciplines," VanBriesen says.

All students will take two years of intensive coursework from a curriculum now being designed, then move to Ph.D. research. "The students will choose whether they want to be 'development' engineers with a degree from one of our engineering departments or 'policy' specialists from EPP," VanBriesen goes on. "But the development people will still have to learn about the policy implications of nano, and the policy people will learn enough about the technology to be effective in their work."

Each aspect in itself is daunting. In the CEINT lab where much of the Ph.D. research will be done, Greg Lowry and other CEINT-affiliated engineering faculty already have been at work for over three years trying to characterize a few of the more common potential nano-hazards. For one experiment, rows of small beakers are filled with soil samples—some dry, some submerged in water and some recently wetted to simulate rainfall. They've all been dosed with silver nanoparticles. After due time, says Lowry, "we'll speciate the silver to see what we've got. Has any of it become silver dioxide, silver sulfate, silver chloride? Has it moved up or down in the soil samples? And so on."

This sounds fairly simple, until Lowry explains that the results will be far from definitive. At the CEINT facilities at Duke University, companion experiments are being run under more "natural" conditions, with much lower doses of nanosilver in controlled environments that include plants, fish and other small life forms. The quandary, Lowry says, is that "if you use high concentrations [of a nanoparticle] in the lab you may see effects that aren't observed, or aren't important, in nature. But with extremely low concentrations it's hard to measure anything." So the researchers conduct a variety of experiments, compare observations, and try to project how long-term exposure to the material might play out in real ecosystems.

Greg Lowry and members of his team examine a nanoparticle suspension prior to injecting it into an experiment that will test transport properties in the environment.

Then the policy work adds further complexity. Once the possible impacts of a material are understood, "we have to choose appropriate policy responses for managing the risks versus the benefits," VanBriesen says. She notes that nanosilver is only one of many nanomaterials, and "if a material has medical benefits, that's a whole different risk-benefit balance than if it just makes your feet not smell." EPP Professor Elizabeth Casman, an expert in nanotech risk analysis, will take the lead in policy education for the IGERT Ph.D. program.

Despite the challenges, Jeanne VanBriesen believes that the first class of eight to ten Ph.D. students starting in September 2011 will represent a key step forward: "Nano is all about control. It's about choosing and altering materials to get the behaviors you want, when you want them. And there's an opportunity to learn how to get a wider range of benefits with less risk. What we do here can affect how the next generation of engineers will think about their work."

New Life on the **Cold Front**

Research in mechanical engineering aims to extend the medical uses of cryo engineering

Extreme cold can destroy or preserve, depending on how it is used. In medicine it is used both ways—to kill cancerous tissue, or to preserve healthy tissue for implanting—and key strides could be made in both areas through new research at Carnegie Mellon.

Yoed Rabin is at the center of the work. Rabin directs the Biothermal Technology Lab in Mechanical Engineering, where he has a busy agenda. Over the past year Rabin won grants from the National Institutes of Health totaling $2.6 million to pursue four distinct lines of research in cryosurgery and cryopreservation.

Rabin says the grants are noteworthy because "cryo is not a glamorous new field; not the type that usually attracts a lot of funding. It has been practiced for many years, so it tends to be seen as a 'mature' field, when in fact there is still much more to be done."

For instance, he points out, our ability to preserve tissues at ultra-low temperatures is limited, where cryopreservation is the only method for long-term preservation. We can store body fluids such as blood, and some small and less complex tissues like corneas—but not blood vessels of significant size, or entire organs such as hearts and livers. Such organs can only be kept viable for a few hours by mildly chilling them. This is why transplant surgery depends on matching the right donor with the right recipient on a very short notice, and within a limited shipping time/travelling distance, then rushing the organ and patient to the surgery site. This process puts an enormous pressure and limitations on the practice of transplantation medicine.


Yoed Rabin

If cryopreservation were extended to more complex and larger tissues, more transplants would be possible and we could think of building comprehensive tissue and organ banks for a very wide range of treatments, similar in concept to blood banks for example. That's one goal that Rabin and his team are working toward. Another is improving the precision of cryosurgery, with tools that range from a "flight simulator" for training surgeons to cutting-edge sensors to display freezing effects in real time. Some of the R&D is fast-track and some longer term, but Rabin says it all has one common theme—"it is cool technology."

No Ice, No Fractures, Please

One trick in preservation is to arrest decay by bringing tissues down to minus-130°C or below without letting ice crystals form. When the water inside or between cells turns to ice, it triggers a sequence of events which eventually leads to cell death. One effect that kills cells is the expansion of water upon freezing, rupturing cell membranes, and another effect is that body solutions become toxic when a significant amount of water is removed in the form of ice. Although blood can be used for transfusion even if many of the cells are lost to ice damage, organs can't absorb high cell loss in critical places and still function. Rabin taps a window in his office: "You want to vitrify the tissue. Make it solid but not crystalline, like glass." This can be done by adding cryo-protective agents (CPAs), which inhibit icing. The trouble is, CPAs have toxic effects. A popular one, DMSO, "was developed as a paint stripper in the early 1950s and may become very toxic to the tissue," Rabin says. Thus a core problem in cryo-cooling is finding ways to add CPAs in amounts that are low enough to not poison the tissue, yet high enough to be effective in affecting ice formation. New and exotic chemicals called synthetic ice blockers are now being developed, but they too have limitations. So with one NIH grant, says Rabin, "the concept we are testing is to mix ice blockers with the CPA, to see if we can use less CPA and get the results we want."

The other big obstacle to preserving organs is macro-fracture. As cooling or thawing proceeds through tissue, the temperature gradients can induce forces that leave structural damage. While the majority of individual cells may survive it, tissue or organ functionality may not. An expert in such fracture, Rabin is using a second NIH grant to develop a much-needed

instrument, a "cryomacroscope" for observing how macro-fractures develop in test specimens.

"I got frustrated by cryobiologists asking me, 'How did this happen?', and I had to speculate by reasoning backward from the results," he says. "We want a movie that shows structural changes in progress, with time and temperature data embedded." Using fiber optics, a scanning mirror and other hardware and software, his MechE team is constructing a prototype system to deliver that result. Says Rabin, "We hope to have a fully computerized system within a year."

Learning and Sensing

Rabin has a passion for his specialty. "I've always been fascinated by heat transfer," he admits. He has done cutting-edge work in heat transfer in biological systems since the early 1990s, first as a graduate student in Israel, then at Pittsburgh's Allegheny General Hospital, where he began building networks of research partners among physicians and biologists while developing surgical devices. At Carnegie Mellon since 2000, beyond his research interest, Rabin is developing new teaching methods in the area of thermal sciences, ranging from hands-on lab activities to thermal design. In recognition of those efforts, he also won teaching awards for "Best Class" and "Professor of the Year" in MechE, and his teaching interests show up in another NIH project.

In cryosurgery, icing is good. The goal is simply to freeze and kill cancer tumors. Slender cryoprobes delivering liquid nitrogen are inserted into the affected area, such as the prostate in men or the breast in women. Targeting and control are crucial to freeze all of the diseased tissue without harming nearby healthy tissue. In previous work Rabin has developed computer-based "planning algorithms" to suggest optimum placement of probes for a given target geometry. But good surgeons, he notes, will want to try improving on what the algorithms suggest.

Hence the flight simulator as a learning tool, a project in collaboration with Kenji Shimada of MechE. "If the computer said 'put the cryoprobes here,' the clinician can say, 'Let's try this instead.' A 3-D visualization will then tell you if the outcome would be better or worse. You can play with different scenarios, and learn to develop intuition"—before trying anything on a patient. Rabin talks about the challenges of getting a very complex simulation and visualization to "run in an acceptable time for the learner" on standard computing resources. Still, he concludes, "We're building a toolkit with a clear path of development along an established line of research. We can see it becoming a product."

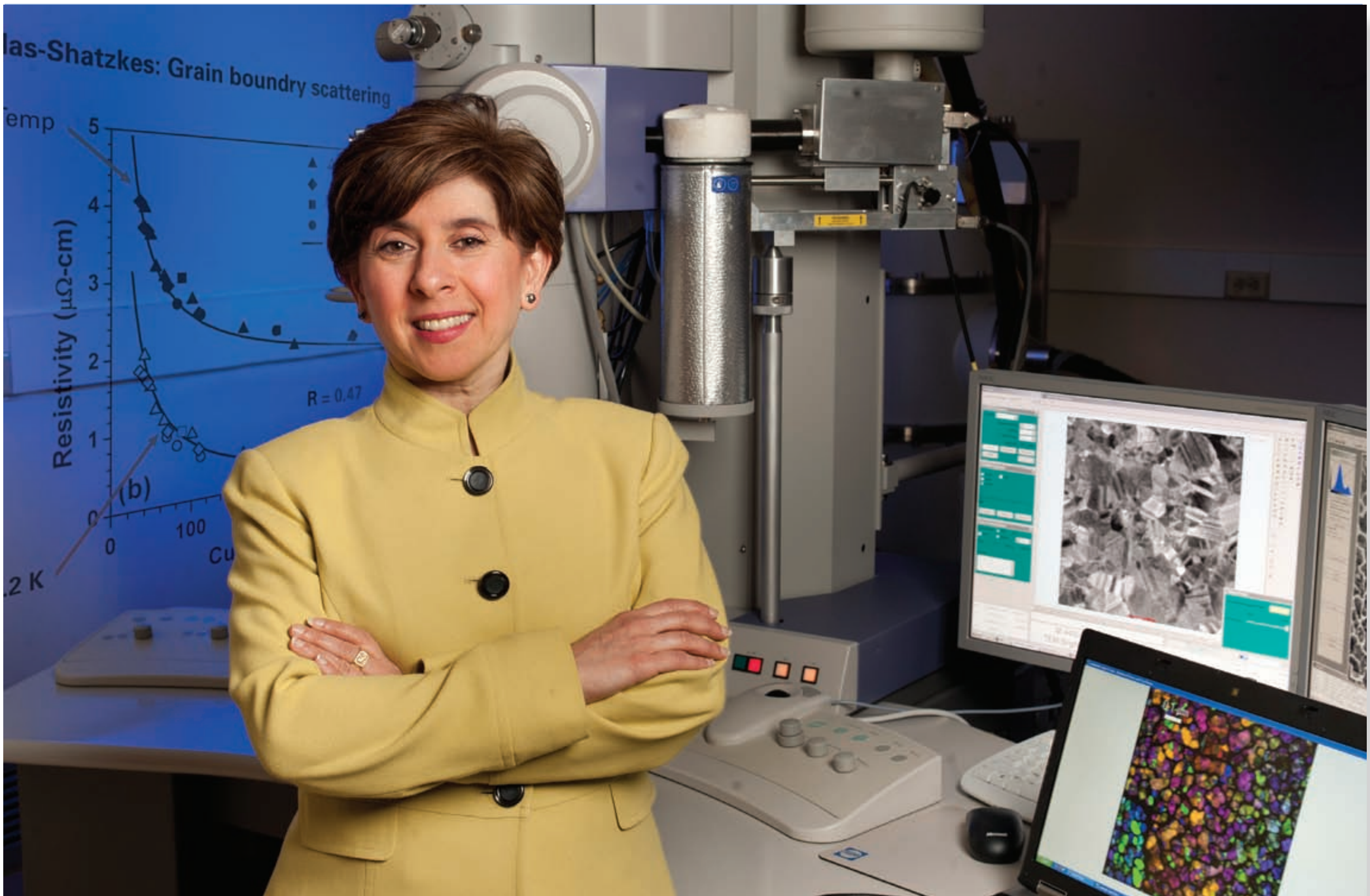
And his ultimate cryosurgery product would allow on-the-fly control during surgery itself. It's a grain-of-rice sized wireless temperature sensor and transmitter. An array of these, pre-embedded around the target region, would show the progress of the freeze front.

Such small sensors don't yet exist. Developing them represents a collaborated effort with Carnegie Mellon's experts in microelectronics fabrication and wireless communication—Gary Fedder and Jeyanandh Paramesh of ECE. The goal for the two-year NIH grant period is just "proof of concept," yet Rabin says he's already heard from a customer. "A company developing a device for hyperthermia"—killing unwanted cells with extreme heat rather than cold—"was hoping the sensors were close to ready. They need them and there are no alternatives."

In Yoed Rabin's view, that reflects the general eagerness of many people for new advances in cryosurgery and cryopreservation. "We're talking about improving the quality of life, possibly extending life expectancy," he says, while distancing his effort from whole-body freezing—a much debatable practice commonly known as cryonics. "Within my lifetime, I want to see our work touching people."

BY MIKE VARGO

CIT Materials Scientist **Solves a 100-Year-Old Mystery**



Old problems are usually hard problems, and those are the types of challenges Katayun Barmak likes.

Barmak is one of a handful of materials scientists in the world to map nanoscale-size polycrystalline structures. Using a technique that took her ten years to implement, she can analyze crystalline materials a thousand times smaller than the diameter of a hair. The applications of this research loom large and affect engineered systems, ranging from silicon chips to fuel cells to medical devices.

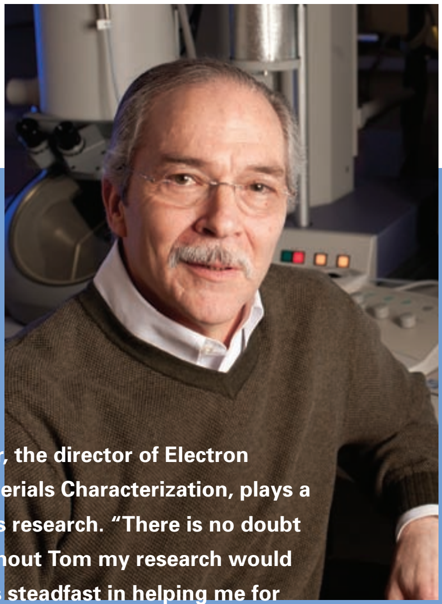
"If you want to create nanoscale technology, you have to have tools for measurement. Engineering is quantitative. You need numbers and models." The mapping process is opening avenues for securing much-needed data. "We all say materials behave differently at the nanoscale. But we have to show the nature of the differences and quantify them. This is not easy."

Executing the mapping program is an achievement, but Barmak says, "I am not interested in developing tools. I want to do science." And here is where Barmak has quietly yet soundly shaken up the field of materials science and engineering. She and colleagues from the University of Central Florida have solved a classic problem that has challenged scientists for more than 100 years.

A professor in Carnegie Mellon's MSE department since 1999, Barmak begins her tale of science and determination with a history lesson. In 1897 the British physicist J. J. Thomson discovered the electron. A few years later, he was measuring electrical resistivity, or how materials resist the flow of electric current, when he observed that the thinner his samples, the greater their resistivity. He couldn't explain why resistivity was subject to a size effect. Quantum mechanics hadn't come along yet.

By the 1930s, explanations for Thomson's discovery began to "surface." Scientists learned that electrons scatter

Katayun Barmak's research examines the electrical and magnetic properties of metal films, which affect the advancement of integrated circuits, information storage systems, displays, sensors and coatings.



Noel Thomas Nuhfer, the director of Electron Microscopy and Materials Characterization, plays a vital role in Barmak's research. "There is no doubt in my mind that without Tom my research would not succeed. He was steadfast in helping me for more than 10 years," says Barmak.

when they bounce off the surfaces of materials. This surface effect was deemed responsible for materials resisting electric charges and that was explanation enough. Then in the 1960s, silicon semiconductors emerged. Researchers were wiring the semiconductors with aluminum when they discovered that metals were comprised of polycrystals that had grain boundaries or surfaces between the crystals. A new theory formed: higher resistivity was the result of the electrons getting scattered by grain boundaries.

Interest in resistivity fizzled out again, that is until around 1998. Researchers at Intel reported that the dimensions of the copper wires used in their chips were getting so small that the size effect that Thomson reported was coming into play and it was affecting performance. A great debate soon ensued: Were surfaces or grain boundaries responsible for obstructing the flow of electrical charges?

Answering this question has been a tremendous struggle because indentifying and measuring enough grains to provide reliable data is a Herculean task. Yet, amid an uproar of controversy, Barmak and colleagues have definitely proven that grain boundaries are the dominant scattering mechanism that causes higher resistivity.

"We conducted the very first, most careful and quantitative experiments, where we measured thicknesses and roughness of surfaces and grain sizes," says Barmak. Measuring grain sizes is very difficult. Working with pure copper, it took her team many months to measure more than 19,000 grains to obtain 22 samples. "We had to do it by hand. The images are very complex and they are not amenable to automated image analysis. We have tried."

Their painstaking work paid off. They published a major paper, "Surface and Grain-Boundary Scattering in Nanometric Cu Films," in *Physical Review B*. "This is exciting," says Barmak. "When we started this work, we couldn't get funding. Initially, all of our papers were rejected. For a long time, people have believed that surfaces were the culprit," says Barmak.

Getting experts to let go of long-held beliefs is not easy. A couple of years ago, Barmak was invited to speak at a conference where other researchers said that surfaces were the key to electrical resistivity. They presented three data points as proof of their theory. Barmak's presentation followed. She decreed that grain boundaries were the culprit. She showed the 44 data points in their model that substantiated their theory. "People in the audience were very vocal in telling me I was wrong. But people are now listening because it is hard to argue against very good data," laughs Barmak.

Unraveling Thomson's mystery is important for science and obviously for the semiconductor industry because it will help researchers decide if they should work to improve surfaces or grain boundaries. "Implementing solutions can be very costly, so you better solve the right problem," says Barmak.

What frustrates Barmak is that currently "we can not easily extend this study to others. There is no way that we are going to measure the grains by hand again." But hopefully, technology like the mapping process she has implemented will lead to more advanced metrology (measuring) and characterization tools. Barmak believes now that they've identified the nature and the extent of the nanoscale differences in copper, in theory they can do it with other metals.

"People have to engineer things at the nanoscale, but they don't have a data bank of properties or easy methods for getting the data." This confines the selection of materials that could be used in new technologies. Developing automated ways of obtaining accurate nanoscale information is vital, and Barmak is continuing work in this area. "I develop tools for projects. There is an excitement in revisiting old, difficult problems with new tools. This allows us to do better science," concludes Barmak.

BY **SHERRY STOKES**

Device Raises Awareness of **Energy Use**

Did you know that a DVR can use more energy than a television? Anthony Rowe, assistant research professor in the Electrical and Computer Engineering Department, knows exactly how much energy his home appliances use. "My DVR is the third biggest energy consumer in my apartment today," said Rowe, pointing to a graph on his computer. He can pull up an energy profile for his refrigerator to make sure it is working correctly and can even turn on his bedroom light from his office.

Rowe's home appliances are all connected to wireless sensor nodes, individual sensors that gather remote information and link to a larger network. The nodes are little black boxes that function like adaptors, plugging into an outlet and connecting to an appliance. Inside each node are sensors that measure an appliance's energy output while recording the area's environmental conditions like light, temperature and vibration. The nodes also contain wireless transmitters that send signals to a receiver, which collects and delivers the data to a web interface, called Sensor Andrew Gateway Agent (SAGA). It is through this interface that Rowe observes and controls his appliances.

The sensor nodes are part of Carnegie Mellon University's FireFly Wireless Sensor Network, a low-cost and low-power hardware platform that collects and transfers data in real-time. It is only in the last two years that Rowe and his collaborators began developing energy monitoring applications for the FireFly technology with funding from the National Science Foundation.

The purpose of the sensor nodes is to generate awareness about energy use. Right now there are six houses being detected and the data from these homes will reveal important information about energy habits. Like Rowe, participants can access their accounts through the SAGA interface and observe their own appliances. "In the future," says Rowe, "this technology and the data it collects will be vital in helping utility companies shift peak usage periods for power-hungry appliances." This would help avoid blackouts and reduce the need for new power plants. The information can also be shared "to educate homeowners about energy waste and encourage them to cut down or divert their usage to off-peak times."

One major concern for broader application is privacy because the sensors are capable of exposing information about lifestyle patterns. To investigate this, Carnegie Mellon CyLab is dedicating a student to study the privacy issues.

Collaborators on this interdisciplinary project are professors Raj Rajkumar of ECE, Lucio Soibelman and Mario Berges from CEE, and CEE Department Head and Co-Director of CenSCIR James Garrett. Carnegie Mellon | Portugal is also involved, but working on independent research.

So back to our question: How does that DVR use more energy than a TV? "It's on all the time," says Rowe. While his TV requires more power to operate, the SAGA energy profile reveals that his DVR's total energy usage is greater.

BY REBEKKA BLAHA

Dr. Aris Candris | Andrew Gellman, Jay Whitacre, Edward Rubin

Westinghouse CEO Launches New CIT Speaker Series

To foster dialog on vital topics between internationally respected thought leaders and the Carnegie Mellon community, the College of Engineering has created the Leadership Speaker Series. Launching the series on Oct. 12, 2010, Dr. Aris Candris (E'74, '78), the CEO of Westinghouse Electric Company, delivered the keynote lecture "Meeting the World's Energy Needs in a CO_2-Constrained Environment: The Role of Nuclear Power."

Candris explained to a packed house why it's essential that the U.S. develops a comprehensive energy plan that taps different technologies, including nuclear power. After his presentation, Candris and CIT energy experts engaged in a panel discussion moderated by CIT's Dean Pradeep K. Khosla. Panel members included Andrew J. Gellman, head of ChemE; Edward S. Rubin, professor of EPP and MechE and a member of the Nobel prize-winning Intergovernmental Panel on Climate Change; and Jay Whitacre, assistant professor of MSE and EPP.

"This lecture series is important because it strengthens CIT's relationships with industry. It creates more opportunities for students to interact with companies and gain insight into real world problems," says Khosla.

One of society's most pressing problems is the need for clean, safe and reliable energy. Projections estimate that the world's population will increase 25% in the next 20 years, placing unprecedented demand on energy supplies. Candris stated that continued reliance on fossil fuels thwarts efforts to reduce greenhouse gases. To address energy and environmental needs, Candris advocates for a balanced portfolio of energy technologies that includes nuclear power, along with increased conservation efforts and the deployment of vehicles powered with cleanly produced electricity and hydrogen.

The CEO's talk outlined the advances made in the nuclear power industry post Three Mile Island. These advances include a greatly improved plant design and a streamlined nuclear regulatory process. Now a mature industry, nuclear power supplies 20% of the world's electricity. The construction and operation of nuclear facilities presents career opportunities for engineers from a variety of disciplines.

The Leadership Speaker Series aims to highlight companies that operate in areas that align with CIT's research. "The goal is to bring senior-level executives from these companies to campus so we can discuss how the multifaceted capabilities of the college align with industry needs," says Michael Ransom, CIT's Senior Advancement and Corporate Relations Officer.

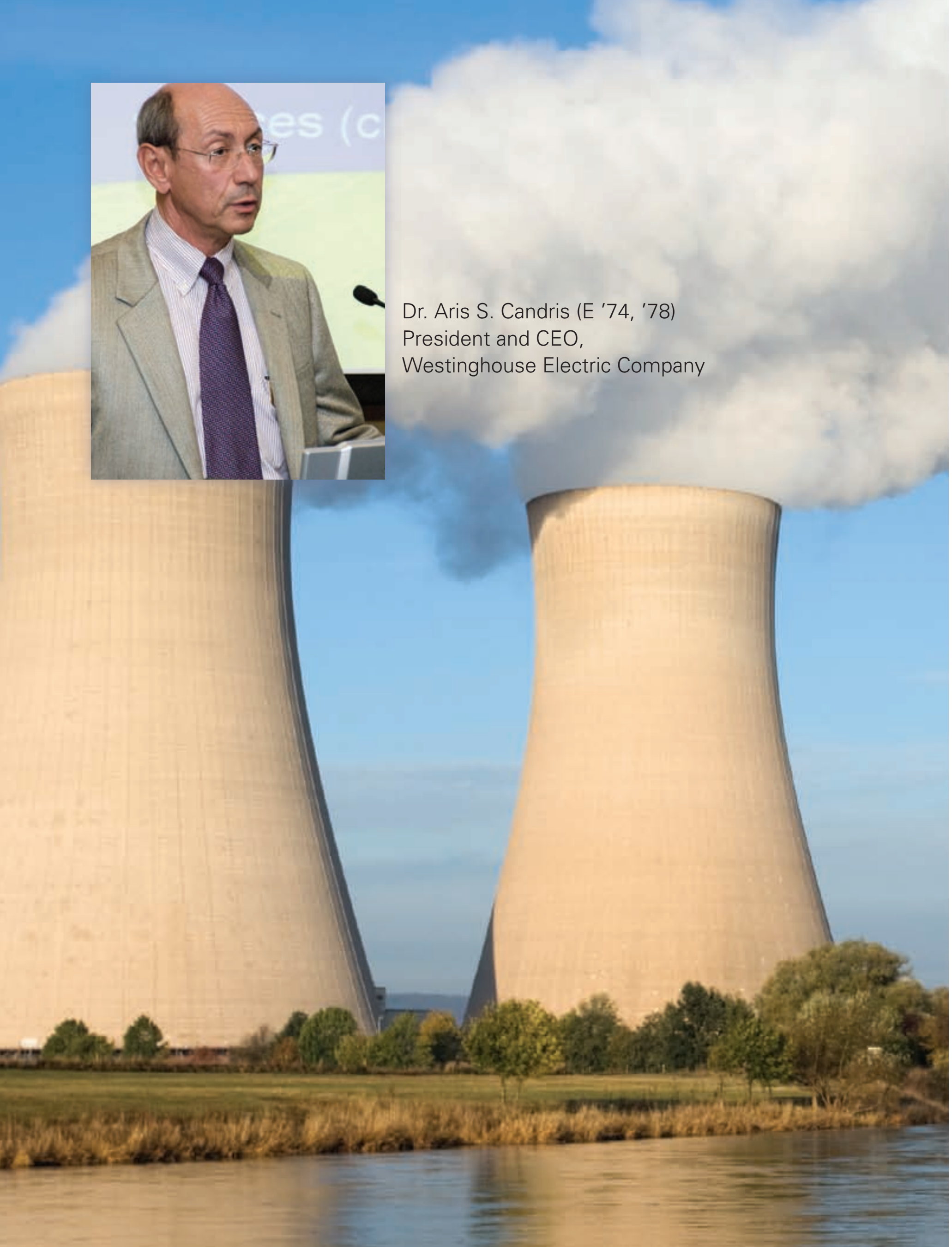
"Our faculty has been successful in working with industry researchers on projects. But this series creates awareness and increases buy-in about partnering with CIT at the top executive level," says Ransom. "By taking part in the series, Westinghouse gained a deeper understanding of our programs, as well as a forum to discuss the future of power generation in the U.S. and abroad." Students, on the other hand, heard directly from the CEO of Westinghouse about the benefits of nuclear power and challenges facing the industry. Students will also benefit from increased research and job recruitment opportunities.

"This first lecture brought together two forward-thinking organizations that are strongly positioned to establish Pittsburgh as a world-renowned energy hub," concludes Ransom.

The Need for Perspective: **The Fukushima Daiichi Crisis and the Reality of Nuclear Energy**

BY DR. ARIS S. CANDRIS

When an unprecedented natural disaster occurs, such as the one that took place in Japan on March 11, it is human nature to respond with some measure of uncertainty. Regarding the events at the Fukushima Daiichi nuclear power plant, while some of that insecurity resulted from exaggerations in the general media, perhaps the more serious issue is the lack of understanding of the unfolding of events at Fukushima, and the true global repercussions of what happened there.



Dr. Aris S. Candris (E '74, '78)
President and CEO,
Westinghouse Electric Company

The Evolution of the Accident

The Fukushima Daiichi nuclear power plant site was made up of six boiling water reactors (BWRs) designed primarily by General Electric and its Japanese licensees (Toshiba and Hitachi) approximately 40 years ago. In a BWR, water is used as a coolant to draw heat away from the reactor core. When it boils, the water forms huge quantities of high-temperature steam. The steam then spins turbines, which drive generators to produce electric power.

Following the 9.1 magnitude earthquake, which was seven times more powerful than the worst earthquake the plants were built to withstand, the three operating reactors at the site shut down automatically, as designed, and the emergency diesel power generators were activated and provided the electricity necessary to allow the standby safety systems to continue cooling the reactors. Had the earthquake alone taken place, even though it was a horrendous event, there would have been no safety issues at the plant.

Unfortunately, about an hour later, the tsunami occurred. It is important to understand that a tsunami is not a beach wave; it is a solid wall of water travelling at the speed of sound, and thus containing a massive amount of energy. This tsunami wave leveled everything in its path around the Fukushima Daiichi plant. Only the reactor buildings were left standing in the vicinity. The plant itself was not damaged. But outside the plant, the tsunami destroyed all supporting electrical infrastructure, such as power lines and emergency diesel generators.

As a result, the incident is considered what the nuclear industry refers to as a "station blackout event," which means there was no offsite or onsite power available. For the first eight hours, battery power was available, but primarily for emergency lights and instrumentation (the batteries were never intended to run

Nuclear energy, like any other energy source, is not without risks. But those risks can be effectively managed. The fact remains that nuclear energy is a clean, cost-effective and reliable source of baseload power.

the pumps and activate the necessary valves). So the available backup systems that were built as safeguards were unable to remove the decay heat[1] from the plant's core. As a result, the decay heat continued to build up steam within the reactor vessel. To control this pressure, the plant operators periodically had to vent the steam into the atmosphere. Hydrogen was generated as a result of the overheating and oxidation of the zirconium tubing around the uranium fuel. When it was released into the broader atmosphere outside containment, it came into contact with oxygen. At certain concentrations, this can cause a chemical explosion, which is what happened at Fukushima. Despite these hydrogen explosions, the containment structures of the units were not breached.

Most importantly, for reasons still unknown, the decision to pump water (seawater in this case) into these damaged reactors was delayed significantly. So for over 24 hours, no cooling was available at the plant. Once the operators began cooling the reactors with seawater, the heat in the core subsided and the risk of additional hydrogen generation was mitigated.

Misconceptions about the Accident

A number of misconceptions have resulted from the situation at Fukushima. While four units at Fukushima released some radiation into the atmosphere, it is extremely unlikely that the amount was enough to result in health concerns for the general public outside the evacuation zone, now, or in the future. Even the radiation levels inside that 12-mile area are not immediately damaging.

Unfortunately, several reports in the media exaggerated the events at the Fukushima plant. For example, some media outlets discussed at length the potential need for U.S. West Coast residents to take Iodine pills, when the highest levels there never exceeded normal background variations.

Comparisons with Chernobyl were also particularly confusing to the general public. First of all, an accident like Chernobyl's is physically impossible at a Western plant, and did not happen at Fukushima. At Chernobyl, a nuclear explosion occurred in which a large fraction of the fission products escaped the plant. Basically, this explosion was similar to a low-efficiency nuclear bomb, and was not at all similar (in strength or consequence) to the chemical (hydrogen) explosions that occurred at Fukushima. Another major difference is that the design of Chernobyl did not include any containment beyond the central reactor area. Fukushima's design comprises several layers of defense—fuel cladding, the reactor vessel and the containment structure—which were successful in preventing large levels of radiation from being released into the atmosphere.

Part of the reason that the focus of the media may have been so confined to the nuclear incident at Fukushima is that it makes for captivating television. The events continued to unfold over many days and weeks. For the sake of comparison, consider the fact that the Fujinuma dam in the Fukushima prefecture was destroyed as a result of the earthquake. The flooding water from that dam demolished 1800 homes. While it is not known precisely how many people were killed, it's estimated to be in the hundreds. Yet this event has received virtually no coverage by the media.

The combination of the slow-evolving events at Fukushima and the public's limited understanding about nuclear energy and radiation, trigger both fascination and fear. In addition, historically the nuclear energy industry has done a less-than-adequate job of educating the public about them. Let's hope that the discussions initiated as a result of Fukushima proves to be a good place to enhance that education process.

Nuclear Energy: A Reliable Source of Power for Future Generations

Nuclear energy, like any other energy source, is not without risks. But those risks can be effectively managed. The fact remains that nuclear energy is a clean, cost-effective and reliable source of baseload power. In fact, it is the only source of baseload electricity generation that produces no greenhouse gases, manages 100 percent of its waste stream, and has the infrastructure in place to meet the world's growing need for electricity.

Reactor designs have evolved dramatically since the 1970s and incorporate safety features that would have prevented the type of accident that occurred in Fukushima. The Westinghouse AP1000® reactor, for example, employs passive safety features—gravity distributes cooling water to the reactor following an emergency—which would enable the plant to remain safely cooled, without the need for AC power.

The nuclear energy industry has a responsibility and an obligation to consider the events at Fukushima and learn from them, as we have done repeatedly in the past, from less severe events. In the meantime, it is imperative that we remain objective about the facts and maintain a perspective on the best strategy for generating the vast amounts of energy that will be required in order to keep humanity continuing to progress.

[1] "Decay heat" is the heat produced by fission products after shutdown. These fission products continue to decay into radioactive and non-radioactive isotopes, producing heat. When this decay heat is not adequately removed, the temperature of the fuel rises.

Excellence

CIT Faculty Nadine Aubry and Chris Hendrickson have been elected into the National Academy of Engineering (NAE)

"This outstanding recognition is a tribute to the leading-edge, innovative spirit of our problem-solving engineering faculty," said Pradeep K. Khosla, dean of CIT. Election into the NAE is one of the highest professional distinctions an engineer can achieve.

Nadine Aubry is the Raymond J. Lane Distinguished Professor and head of the Department of Mechanical Engineering. Her leadership in engineering education and research in low-dimensional models of turbulence and microfluidic devices contributed to her election into the NAE. Her research in fluid dynamics has applications in aerospace, biotechnology, energy, the environment, materials engineering and nanotechnology. Her accomplishments include the enhancement and control of fluid mixing, the manipulation of suspended particles and drops and the self-assembly of particles into adjustable monolayers. Aubry serves on numerous committees and recently completed her term as chair of the National Research Council's U.S. National Research Committee on Theoretical and Applied Mechanics. She is also an elected member of the Congress Committee on the International Union of Theoretical and Applied Mechanics and is the associate editor for the American Society of Mechanical Engineers' *Journal of Applied Mechanics*.

Nadine Aubry

Chris Hendrickson is the Duquesne Light Professor of Civil and Environmental Engineering and co-director of the Green Design Institute at Carnegie Mellon. He will be inducted into the NAE for his leadership and contributions in transportation and green design engineering. His current research projects include life cycle assessment methods, assessment of alternative construction materials, economic and environmental implications of e-commerce, product takeback planning and infrastructure for alternative fuels. He has co-authored three textbooks, two monographs and many research articles. Hendrickson is active in professional organizations, including the American Society for Civil Engineers (ASCE) where he is a distinguished member. He has received the ASCE's Turner Lecture Award and serves as the editor-in-chief of the ASCE *Journal of Transportation Engineering*.

Chris Hendrickson

Carnegie Mellon University's NAE Members

Nadine N. Aubry, 2011
Chris T. Hendrickson, 2011
Jacobo Bielak, 2010
Tom Mitchell, 2010
Paul Nielsen, 2010
William "Red" Whittaker, 2009
David Dzombak, 2008
Stuart Card, 2007
Cristina H. Amon, 2006
Egon Balas, 2006
Manuel Blum, 2006
Pradeep K. Khosla, 2006
Krzysztof A. Matyjaszewski, 2006
Edmund M. Clarke, 2005
Randal E. Bryant, 2003
Robert F. Davis, 2001
Stephanie Kwolek, 2001
Ignacio E. Grossman, 2000
Daniel P. Siewiorek, 2000
Richard J. Fruehan, 1999
Alfred Blumstein, 1998
Takeo Kanade, 1998
Hubert Aaronson, 1997
Arthur W. Westerberg, 1997
Charles M. Geschke, 1995
Mark Kryder, 1994
William Wulf, 1993
John L. Anderson, 1992
Herbert L. Toor, 1990
Robert M. White, 1989
Julia Weertman, 1988
Angel G. Jordan, 1986
Raj Reddy, 1984
Allen Newell, 1980
Harold W. Paxton, 1978
Alan Perlis, 1977
Steven Fenves, 1976
John Wachtman Jr., 1976
Johannes "Hans" Weertman, 1976
John Hirth, 1974

National Recognition for CMU's Society of Women Engineers

Carnegie Mellon's chapter of the Society of Women Engineers (SWE) took top honors at the SWE National Conference (WE10) in November. The CMU chapter won Gold in the Outstanding Collegiate Section Competition for the 2009-2010 academic year.

The group also won the first ever SWE History Award, celebrating SWE's 60th anniversary. They created a video documenting their history and achievements throughout the years. While these achievements are impressive, there's even more: Theresa LaFollette (Ph.D. ChemE, 2010), won the Outstanding Collegiate Member Award. She was cited for her "graceful, compelling and visionary leadership as both an undergraduate and graduate collegiate member." "It is a great feeling to be nationally recognized for the outstanding programs and hard work that our SWE executive board puts into the chapter year after year," said LaFollette, the former chapter president. Today she works for Exxon Mobil Process Research Laboratories.

Nikunja Kolluri, SWE's vice president at CMU, was one of 16 members who attended the national conference in Orlando, Florida. She believes that it was CMU's diversity in membership and activities that made them stand out in the competition. "We offer unique opportunities for professional development, community service and mentorship not only for our members, but for the campus community at large," said Kolluri.

These activities include the annual Technical Opportunities Conference (TOC) that is sponsored by the College of Engineering. This major conference began 30 years ago as a way to connect engineering majors directly with employers. Today it has swelled into a two-day event that benefits the entire university. More than 200 companies participate.

On campus SWE works to fulfill the organization's national mission of empowering women "to succeed and advance in the field of engineering." SWE recognizes female engineers as they advance through their academic and professional careers. "It's no secret that women are a minority among engineering degree earners," said Michelle Stolwyk, section secretary. "Before joining SWE, I felt rather lost and didn't know exactly why. SWE gives its members access to resources so they learn and grow." – RB

Left: Nikunja Kolluri and Michelle Stolwyk
Below: L-R SWE Chairs: Teresa Kirschling, Katelyn Bruce, Nikunja Kolluri, Daria Wong, Amy Nagengast, Tanushree Chellam, Kathryn Kukla, Christine Sidoti, Anjana Tayi and Michelle Stolwyk

The Trophy

"Track provides a great support network for students from both a social and athletic standpoint, and it teaches them how to juggle the time commitments of athletics with the rigors of academics."

Kurt Larsen, CIT's Assistant Dean for Undergraduate Studies and the Faculty Advisor for the Tartan Track & Field team. To learn more about athletics at Carnegie Mellon visit www.cmu.edu/athletics.

CIT students have a reputation for their academic achievements and steadfast study habits. Yet as busy as they are, many of them participate in athletic activities, and track & field ranks as a favorite pursuit. The following story, written by ECE senior LisaMarion Garcia, expresses the camaraderie and spirit of competition that flourished at a track meet between Carnegie Mellon and Case Western late last fall.

The Tartans versus the Spartans from Case Western Reserve University is the only dual meet of our season, and a bit of a rivalry has built up around it. The meet is scored by adding the men's and women's team scores, and the school that wins gets to keep a giant obelisk trophy for a year. Last year Case Western won it, so we headed off to this year's meet determined to get back what was ours.

When we got to Cleveland, we were met with a surprisingly large crowd of fans for a track meet. Case made signs, prepared cheers, and their fans wore T shirts that said "Spartans > Tartans = Obelisk." We quickly pointed out that the shirts didn't make mathematical sense, but the Spartans seemed inspired. At first, Case pulled ahead of us by a lot of points, but then, halfway through the meet, a comeback started. Our guys swept the high jump and the triple jump. We should have gone 1st and 3rd in the pole vault, but a Case vaulter sat on a bar that miraculously stayed up, and he grabbed third.

Case realized we were catching up, and the pressure was on for the running events. CMU first-year student Jacqueline Guevel won the 55m hurdles and the 55m dash with two new school records. The men's 5k started off with three Case runners in front, but with a few laps left, CMU's J.P. Allera moved up to second place and Evan Gates

LisaMarion Garcia is a pole vaulter and a senior in electrical and computer engineering.

is Ours!

to third. We rushed to the side of the track and started cheering and screaming. Allera shot up to first place, and in the very last lap, Gates sprinted past a Case runner, taking second.

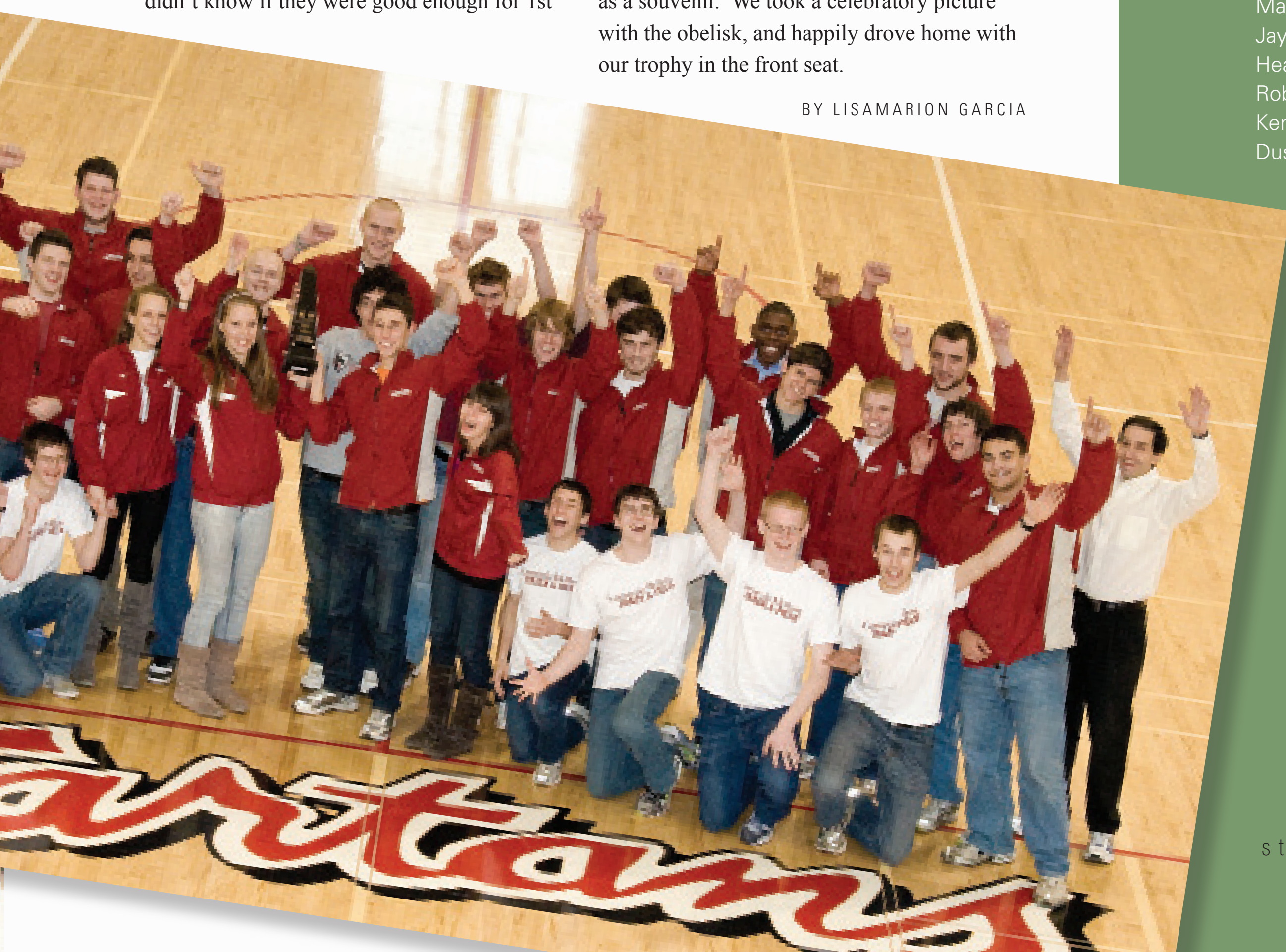
The relays were just as dramatic with the anchor runners in the men's 4x400 going neck and neck until the Case runner face planted trying to get around Dustin Musselman. We figured this made us even for the sticky bar incident during the pole vault.

Finally with running done and the score 119-135 in favor of Case Western, the last event was the men's shot put. We would have to take 1st and 2nd here to win the meet. Our star throwers graduated last year, and our new guys were still a mystery to us. We didn't know if they were good enough for 1st and 2nd, especially since they had a veritable army of Case throwers to contend with.

Both teams and the fans crowded around the shot put circle to watch. (I'm sure the throwers never received such attention before!) All three of our throwers made it into the finals, but not in the top ranks. It didn't look like a winning sweep was in our future. But then the official results were announced. In second place, from Carnegie Mellon, Nathan Cheek. In first place, from Carnegie Mellon, Zachary Erra-Hernandez. Final score: Carnegie Mellon 137, Case Western 136.

The stunned Case team and fans were silent as we cheered our last-minute victory. Someone got hold of one of the equation shirts as a souvenir. We took a celebratory picture with the obelisk, and happily drove home with our trophy in the front seat.

BY LISAMARION GARCIA



CIT Team Members

Women's Team

Courtney Baker
Amal El-Ghazaly
LisaMarion Garcia
Jacqueline Guevel
Morgan Heskett
Carissa Iannone
Anna Lenhart
Lindsay MacGillivray
Laura McKee
Lisa Rising
Lauren Sittler

Men's Team

J.P. Allera
Nate Bussiere
Adam Cantini
Daniel Cardenas Rivero
Daniel Ching
Nathan Cheek
Robert Cross
Zachary Erra-Hernandez
Evan Gates
Chris Holliday
Matt Jacob
Tim Kikta
Ryan Kissell
Justin Kurp
Matthew Kusbit
Jay Kuvelker
Heath McAlister
Rob Morhard
Kenneth Murphy
Dustin Musselman
Brendan O'Hara
Essien Ohues
Pat Robinson
Mike Standish
Noel Titus
Nick Zukoski

l. to r.: John Walker (E '05), Mary Koes (E, CS, Robotics '02, '04) Justine Rembisz (E '08), Rich Juchniewicz (E '06), Fred Hopke (E '01), Henry Thorne (E '82, '84)

DISRUPTIVE BY DESIGN

When Henry Thorne (B.S., M.S. MechE '82, '84) graduated from the College of Engineering he set out to start his own company. His business strategy was simple: he would invent an amazing high-tech product and a lucrative company would follow.

His success didn't happen the way he planned.

Thorne created a wildly innovative product. By combining robotics with a graphic interface, he invented Cye, the first personal robot. It could vacuum the house and carry 15 pounds of goods to and fro. Cye was impressive—it appeared on TV shows like "Good Morning America" and "The Early Show"—but there wasn't a market for personal robots.

"After inventing Cye, I started asking who would buy it," says Thorne. "This isn't a good way to work, but it's the way a lot of engineers go. They get excited about the technology as opposed to the market."

Although Cye didn't pan out, Thorne applied Cye's technology to develop TUG©, an automated robotic delivery system that transports materials in hospitals. In 2001, Thorne founded Aethon, Inc., a Pittsburgh-based company that today provides robots for more than 100 U.S. hospitals.

Moving forward, Thorne, an engineer to the core, partnered with "a brilliant market and business person" Rob Daley, and they "explored markets that were ripe for innovation." They studied products that lacked batteries and processors, seeking a niche where inexpensive electronics could be applied. They discovered that infant products, like seats and strollers, hadn't fundamentally changed in decades. In 2005 their company, 4moms®, was born.

They found their market, but they had to determine what consumers wanted. The team was venturing into tricky territory because "what people truly need and their perceptions of what they need are different," says Thorne. He elaborates, "People don't know what they want because they can't see it. Henry Ford said that if he had asked people what they wanted, they would have said faster horses."

Thorne and Daley set a precedent to talk to mothers about their daily interactions with their children. They listened carefully, interpreting what the women said. These conversations led to the development of pioneering products, such as the Cleanwater Infant Tub™ and the mamaRoo® Infant Seat, which are sold in the U.S., the United Kingdom, Canada, Mexico and China.

Henry Thorne | Mary Koes

4moms Vice President of Operations Mary Koes (B.S. MechE, SCS '02; M.S. Robotics '04) is keenly aware of how market research contributes to 4moms' success. "There are at least a dozen moms who form focus groups and provide us with feedback. In product development cycles we talk to these women. Their challenges guide our product development." Koes, the mother of two boys, was attracted to 4moms because she wanted to apply robotics to consumer products. Further, the company's entrepreneurial climate excites her.

"Baby products have remained the same for generations. At tradeshows, folks are floored by our products," says Koes. Thorne concurs, "Our company has been labeled as disruptive in the juvenile market."

The story gets even better. "Our sales have increased by at least a factor of three every year. In Pittsburgh alone, we have at least 20 employees and most of our engineers are CIT graduates. We're designing infant products, so we need engineers who meet our high standards of technical excellence. Carnegie Mellon is the first place we look,"says Thorne.

As for future products, in the works is the Origami, a stroller that folds itself with the touch of a button. It will even charge a cell phone thanks to a generator in the wheels that charges the stroller while you walk. Collectively, 4moms' products are redefining a long-established market.

America's infrastructure, especially in urban areas, is aging and failing. How will innovations in technology address this major challenge?

Shane Rife
Senior, Civil and Environmental Engineering

Over the next 20 years, engineers and scientists will begin the process of providing America's infrastructure with a nervous system. Data gathering and computing costs will continue to decrease and data-driven approaches will be used to make intelligent infrastructure decisions. For example, the replacement and renovation of deteriorating bridges has been based on sufficiency ratings provided by manual bridge inspections. A potential alternative method to manual inspection is to equip bridges with X-ray machines to detect cracks, strain gauges to detect stresses and other sensors that can provide data and valuable information. Innovations in infrastructure management techniques will not be simply a civil engineering project but a joint venture with computer science, electrical engineers and many other disciplines.

Student

Mario Bergés
(M.S., Ph.D. CEE, 2007, 2010)
Assistant Professor, Civil and Environmental Engineering

Information and communication technologies are changing the way we design, build, operate and manage our built environment. In particular, innovations in these technologies are allowing us to move from a passive and static mode of interacting with our infrastructure to a much more active and dynamic one. Sensors and actuators are being embedded everywhere and in everything. It is suddenly possible for our bridges to inform us about dangerous loading conditions or health problems. The wealth of data that will become available is impressive. The question now is how to make the best use of it.

Faculty

John R. Kenny, P.E.
(B.S., CEE, 1982)
Senior Vice President
Gannett Fleming, Inc.

As is the case with human beings, our infrastructure systems suffer ailments as they age. Unfortunately, the tools we've traditionally used to assess their overall condition have been both limited and discrete, resulting in a somewhat crude understanding of the presence and severity of the ailments … and sometimes not until it's too late. That is changing. Innovations in technology will allow us to use sensor networks to routinely identify, in real time, when a component or series of components within our infrastructure system "gets sick." We will not have to wait for a water main to burst or a bridge to collapse before knowing there is a problem. The infrastructure system itself will tell us through formerly undetectable changes in "behavior" that will be picked up by continuously operating sensors. Once these changes are identified, we will be able to diagnose the problem based on symptoms that have been clearly expressed by the patient.

Alumni

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