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Iowa Poised to Take the Lead in Wind Energy
As the challenges that face our economy, our society, and our world rise up to demand action—and as America has elected a new leader to face those challenges—one thing becomes clear: we have been to a place like this before.

Consider the outlook of the United States fifty years ago. The circumstances and the challenges were different, but the similarity was the urgent need to respond at a watershed moment.

Most of the world’s infrastructure had been severely damaged by World War II and the subsequent conflicts in China and Korea. Many of today’s strongest powers were crippled. The United States had supplanted Great Britain as the preeminent economic influence in the world. We believed that we were, rightfully, world leaders.

But there were some worrisome developments. Throughout the 1950s the Cold War was gaining momentum. The Soviet Union carried out a continuing nuclear test program, an amazing technical feat for a country that was mostly destroyed by war. And then came another remarkable technical feat, one visible to all. Sputnik launched on October 4, 1957. A scientific achievement symbolized an open competition between ideologies and spurred an epic series of events that came to be known as the Space Race.

Then in 1960 came a young and charismatic new president. In his inauguration speech on January 21, 1961, he said:

“No the trumpet summons us again—not as a call to bear arms, though arms we need; not as a call to battle, though embattled we are—but a call to bear the burden of a long twilight struggle, year in and year out, ‘rejoicing in hope, patient in tribulation’—a struggle against the common enemies of man: tyranny, poverty, disease, and war itself.”

Soon thereafter came Kennedy’s daunting and defining technical challenge: America would send astronauts to the moon.

Kennedy knew that American ascendency—and possibly even survival—was at stake, and he understood the power of a focused challenge. The nation soon reaped the benefits of facing up to that challenge of building intellectual capacity and technical strength. Going to the moon was followed by U.S.-led digital and information revolutions. This was America at peak power.

Now, several decades into this boom time of intellectual achievement, it is clear that we have reached another watershed moment. America, still preeminent but now inextricably linked to a global network of economies and cultures, faces a new set of challenges, and more than just political ideologies are at stake. Our leadership is crucial to quality of life, if not survival, on a global scale.

By looking back to the lessons of the late 1950s and early 1960s, we can sort out powerful positives. We are an innovative people with excellent institutions of higher education. We are capable of the breakthroughs that can change the world. And we have just inaugurated a charismatic young president.

In his inauguration speech on January 20, 2009, President Obama said:

“Starting today, we must pick ourselves up, dust ourselves off, and begin again the work of remaking America.

“We will build the roads and bridges, the electric grids and digital lines that feed our commerce and bind us together. We will restore science to its rightful place, and wield technology’s wonders to raise health care’s quality and lower its cost. We will harness the sun and the winds and the soil to fuel our cars and run our factories. And we will transform our schools and colleges and universities to meet the demands of a new age. All this we can do. All this we will do.”

As engineers, this is our charge: to build and restore, create and transform. To meet the demands of a new age.

In the long view, our work has just begun.
**QUICK HITS**

**CCEE RESEARCHER STUDIES FUNGUS USE IN ETHANOL PRODUCTION**

When Hans Van Leeuwen first considered using fungi to clean up the water used in the corn wet-milling process, he learned that although the fungi grow well, the process would be somewhat marginal in terms of increasing the profitability of a corn wet mill. When his team turned to the dry-mill ethanol process, they found a different story. Not only do the fungi grow prolifically, promising new coproducts, but the energy and water savings could be significant. The researchers dubbed the new process MycoMax and formed MycolInnovations, Inc., to facilitate commercialization. There is one patent pending for the process and another one in development.


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**STUDENT’S SOLAR PANEL PURSE FEATURED IN THE NEW YORK TIMES**

Joe Hynek may be the only student at Iowa State who carries a handbag for “scientific purposes.” On cloudless days, he wanders his neighborhood to test whether the purse, which is plated in thin solar panels and contains a lightweight battery, is absorbing energy from the sun. After three hours of direct exposure, the purse generates enough electricity to charge an iPod, camera, or cellphone. (The bag will also charge—more slowly—if placed next to a window.) Hynek is currently working on the final touch: a small display screen that will indicate when the purse is best angled for absorbing the day’s light.


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**RESEARCH BREAKTHROUGH COULD SAVE MILLIONS OF BTUS AND DOLLARS**

Researchers at the Department of Energy’s Ames Laboratory have announced a breakthrough that could boost efficiency in several industry sectors and lead to saving trillions of BTUs and millions of dollars annually. The technology, a nanocoating made from a boron-aluminum-magnesium ceramic alloy nicknamed BAM, reduces friction and wear on industrial machines and tools. Bruce Cook, an Ames Laboratory scientist and the co-principal investigator, made the discovery with Alan Russell, a fellow Ames Laboratory researcher and Iowa State University professor of materials science and engineering, when an experiment caught their attention because its results represented a “positive deviation from the rule of mixtures.”


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**ENGINEERS RESEARCH BIODIESEL AS RECYCLING AGENT**

Iowa State professors are studying how the solvent properties of biodiesel can benefit military applications by investigating if, or how well, certain varieties of battlefield-generated waste plastics dissolve into biodiesel and how that fuel would work in powering a military base generator. “Mobile military bases produce a lot of garbage,” says Iowa State professor Balaji Narasimhan. “If you burn it, you announce your presence. If you bury it, you leave evidence of how big a unit you’re traveling with and in which direction you’re headed.” Since the next option is to carry the waste, the U.S. Army initiated research to investigate which plastic materials best dissolve into biodiesel and how stationary engines perform when running on the polymer-rich fuel.

Read more at [www.biodieselmagazine.com/article.jsp?article_id=2948.](http://www.biodieselmagazine.com/article.jsp?article_id=2948)
When Glynis (Fluhr) Hinschberger decided to major in electrical engineering at Iowa State in the early 1970s, she didn’t realize how few women there were in engineering in general—or that even fewer were in electrical engineering. But being a minority in the profession hardly fazed her, as she would soon become the national president of a professional organization, lead the first wind energy project in the Midwest, and be named the CEO of an organization.

Hinschberger attributes her success to several factors, among them hard work and persistence; however, she believes being a woman in male-dominated environs gave her an opportunity to set the stage for how others perceived female engineers. While it was a challenge to be so visible, she appreciated the chance to introduce the industry to a woman’s perspective.

Looking back on her college years, Hinschberger feels that being one of the few women (if not the only one) in her classes was challenging, but it also taught her some valuable life lessons. “I learned that it is possible to do the impossible—or what others might think is the impossible,” she says, “to challenge the status quo. And that being different is a great thing.”

She also quickly found that surrounding herself with a positive network of people was important. In 1973, she was part of a small group of women who reactivated the Society of Women Engineers (SWE) student section charter. “SWE was one of the only places at that time where I could find other women engineers to build connections with,” she says. “I could channel my energy there, especially as I was trying to figure out just where I was going to fit into this field.”

‘A singular position’

After finishing graduate school, Hinschberger entered the workforce in 1976 with Northern States Power. The company had 5,000 employees, and she was only the second female engineer to be hired. “I was in a singular position,” she recalls. “When someone is one of the first from a certain background, whether an ethnic group or gender, that person is invariably the one who sets the bar for how others will perceive those who follow.”

The extra pressure of being perceived as the representative for female engineers was something Hinschberger did not take lightly. “Diversity is important in every field,” she says. “In simple terms, it gives organizations a different point of view.”

Moreover, Hinschberger adds, she appreciates the experiences and varying contributions that individuals from different backgrounds bring to projects. “When everyone sees things the same way,
with the same frame of mind, something important can be missed,” she says.

During her time with Northern States, Hinschberger sought and received promotions and was often known for shaking things up in the workplace. As she entered management, she enjoyed working with a variety of people and soon realized that a large element of her success was in part due to her communication skills.

“Not everyone speaks like an engineer,” Hinschberger says. “The ability to communicate or convey a technical or complicated idea to someone who is not an expert is important for all engineers.”

An ambassador for women

Applied at what she calls “the right time,” Hinschberger's ambition, knowledge, and skills would lead her to some of her proudest achievements. When she moved to Minnesota, for example, she discovered that the local chapter of SWE had been only recently established.

Hinschberger saw an opportunity to make a difference and worked closely with the chapter as the national organization went through restructuring. SWE was developing regions, and Hinschberger jumped at the chance to become the Region H director.

“We were on the move to becoming a large organization, with a greater influx of new students and recent graduates becoming full-fledged members,” she says. “Our priorities were shifting from the very early stages of affirmative action and focusing on women becoming naturally integrated into businesses.”

Hinschberger stayed connected to the organization that had provided her with a professional network throughout college, and in 1990 she became national president of SWE. Seeing herself as an ambassador for women entering the engineering profession, she focused on providing new female engineers resources to help them succeed.

“The organization continues changing, which is a good sign,” she says. “The leaders are now working to bring more family networking into the organization, addressing the dichotomy that many female professionals feel between working and being a mother.”

Leadership in innovation

Hinschberger was still working for Northern States in the early ‘90s, managing the organization’s energy resource planning. Not many utility companies were headed in the direction of wind energy then, but many were starting to realize the importance of using renewable, clean energy sources.

At the same time, the state of Minnesota had instituted resource planning in order to comply with the federal Clean Air Act Amendments of 1990. Having Hinschberger work on the state-mandated plan was a natural, given her position with the company. So when the first wind project in Minnesota arose from the plan, few were surprised, given Hinschberger’s penchant for nontraditional thinking.

Three people were assigned to manage the project, for which Hinschberger became spokesperson, simultaneously wearing the hats of utility company employee, wind energy advocate, and regulator. “It was such a novel opportunity,” she says.

“Now, as I look at Iowa and Minnesota vying for the top spots in terms of wind energy production, I feel proud to be a part of the beginning.”

Next, when Northern States was looking to expand beyond standard utilities, several employees, including Hinschberger and the company’s CEO, got together to explore how telecommunications could benefit the power industry. “This was at a time when companies were trying to figure out how to bundle services such as cable, telephone, and Internet to increase customer loyalty,” she remembers. “The CEO looked at me across the table and said ‘figure out if we have a business here.’"

Beginning with a business plan, Hinschberger led the team that would found Seren Innovations and was named CEO of the new company. As a subsidiary of Northern States, Seren Innovations became an integrated communications provider in Minnesota and California. Hinschberger was even responsible for the company name, which means “star” in Welsh. “We wanted to find something that had meaning,” she says. “I think it was luck more than anything, but the name stuck.”

‘Coming full circle’

While Hinschberger’s career is far from over, she has had much success, and Iowa State has recognized her accomplishments by awarding her a Professional Achievement Citation in Engineering in 2001 and a Professional Progress in Engineering Award in 1992, as well as naming her Outstanding Young Alumna in 1990. “The awards are honors,” she says. “Sometimes I look at them and wonder what I did to deserve them. But I am always proud to have them.”

Today Hinschberger enjoys working part time for Excel Engineering, a Minnesota consulting company she serves as a transmission planning engineer, acting as liaison between engineers and their clients by taking raw engineering information and packaging it into full-scale reports. “It is like I am coming back full circle in my career,” she says.

Her schedule is more flexible, a benefit she appreciates as a mother of four. “Things are not always in perfect balance,” she says. “You learn how much you can handle and juggle among what you need to do and what is important at that time.”

Pleased that women who enter the field now have a greater network of resources, Hinschberger does not see herself as a pioneer for all her accomplishments. “Solving engineering problems requires people to think from all angles,” she says. “I just happened to be there at the right time and the right place to help bring a different perspective to the industry.”
Feature Focus:
Catalyzing the Biosciences and Engineering at Iowa State

Amazing as last century’s technologies were, the 21st century promises even greater wonders as engineering intersects more intimately with the processes of nature. Featured in this issue, biosciences and engineering is one of five clusters around which the college is centering faculty recruitment and many of its frontline research initiatives. In the following pages we revisit four senior researchers whose work is bearing fruit and building bridges, meet three new faces hired specifically for their interest in bioscience research, and check out three young ECpE faculty whose recent acquisition of advanced facilities and equipment has energized their labors in the field. We’ll also look at the college’s new bioengineering minor for undergraduates and some exciting developments on the IT front, as well as the subject of our Profile 2050. But first, bioethicist Clark Wolf examines some critical questions for all of us as we delve more deeply into nature’s secrets.
Technology, Policy, Values:
Toward a New Bioethics for the Twenty-First Century

When Stravinsky’s Rite of Spring was first performed in Paris at the Théâtre des Champs-Élysées in 1913, it inspired a famous riot. The audience was not prepared for this new music and heard as violent and chaotic what we now recognize as a masterpiece. Yet over time, we have become comfortable with Stravinsky’s musical language and have grown to love what once seemed strange and even dangerous to a Paris audience almost a century ago.

New technology often inspires a similar reaction. Still, what we initially encounter with apprehension and alarm may come to seem ordinary as we incorporate it into our daily lives and as we come to rely on complex tools (and toys) that would have seemed like magic only a few years ago.

For example, when in vitro fertilization (IVF) techniques were first developed, critics worried that this new technology would break the bond between parent and child. Children conceived with this new method might be subtly “different” from “normal” children, they cautioned, and the technique would impose unacceptable risks on mother and child. And today? IVF is a standard fertility treatment available worldwide, used by many thousands of people every year.

Americans rely on technology in every aspect of our lives. We consume food that contains or is derived from transgenic organisms. We rely on innovative chemical compounds in a wide variety of different contexts. But many of the same people who use and consume these products every day express concern about “genetically modified” foods and equate “chemicals” with toxic pollutants.

It sometimes seems as if resistance to unfamiliar technologies were almost instinctive, as if people were somehow psychologically disposed to reject, at least at first, whatever seems unfamiliar...
and new. What explains our love-hate relationship with technology? And what should we do about it?

A vehicle for informed decisions

The 20th century brought an unparalleled rate of technological and scientific progress that we have only begun to absorb and accommodate. Together with the identification of genetic markers, today in vitro fertilization makes it possible for parents to select some of the characteristics they might wish their children to possess. Computer technology makes it possible for us to gather information with unprecedented speed, but also brings complicated issues of personal privacy and information security.

Advances in knowledge of the human genome make it possible to predict, diagnose, and treat disease and disability, but also raise important concerns about genetic privacy and the possibility of unjust discrimination. And while the development of genetically modified and transgenic crop varieties has made it possible to reduce the use of agricultural inputs while increasing crop yields, it has raised public concerns about safety and the possibility of unintended environmental effects.

As we move through this era of unprecedented technological change, it is crucial that we create opportunities to step back and consider the implications in order to make informed decisions about the choices these new technologies present. For more than twenty years, the Iowa State University Bioethics Program has worked to ensure that these opportunities will continue to be available both on the Iowa State campus and across the state of Iowa, providing faculty, students, and members of the larger Iowa State community with opportunities to engage the ethical and policy implications of scientific research.

Through workshops, classes, lecture series, institutes, and faculty retreats, the program has pursued innovative ways to inspire reflection and discussion of science, ethics, and public policy. Every year, the Bioethics Program works with other campus organizations to sponsor a lecture series that brings a variety of different speakers from around the world to the Iowa State campus in Ames. Recent speakers have discussed biotechnology, environmental restoration, evolutionary theory, intellectual property, sustainable agriculture, and a wide variety of other important topics.

Differing opinions welcome

The Bioethics Program also hosts an annual faculty retreat to provide Iowa State faculty members with an opportunity to address crucial issues involving ethics, values, and public policy. The retreat is a daylong event that includes presentations by leading experts, with time for discussion and dialogue. And though designed primarily as a faculty development service, the retreat is regularly attended by students and other members of the Iowa State University community as well.

In selecting topics for the retreat, there has been no reluctance to address “hot button” issues that generate heated debate. Past retreats have included “Science and Politics,” “Do Iowa Farm Subsidies Export Poverty to Poor Farmers in the Developing World?,” “Who Owns Life? Intellectual Property and Biotechnology,” “The Precautionary Principle,” “Is Iowa Agriculture Sustainable?,” and “The Ethics of International Aid and Trade.”

For each of these topics, an effort was made to include speakers who would take different and perhaps opposing stands on the issue under consideration. For example, this year’s retreat was titled “Food vs. Fuel? Energy Alternatives for Iowa and the World.” The presentations addressed popular concerns that ethanol production shifts resources from a more...
basic need (food) to a less basic need (transportation), and that the production of ethanol from corn might be morally problematic in a world where people are hungry. Presenters included Iowa State faculty members, speakers from the Iowa Office of Energy Independence, and well-known proponents and opponents of corn ethanol production.

In addition, the program organizes occasional seminars and symposia. These events typically include between two and four speakers and are open to all members of the Iowa State community. Recent symposia have covered “The Ethics of Environmental Restoration,” “Coexistence of Organic and Biotech Agriculture,” “Sustainability in Philosophy, Environmental Science, and Economics,” “Climate Science, Climate Politics,” and “The Ethical Treatment of Animals in Teaching and Research.”

**Education for a new century**

The Bioethics Program also offers regular workshops on ethics in the practice of scientific research. These workshops focus on ethical issues that arise in research contexts and focus on responsible research conduct. While these workshops are aimed at Iowa State graduate students, they are open to anyone who wishes to attend.

Bioethics, however, are not just the province of academic elites in the universities, but instead the concern of all citizens. The program therefore offers special workshops for Iowa K-12 teachers that provide them with resources that can be used to incorporate the discussion of ethics in the school science curriculum.

It is important for students to reflect upon ethical issues as they arise, but it is also important that ethical discussion should be free, open, and respectful toward students who may have different values and views. In the teacher training courses offered through the Bioethics Program, teachers are introduced to a “case study” method for encouraging the discussion of controversial ethical issues. This method invites students to investigate and reflect on ethical aspects of science and technology and to think about issues of ethics and public policy.

In addition to these regular activities, the Bioethics Program also supports other campus events. Most recently, the program worked with the Center for Excellence in the Arts and Humanities to bring a photography exhibit, “Imaging a Shattering Earth,” to Iowa State’s Brunnier Art Gallery. The exhibit, which includes paradoxically beautiful photographs of environmental disaster, was accompanied by lectures; a film screening; a campus visit by David Hanson, one of the photographers featured in the show; and a talk by curator Claude Baillargeon.

**Reflection and response to change**

Just as the audience at the premier of The Rite of Spring felt shock and dismay at Stravinsky’s new musical language, we may feel similar dismay as the next wave of technological innovation—some of it previewed in the pages of this magazine—promises to change such fundamental and intimate aspects of our lives as sex and reproduction, health and medical care, agriculture and food.

The Bioethics Program is always looking for new ways to inspire reflection on ethical issues that inevitably accompany scientific research and technological change. As a major driver of bioengineering research in Iowa and the nation, the College of Engineering at Iowa State has a critical role to play in setting ethical standards across a wide variety of new technologies, and we welcome the participation of the engineering community in this important work.

The Iowa State University Bioethics Program receives substantial support from the Office of Biotechnology, which is now celebrating its 25th anniversary on the Iowa State campus. The Office of Biotechnology has continued to promote discussion and evaluation of the ethical implications of biotechnology research. Additional support for the program comes from the Iowa State Colleges of Agriculture, Arts and Sciences, and Engineering. The program has been fortunate to partner with many campus organizations and groups, including the Center for Excellence in the Arts and Humanities, the Graduate Program in Sustainable Agriculture, the Leopold Center for Sustainable Agriculture, the Iowa State University Biotechnology Council, the College of Veterinary Medicine, the Wilderness Symposium, and others.
ALTHOUGH THIS ISSUE BRINGS A SPECIAL FOCUS TO THE FIELD, ENGINEERING AND THE BIOSCIENCES HAVE HARDLY BEEN STRANGERS TO THE PAGES OF INNOVATE OVER THE PAST COUPLE OF YEARS. AND WHILE WE’RE EXCITED ABOUT THE YOUNG NEW TALENT ADDED TO THE COLLEGE OF ENGINEERING’S RANKS IN THIS CRITICAL CLUSTER AREA, ALL OF OUR NEW RESEARCHERS HAVE A HIGH STANDARD TO WHICH THEY CAN ASPIRE IN THE CONTINUING WORK OF THESE FOUR SENIOR MEMBERS OF OUR RESEARCH FACULTY. HERE, THEN, ARE SOME BRIEF UPDATES ON PROJECTS PREVIOUSLY FEATURED IN THE MAGAZINE.

Julie Dickerson: ‘Meta!Blasting’ knowledge into young minds

A computer engineer, Julie Dickerson got into bioinformatics early this decade after taking a biology course for computer specialists, which put her on track to develop models of biological systems using a combination of relatively precise computation principles and the “fuzzy logic” she had studied as a graduate student. The fuzzy logic approach, she says, is better suited for dealing with the uncertainty in metabolic system modeling due to imprecise measurements and lack of knowledge within the field.

One product of her studies was an educational tool for high school students, in fact a video game called Meta!Blast that Dickerson developed with collaborator Eve Wurtele of the Department of Genetics, Development, and Cell Biology. Through interactive exploration, the goal of the game is to creatively engage students with some of the key biochemical processes in photosynthesis and other plant metabolic procedures in a compelling and active medium.

Dickerson and Wurtele recently received an educational grant from the National Institutes of Health (NIH) to evaluate the effectiveness of Meta!Blast as a teaching tool in several Iowa school systems. With the assistance of Ben Herman, currently a PhD student in education and a former high school science teacher, the team hopes to position Meta!Blast as an open-source teaching tool in schools across the country.

Beyond this, Dickerson is working with Robert Jernigan, director of Iowa State’s Laurence H. Baker Center for Bioinformatics and Biomedical Statistics, on proposals for the National Science Foundation’s Cyber-Enabled Discovery and Innovation Program to develop high-level 3-D microscopy models of how cell membranes change in real time. She is also collaborating with Jackie Shanks in Iowa State’s new Center for Biorenewable Chemicals (CBirC) to model E. coli in order to optimize metabolic pathways for chemical production from plants.

Jackie Shanks: New twists in an ongoing project

When featured in the spring 2007 issue of Innovate, chemical engineer Jackie Shanks was working on optimizing the extraction of the alkaloids vincristine and vinblastine, two drugs used to fight leukemia and non-Hodgkin’s lymphoma, from the Madagascar periwinkle (C. roseus).

An ongoing project since 1999, Shanks has no plans to leave off this effort anytime soon, especially since her steady progress continues to attract funding and raise her profile in the plant engineering community. She recently chaired a conference session in Canada, bringing together several leading researchers working on C. roseus, and was an invited speaker at the Danforth Plant Science Center and the Phytochemistry Society of North America.

A new area Shanks is looking at involves transcription factor engineering to manipulate the genes of plants to overproduce valuable alkaloids, such as those associated with C. roseus, as well as other chemical agents. It’s an approach to plant engineering Shanks admits viewing with some skepticism.

“There are negative effects you could have when you do that,” Shanks warns. “But our research team, including Professor Ka-Yiu San and Christie Peebles from Rice...
“It’s interesting,” she continues. “Several genes do get induced that are important in the alkaloid pathway. But then the plant reacts by turning on new genes that turn these off. We knew it wouldn’t work, but it has identified other genes we normally wouldn’t think of that we could alter to allow the genes we want to stay ‘on’. So we learn more about the pathway, and it gives us some new strategies. But it’s not a magic bullet.”

Shanks is also co-leader of CBiRC’s metabolic engineering group, where she coordinates research activities with the center’s other research arms. And though CBiRC’s emphasis is on industrial chemicals, she stresses that her work with the center isn’t wholly different from the study of central carbon metabolism in her other projects in plants and even microbes.

“It’s a different twist,” Shanks says, “but I’ve interacted with the people in my thrust before on different types of projects.”

Surya Mallapragada: A ‘step back’ moves cell study forward

By 2007, Surya Mallapragada and her collaborators had taken a “step back” from their continuing quest to repair and regenerate damaged nerve tissue across micropatterned polymer conduits in order to study and better understand the secrets of cell differentiation in the human body. By culturing adult stem cells in different media and over various substrates, their thinking went, they might better control the regeneration process by directing those stem cells to develop into mature cells that serve a specific purpose in the healing process.

Mallapragada calls the results of the past two years “pretty good.”

“By using a combination of soluble factors from other cells,” she says, “we’ve shown that we can spatially control on one part of the substrate and have more neuron-like cells. On other parts of the substrate, where we don’t have the micropatterning, we have fewer neuron-like cells.”

Working with support from the National Institutes of Health, Mallapragada’s team is wrapping up the first phase of their in vitro studies and will move the project into animal studies later this year.

Future goals in this research line include development of a stem cell substitute for the commercially unavailable Schwann cells that constitute the myelin sheath for nerve cells in the peripheral nervous system, as well as adapting this process for applications in the central nervous system. Also, Mallapragada says, her work may be facilitated by the potentially greater availability of embryonic stem cell lines under the new Obama administration.

In addition, Mallapragada has undertaken a series of polymer-based studies with collaborators in the Department of Materials Science and Engineering, where she holds a courtesy appointment, and the University of Iowa Hospitals and Clinics in Iowa City. The studies, she says, focus on developing injectable substitutes to repair cartilage damage in order to prevent or minimize post-injury osteoarthritis.

Balaji Narasimhan: Integrating particle size and chemistry in vaccines

By 2007, Surya Mallapragada and her collaborators had taken a “step back” from their continuing quest to repair and regenerate damaged nerve tissue across micropatterned polymer conduits in order to study and better understand the secrets of cell differentiation in the human body. By culturing adult stem cells in different media and over various substrates, their thinking went, they might better control the regeneration process by directing those stem cells to develop into mature cells that serve a specific purpose in the healing process.

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Balaji Narasimhan: Integrating particle size and chemistry in vaccines

Searching for ways to boost the effectiveness of vaccines, Balaji Narasimhan has experimented alternately with both the chemical composition and size of the polymer adjuvants he uses to deliver antigens that trigger the body’s immune response, tailoring these to be released over an extended period of time—a technology especially valuable in parts of the world where follow-up booster shots aren’t always practical or even possible.

In the process of refining this technology, Narasimhan made a significant discovery: while some chemistries are internalized by immune cells rapidly, others are not internalized at all—yet these still trigger an immune response.

“Why does that happen?” Narasimhan asks. “Is the particle interacting with the cell at the surface level? Maybe ‘tickling’ the cell in a way that initiates a cascade of events that leads to an immune response? And how is that different from the particle that actually gets internalized by the cell?”

This line of inquiry has led Narasimhan to postulate a possible relationship between the size and the chemistry of the polymer adjuvant, a relationship he might be able to tweak in order to find what he calls the “sweet spots” that optimize the effectiveness of a given vaccine. In the meantime, Narasimhan’s vaccine group is currently conducting challenge studies, monitoring the effectiveness of their vaccines with mice infected with pneumonic plague, after which they will enter clinical trials with human subjects.

New projects include a $5 million grant from the U.S. Army to work with University of Nebraska Medical Center researchers to develop inter-nasal and epidermal patch vaccines against bird flu, as well as support from NIH to study the development of a single-dose anthrax vaccine. Finally, Narasimhan and his vaccine research colleagues across the Iowa State campus are exploring the possibility of creating a joint institute for the study of vaccine technologies with their counterparts at the University of Iowa.
Bioengineering Minor
A Major Step in Engineering’s Transformation

BY ERIC DIETERLE

THE EMERGING DISCIPLINE HOLDS THE POTENTIAL TO TRANSFORM THE LIVES OF STUDENTS—AND EVEN THE PERCEPTION OF ENGINEERING ITSELF.

It must be a consequence of the speed with which technology changes—the way, that is, the term “bioengineering” is greeted as pedestrian, merely another transitory addition to our vocabulary of rapid scientific achievement. Yet as we easily grow accustomed to the news of engineered manipulations of biological systems, we could miss the full implications of the term.

Engineering is evolving. Its deepening crossover with biology is a discipline-altering development. This is no secret to researchers, and yet few academic programs formally acknowledge the shift. The very students who would populate such programs are generally being presented with discipline-specific choices in one engineering field or the other, as they have been for decades.

That is changing at Iowa State’s College of Engineering, where a long-standing reputation for interdisciplinary research is finding its way into degree programs. In that spirit, the newly established bioengineering minor began offering its first course, BioE 201X, in January 2009.

‘Engineering is changing dramatically’

The minor, which is open to all undergraduate engineering majors, is an interdisciplinary program that will provide students with more career options as engineers increasingly seek to solve biological problems. The minor provides specializations in bioinformatics and systems biology, biomaterials, biomechanics, biomicrosystems, biobased products, and bioprocessing.

Through this program, it is hoped, current engineering students will be able to explore the burgeoning potential of biological systems applications, and potential students will consider engineering as a career because of the growing possibilities of applying engineering to medical, environmental, and other biology-related fields.

Peter Reilly, Anson Marston Distinguished Professor in Engineering and professor of chemical and biological engineering, is director of the program. Reilly chairs the Bioengineering Minor Supervisory Committee, provides leadership for curriculum development, and oversees implementation of the program.

“It’s important for our students to appreciate the increasing role that biology is playing in engineering,” Reilly says. “The field of engineering is changing dramatically, especially as it overlaps with biology. Students need to become aware of that overlap today so that they can be fully prepared for their careers.”

Reilly also happens to be the lead instructor for BioE 201X, a course he calls “a major experiment in how to teach a non-engineering course to a very diverse group of engineering students.” Six of Iowa State’s eight engineering disciplines are represented by students ranging from freshmen to seniors, nearly one-third of them women. Even the instruction is interdisciplinary: the course will be co-taught by Chenxu Yu, assistant professor of agricultural and biosystems engineering.

“We want to try to show how varied life is and the structure of it,” says Reilly, “and how it all plays out into so many different species.”
**The human face of a profession**

One of the 36 students in BioE 201X, Jordan Trachtenberg, is a prime example of why the bioengineering minor is being offered. The former chemical engineering student, who has transferred to materials science and engineering, was motivated by a mechanical engineering professor to pursue her interest in biomaterials for prostheses and minimally invasive surgical tools. Thus, she has chosen the biomaterials and biomechanics track of the minor.

Before college, Trachtenberg explains, “I always thought, ‘Well I don’t really want to be a doctor, but I would love to work in a lab and do research.’” She found that opportunity with Pranav Shrotriya (see “Profile 2050,” page 13), an assistant professor in mechanical engineering. Shrotriya’s work involves modifying and testing prosthetic hip implants, and Trachtenberg was given the undergraduate research opportunity of testing corrosive properties of the metal alloys that make up the implants.

“After working with him for several months,” Trachtenberg says, “I was convinced that a career in biomaterials research would be exciting and challenging. With the constantly growing need for engineers in the medical industry, it is my hope that this program will provide me with valuable tools to solve engineering problems in medicine.”

Trachtenberg’s motivations stem from pragmatism—“I didn’t want to go to college with no idea of what to do,” she says—as well as the altruism that is drawing many students to the biomedical and other “bio”-influenced fields. Those fields continue to draw students, particularly women, who are interested in helping people and making a difference in the world.

Warranted or not, engineering has long suffered from the perception that it offers neither of those opportunities. Programs such as bioengineering, and students such as Trachtenberg, may help change that view. “I grew up in a family that was very deeply rooted in volunteering and helping others,” she says. Her goals of joining the Peace Corps after graduation and working in Africa on issues such as sustainability exemplify an emerging spirit of engineers as difference makers in humanistic, and not just technical, ways.

**Still plenty of equations**

Just as Trachtenberg sees BioE 201X as her springboard into a minor that will augment a materials engineering degree, Reilly envisions a course that will be an important step in the integration of engineering and biology at Iowa State.

But there will be a few interesting challenges along the way. For example, the textbook, *Biotechnology for Beginners*, contains no equations.

“It’s a wonderful book, but we will need to give lectures that are more engineering oriented,” Reilly says. And that includes plenty of equations, he notes with a smile.

“This really is an experiment,” he says.
Three for a New Model of Research

ONE’S A NEW PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING AND MECHANICAL ENGINEERING WHO IS MOVING BEYOND IMAGING AND DIAGNOSTICS TO USE ULTRASOUND AS A CANCER THERAPY. THE SECOND IS A CHEMICAL ENGINEER WHO IMMERSED HIMSELF IN THE WORLD OF BIOLOGISTS TO UNLOCK THE SECRETS OF CELLULAR LIFE. AND THE THIRD IS A THEORETICIAN IN BOTH AEROSPACE AND MATERIALS ENGINEERING WHO WANTS TO USE ELECTRO-ACTIVE MATERIALS TO BUILD ARTIFICIAL MUSCLES. TIM BIGELOW, IAN SCHNEIDER, AND WEI HONG ARE THREE YOUNG ENGINEERS RECENTLY ARRIVED AT IOWA STATE TO FULFILL THE COLLEGE’S MANDATE TO ITS FACULTY: TO RECRUIT AND DEVELOP “CLUSTERS” OF RESEARCHERS WHOSE INTERESTS BESTRIDE THE TRADITIONAL SCIENTIFIC AND ENGINEERING DISCIPLINES TO DEVELOP INNOVATIVE APPLICATIONS IN MEDICINE, AGRICULTURE, ENERGY AND MORE.
A grainy, black-and-white ultrasound image can show an expectant mother the first glimpse of her baby. And while the picture is not entirely comprehensible, it provides physicians with a great deal of information about the health of the child.

Now imagine a more sophisticated form of this technology used on the same woman, one that instead can determine if a mass in her breast is cancerous. Advances in ultrasound such as this are at the heart of Tim Bigelow’s research.

Bigelow, an assistant professor in both the electrical and computer engineering and mechanical engineering departments, came to Iowa State in August 2008 from the University of North Dakota, where his investigation into ultrasound had accelerated to the point where, by January 2007, he received a prestigious National Science Foundation CAREER Award to develop a system to use ultrasound to treat cancer.

He joins a 75-year exploration of ultrasound energy in the medical field, engaging both past uses of the technology, which included treatment for ailments such as brain disorders, as well as the medical imaging that is seen today during prenatal care. Using an integrated approach, Bigelow’s work seeks to make some medical practices more efficient while providing immense benefits to patients.

A measurable improvement

The diagnostic use of ultrasound comes with some imperfections, primarily because it requires a skilled technician to read the image and make judgments based on qualitative attributes. However, incorporating mathematical analysis into the process, as Bigelow strives to do, provides new details to health care providers.

Working with a faculty member in nursing at the University of Illinois, Chicago, Bigelow analyzes the echoes from an expectant mother’s cervix to assess the risk of premature delivery. The team identifies risk indicators, such as an increase in water concentration in the cervix’s lining, by placing a color map derived from mathematical analysis over a gray-scale ultrasound image of the cervix. With this information, they are able to determine if the mother needs to take any action to protect herself and her child.

A precise treatment

At significantly greater amplitudes, ultrasound can be used for therapeutic purposes as well, offering physicians more control than is typical with most current procedures. Within this research avenue, Bigelow is identifying ways to remove infection from an implant and treat metastatic cancer of the liver.

Common cancer treatments such as thermal ablation can destroy healthy tissue by heating up an entire area to attack a tumor, and surgery often removes good tissue along with cancerous tissue. By contrast, ultrasound can provide a less invasive process that allows patients to recover more quickly and with fewer side effects.

Ultrasound essentially liquefies cancerous tissue as the amplitudes interact with small bodies of gas in the tumor. This reaction causes the gas bodies to expand and collapse violently, Bigelow says, during which cells exposed to the ultrasound are completely fragmented, a process he likens to sending them through a microscopic blender.

With ultrasound offering vast improvements in patient care, Bigelow and his multidisciplinary collaborators are keen to continue their biomedical research.

“While we still have many challenges,” he says, “the potential of our work keeps our ambitions high.”
Ask Ian Schneider what chemical engineers bring to the study of biological systems, and he’ll dutifully cite the core principles of thermodynamics, transport phenomena, and reaction and diffusion systems.

Yet despite an early interest in biology as an Iowa State undergraduate, it wasn’t until graduate school at North Carolina State that the Carlisle, Iowa, native began to see deeper into his own chosen profession and his avocation—all the way to the level of the individual cell.

“As an undergraduate, biology was just another thing in my life, like playing the trumpet,” Schneider acknowledges. “I wasn’t really able to make the connection.”

That would change in graduate school, where Schneider’s fascination with both the biochemistry and mechanics of living cells compelled him to view the two disciplines not as alternative but complementary ways of describing intracellular phenomena. Indeed, the application of engineering principles to biology deepened Schneider’s appreciation of what is in fact an intimate relationship between the mechanical and biochemical aspects of cellular activity within organisms.

A temporary change of community

Yet as he became fluent in the language and practice of biology, Schneider felt something was missing in his professional preparation: a close working relationship with biologists themselves. So instead of a faculty job after the PhD, Schneider continued his apprenticeship in the biological sciences with a postdoctoral appointment at The Scripps Research Institute in San Diego.

His “community” changed virtually overnight, as Schneider was immersed in a world of biologists for whom the professional interests of chemical engineers were secondary at best. And though it’s been a long road to refocus upon chemical engineering, Schneider has no regrets.

“I chose Scripps because Clare Waterman is one of the leading scientists in using fluorescent microscopy techniques to analyze the cytoskeletal dynamics in cell migration,” says Schneider. “She pushed forward an entirely new technique to measure this phenomenon, and I wanted to learn that and bolster my knowledge in microscopy.”

That interdisciplinary risk-taking made Schneider attractive to his alma mater, as the College of Engineering championed “cluster” hiring across disciplines to address 21st-century challenges. And for Schneider, that challenge means nothing less than understanding the intracellular processes that allow both wounds to heal and cancers to spread throughout the body.

“Eventually,” he says, “we need to understand the system as a whole. But in order to understand the system, you have to understand three primary processes: cell migration, cell-to-cell adhesion, and the ways cells communicate with each other.”

‘Listening in’ on a critical communication

As he prepares his research regimen at Iowa State, Schneider says that he and his students will focus on how the mechanical forces exerted by cells affect biochemistry, and how that in turn affects the migration of cells—including cancer cells in metastasis—from one part of the body to another. For instance, he notes, when a cell extends its edge and adheres to its surroundings, it forms mechanically sensitive macromolecular complexes called focal adhesions, which allow the cell to move forward.

However, Schneider stresses, such extension is not spontaneous but instead caused by the transmission of a biochemical signal from another cell. “Cells migrate out of wounds or tumors,” he says. “But they have to migrate for some reason. And the reason is that there are other cells that secrete communication signals.”

Furthermore, he adds, not only do cells “talk” to each other through this biochemical pathway, they also talk through mechanical pathways by rearranging the extracellular environment. By understanding the relationship of biochemical “signals” to biomechanical behavior, Schneider says, chemical engineers can contribute to the development of therapies to speed the healing of wounds and impede the metastasis of cancers within the body.

“Applying an understanding of transport phenomena and reaction kinetics will allow us to better understand that system,” Schneider says. “And then, perhaps, we can come up with ways to influence that communication.”
Wei Hong considers himself a theoretician, yet he seeks to collaborate with experimentalists from across the College of Engineering and the university as a whole as he strives to gain a basic understanding of how various so-called “smart” materials respond to stimuli, and how those responses can be optimized for specific applications.

An assistant professor in aerospace engineering with a courtesy appointment in materials science and engineering, Hong earned BS degrees in computer science and engineering mechanics and an MS in solid mechanics from Beijing’s Tsinghua University before going to Harvard University in 2002 for his PhD in engineering science, followed by a postdoc working in smart materials.

**Inspiration from nature**

Essentially, smart materials are “smart” because their fundamental properties can be significantly altered by external stimuli such as temperature, moisture, stress, pH value, and electric or magnetic fields. A smart material, for example, might deform as the result of an electrical charge or swell when put into water.

Nature, of course, is full of active materials such as the structures in plants and animals that respond to stimuli in order to adapt to conditions in their environment. Scientists and engineers, therefore, look to nature for inspiration in designing devices and structures that can perform specific functions based upon their responses to various stimuli.

Smart materials have significant potential over the long term for a wide variety of bioengineering applications. For example, a capsule could be designed someday to release its contents when it senses a specific type of diseased cell. Or a polymer that responds to magnetic fields could improve tactile feedback in virtual reality applications to train physicians in a given medical procedure.

The field, though, is still in its infancy. “We have found that there is a deficiency between our current understanding of the physical behavior of smart materials and what we need to know to take full advantage of their properties,” Hong says. “On the one side, people want to apply these materials to engineering to make things out of them because of their ‘smartness.’ On the other side, our understanding of these materials is very limited, so we are trying to bridge the gap and make both sides better.”

**Seeking ‘muscular’ insights**

One area Hong has been researching is the development of artificial muscles made from electro-active materials whose shape can be modified with the application of an electric current. The goal, according to Hong, is to optimize shrinkage and enlargement of the material in order to use it as an actuator for an artificial muscle that would expand and contract in response to an electrical impulse, much like a human muscle.

“What has been found is that once the voltage reaches a critical value, the material, which is a thin sheet, gets wrinkles in it rather than expanding or shrinking uniformly,” Hong explains. “We are making a computational model to help us understand this phenomenon. It will tell us how the material should respond both qualitatively—that is, what properties are causing the wrinkles—and quantitatively, which will enable us to predict things like what deformation to expect at various voltages or how much force will result from the deformation.”

Once Hong has developed the model, he will turn to experimentalists to verify the model’s validity. If it is incorrect, then more research into the basic physics underlying the behavior will be required; if correct, the model will be used to determine design parameters to achieve optimum performance for the smart materials.

“What we want to learn from the models is how to optimize the material or structure for the best performance in specific applications,” says Hong, who sees the actuator as a possible alternative to motors for operating robots or micro aerial vehicles. “It will be much more flexible and much smaller than a traditional engine.”
Pranav Shrotriya
Ponders the Mechanics of Nanoscale Structures

If Pranav Shrotriya’s research goes as planned, the process of detecting an illegal drug such as cocaine could become much easier and less expensive. The 34-year-old Virginia and William Binger Assistant Professor in Mechanical Engineering is working on a miniaturized sensor to do the job.

The premise is relatively simple: You coat the surface of a device with a compound that reacts only to the substance you are trying to detect. When that substance is present, the compound absorbs molecules that rearrange its atoms. This, in turn, changes the stress on the surface of the device, bending or otherwise deforming it.

Learning how structures fail

Working with atoms and molecules, of course, means working at the nanoscale. While researchers know that materials have different properties at these very small sizes, there is still much to be learned about the causes of these unique behaviors. That is where Shrotriya’s interest lies.

Shrotriya, who came to the United States from Gwalior, India, first became interested in the mechanics of nanoscale structures while studying polymer composites as a PhD student at the University of Illinois, Urbana-Champaign. After graduating in 2001, he continued to explore mechanics at the micro- and nanoscale as a postdoctoral fellow, first at Princeton and later at Brown University.

In the course of these appointments, he developed models to study how these small structures fail under different loads and began work on computational simulations to understand how molecular
The art of detection

A National Science Foundation CAREER Award in 2006 allowed Shrotriya to expand his research. Titled “High-resolution interferometry-based surface stress sensors for chemical and biological species detection,” the project’s goal is to build a working model of a sensor that is able to detect the presence of substances such as drugs, bacteria, or explosives that pose a threat to health, national security, or the environment.

The project encompasses both experimental and computational components. For the experimental part, Shrotriya has developed a mechanical platform for the sensing device that coats a cantilever with an aptamer, a substance that reacts only with the species that needs to be detected.

“Anytime you deposit something on a solid surface and a chemical reaction happens, the surface stress changes,” Shrotriya explains. “We can’t see that effect in large objects because the magnitude of the energy involved is very small. But if you make the structure very small—for example, one micron thick and 100 microns long—and deposit the species on just one side, the surface stress change causes the structure to deform or bend.”

Shrotriya has developed a high-resolution interferometry-based technique that can measure the deformation differences between a reference surface and a sensor surface. The presence of the harmful species will be indicated by the measurements.

Smaller is better

The primary advantage of Shrotriya’s device, he says, is the ability to miniaturize it. “We have a large-scale model in the lab that we are using now, but the goal of the project is to build a MEMS (i.e., microelectricalmechanical systems) device,” he notes. “The reaction itself can occur on a surface as small as one millimeter by one millimeter.

“Making the device very small will make it easy to transport and use on site,” Shrotriya adds. “In addition, it can be mass produced, which means it will be quick and cheap to manufacture.”

The platform can be used for detecting a wide variety of substances, and Shrotriya is collaborating with researchers in biochemistry, biophysics, and molecular biology to design aptamers that will react to a specific target species. “Anytime you have a very specific interaction between one molecule and another,” he says, “you can put it on our platform to see whether a surface stress change occurs.”

A new three-year project recently funded through the National Institute of Justice is giving Shrotriya the opportunity to use his platform for cocaine detection. The advantage of using such small surfaces, he says, is that they are capable of detecting the very small amounts of the drug that may appear only as trace elements in other substances.

“Usually, cocaine molecules are part of a biological matrix or solution in urine or saliva or blood,” Shrotriya explains, “so we are trying to see how these affect our measurements. It is quite a challenging task with all sorts of variables, but if we can show that it works, we will have a sensor that can be carried anywhere and that has very high sensitivity and specificity for cocaine or whatever you want to detect.”

An interdisciplinary bias

While Shrotriya and his students have been busy conducting experiments on the mechanical platform, his primary interest lies not so much in developing technologies for sensing species, but rather in trying to understand the mechanics underlying the reactions. For this aspect of the project, Shrotriya is using computer simulations to explain exactly what is happening to the molecules and atoms that cause the surface stress changes. To find these answers, he is turning to experts in molecular dynamic simulations and quantum chemical calculations.

“We want to know, for example, how sulfur and gold interact with each other. And how does that interaction change when you attach different molecules?” Shrotriya says. At these very small scales, the energies associated with chemical reaction, deformation, and surface stress change are all equal. All of these are interrelated, and to understand what is happening requires learning new things and collaborating across disciplines.”

Shrotriya’s interdisciplinary outlook extends to the classroom as well, where he teaches a course in nanomechanics that attracts students from across the college. The course includes discussion about chemical reactions and applications to such things as detection of harmful species. Shrotriya has also developed a module for the machine design class that allows students to explore nanoscale machines.

Shrotriya believes that constantly learning and working across disciplines will provide future opportunities. “The future of the discipline relies on our ability to learn multiple things and apply that information to a mechanical framework,” he says. “By doing so, we will have the tools to attack the challenging problems of the future.”
If, as Julie Dickerson (page 10) asserts, the appreciation of “fuzzy logic”—at first blush, a contradiction in terms—is critical for understanding the metabolic pathways of plants, what role, then, does advanced computation play in the engineering of biosystems?

Computation, after all, is inalterably anchored in the hard, immutable binary logic of 1s and 0s. And while in theory these can be configured infinitely and on as vast a scale as money, materials, and imagination can afford, there is no “fuzzy” scheme in which two plus two can possibly equal anything other than four.

The objective of advanced computation, however, is not so much to model natural systems precisely, if that could even be done, but instead to compile, collate, and analyze our collective experimental knowledge of those systems on a scale not otherwise possible.

Accelerating Speed
To date, the tools available to Iowa State scientists and engineers seeking to unlock nature’s secrets have been formidable, from the BlueGene/L supercomputer acquired in 2006 to last year’s $5 million dollar upgrade of the C6 virtual reality chamber, an improvement in imaging Dickerson calls “amazing.” Yet as impressive as these have been, Iowa State engineers working in the biosciences will soon have at their disposal even greater resources, both on and off campus.

When Srinivas Aluru brought an IBM BlueGene/L to Iowa State in order to complete his work in sequencing the corn genome, “CyBlue,” as it’s called, was among the 100 fastest supercomputers in the world. Yet although hardly ready for the cyberboneyard, today CyBlue no longer ranks even in the top 500, so rapidly does the power and availability of computation increase.

That’s about to change. In 2008 Aluru and his colleagues took possession of a new Sun Microsystems supercomputer. Tentatively named “CyStorm,” the new unit will operate at 28.16 teraflops—that’s 28.16 trillion floating-point operations per second, well over five times the speed of CyBlue. Yet while CyStorm ranked among the top 100 supercomputers upon acquisition, by the time it is fully operational later this year Aluru expects it to rank no higher than 200.

However, even more impressive—and potentially more valuable—will be the Blue waters supercomputer housed on the campus of the University of Illinois. A project of the Great Lakes Consortium for Petascale Computation, of which Iowa State is a charter member, when fully operational the $200 million Blue waters supercomputer will operate at a few petaflops—each petaflop being one quadrillion calculations per second, nearly 36 times faster than CyStorm.

While tools such as Blue Waters will be applied to a host of “grand” challenges in science and engineering, including the simulation of complex engineered systems, much of its prodigious computing capacity will be directed toward modeling and predicting natural phenomena, including, in the words of its designers, “the behavior of...
complex biological systems” and “changes in the earth’s climate and ecosystems.”

**Two challenges**

In order to take advantage of tools such as Blue Waters or even CyStorm, however, engineers working in bioinformatics and systems biology face two core challenges: first, they must immerse themselves in a particular knowledge base in the natural sciences in order to understand the problem to be addressed; and, second, they must go back to the drawing board to develop applications that will actually work on systems the likes of which they’ve never before encountered.

“Blue Waters represents a radically new architecture for supercomputing,” says Jim Oliver, director of Iowa State’s CyberInnovation Institute and a participant in the Great Lakes Consortium. “You can’t just take the code you’ve been running on today’s hardware and simply move it to Blue Waters, which is orders of magnitude more powerful—it may not even be possible. You have to go back to first principles and look at your algorithms.”

For that reason, a key element of Blue Waters will be for project partners, including those at Iowa State, to work with collaborating scientists on revising their applications in order to optimize performance and scalability so they can take advantage of the project’s capabilities. However, the ultimate value of supercomputing lies not in incremental or evolutionary progress on existing work, but revolutionary leaps in the application of computers to both natural and engineered systems.

“Ultimately, Blue Waters doesn’t want to encourage science that is already being done,” Oliver says. “The project wants to radically open doors that haven’t been opened before, and that goes back to how you rethink the problem and how you map it onto this new architecture.”

The other challenge—understanding the problem in the first place—is, according to Aluru, at least as formidable as revising or scaling up previous work to a new platform.

“We really need to understand what it is being solved and how people would solve it if they were solving it, say, by hand,” says Aluru. “That requires us to go into that domain and learn something about what they are doing. It’s fortunate in that we learn a lot, but unfortunate because for every different problem we are working on we need to develop expertise, and that takes time.

“You can always buy speed,” he adds. “You can always buy capacity. What you cannot buy is the intellectual ability to utilize it.”

**Dealing with data in depth**

The truth of this observation is reflected in Aluru’s own experience, as he has spent the past dozen or so years immersing himself in the world of plant genomics in addition to his core expertise in computer engineering. Yet beyond the knowledge a computer engineer needs simply to comprehend the scope of key questions in the biosciences in order to be of use to, say, an agronomist or plant geneticist, there is also the additional expertise required to manage the sheer volume of data generated by a myriad of experimental devices.

In both his areas of bioinformatics and systems biology, says Aluru, new experimental devices capable of generating once unimaginable volumes of data are coming on board continually. Cutting-edge instruments such as Iowa State’s atom probe microscope or the Solexa sequencing machine recently acquired by Iowa State’s Plant Sciences Institute, which produce massive data sets over very short time scales, represent a particular challenge for researchers.

“The Solexa can read tens of millions of sequences in the same experiment,” Aluru says, “but they will be very short. So if you look at a genome as a very long string, you’d need multimillions of those. This instrument can generate nearly a billion base pairs a day. You would need vast computation to process such large quantities of data.”

Not only must these huge data sets be analyzed individually, progress in the biosciences will hinge on researchers’ abilities to integrate them both with other data from similar devices and with those produced by other means and even for other purposes altogether.

“This is high throughput data generation through experimental devices,” Aluru notes. “You take a large number of such experiments, and you look at them collectively and ask, ‘what kind of system would produce this kind of response?’ And you try to infer the system from these responses.”

**‘Dramatic change’ at hand**

From that computer-enabled “inference” (call it the “fuzzy logic” of the digerati) drawn from multiple combinatorial data sets will come the knowledge base that turns information into innovation, whether it’s the next generation of cancer drugs, drought- and disease-resistant crops, or predictive modeling of the global climate that enables policy makers to reliably see the consequences of today’s industrial decisions 10, 20, or even 50 years out.

For that to happen, though, will require not just a revolution in computer hardware, but in the human mind as well, as engineers seek to assimilate and adapt to the exponentially more powerful tools at their disposal.

“The bottom line,” says Oliver, “is that the machines are advancing at a tremendous rate. And the challenge with Blue Waters or any other supercomputer is that all of the associated tools—be they compilers or run times or drivers and all this stuff—have to be done in addition to the physics and the algorithms and the modeling we use to simulate the drug or the atmosphere or whatever.

“There’s a whole bunch of work that will be done over the next five years,” Oliver concludes. “If it goes well, we could see some dramatic changes.”
When Iowa State University established its electrical engineering department in 1909, then-department head Fred A. Fish and his colleagues concentrated their research on areas such as telephone switchboard communications and electric motors. Since then, electrical engineers at Iowa State have expanded their research as they helped build the world’s first electronic digital computer and invented the encoding process used in nearly all fax machines.

Today, as the Department of Electrical and Computer Engineering (ECpE) celebrates its centennial, three young faculty members equipped with a new lab filled with high-powered microscopes and other tools are paving the way for electrical engineers at Iowa State to create bio-related tools and applications for agriculture, medicine, and other fields.

If it seems odd that electrical engineers are studying living organisms using Petri dishes and atomic force microscopes, it’s not so odd to three assistant professors—Santosh Pandey, Liang Dong, and Jaeyoun Kim—who are on the forefront of the rapidly growing bioengineering research area. The professors are addressing three bioengineering problems from different angles and are part of ECpE’s newly created bioengineering research group.

**Mining the biological intelligence of parasites**

With new equipment that includes an atomic force microscope that can study nanoengineered materials and single molecules, as well as a carbon dioxide incubator for growing biological specimens...
in the lab, Santosh Pandey recently began a research project to study the behaviors of parasitic nematodes that destroy crops and infect farm animals.

Pandey and his interdisciplinary research team of plant pathologists and biomedical scientists fabricate microscale fluidic devices for experiments to understand the relationship between the nematodes’ behavior and their genetic composition. In addition, they are developing bioassays (i.e., quantitative scientific experiments designed to test a material’s effect on a living organism) to isolate individual behavioral modalities, which eventually can be linked to specific genetic mutations and signal transduction in an organism’s neural network.

“Experimental techniques to observe nematodes’ parasitic behavior are limited,” says Pandey, “and there is an urgency to develop new bioassays that can detect and sense nematode behavior with high precision and specificity.

“The ultimate goal,” he continues, “is to understand how the behavior of this parasitic organism is related to its genetic makeup and its neural network. Eventually, we could use these nematodes as model organisms to understand the fundamentals of parasitism and extrapolate their learning, memory, and aging properties to certain human behavior.”

The team is also conducting tests to learn about the nematodes’ social behavior, migratory and host-invasion patterns, sense of smell and taste, memory and learning abilities, and feeding, mating, and reproductive habits. Once the current research is complete, bioinformatics technology will help the researchers to understand the vast data collected from their experiments and decipher the various gene-regulating circuits that control a nematode’s specific behaviors.

The U.S. Army and Department of Defense are highly interested in this research area, Pandey explains, because the biological intelligence of nematodes could be mimicked in devices such as search and navigation tools that use artificial intelligence.

“Because nematodes have highly sensitive and specialized sensing mechanisms, it is expected that their inherent search and navigation ‘algorithms’ are far more advanced than humans ever imagined,” Pandey says. “Hopefully, knowledge of this biological intelligence could be used to enhance artificial intelligence—the kind that controls robots and other man-made systems.”

A ‘pacemaker’ for the inner ear

More than 90 million Americans will experience balance problems in their lifetimes, according to the National Institutes of Health. Of these, at least two million will suffer chronic impairment, costing more than $1 billion a year to treat.

That’s why Liang Dong is working with two microelectronics scientists from the ECpE department and physicians from the University of Minnesota and the University of Iowa to develop a vestibular prosthesis, an electronic device to replace the inner ear’s vestibular organ, which helps people maintain balance, posture, and their body’s orientation.

The research could help farmers, too. According to a California State University Agricultural Research Initiative report, the U.S. agricultural industry loses more than $10 billion of crop produce each year due to parasitic nematode infestation.

“Understanding why, when, and how nematodes invade a land, migrate to the root system, and infect the plant will enable us to develop better strategies to obstruct their migration, mitigate their parasitic effects, and eventually stop their devastating effects on crops in the least toxic and most sustainable manner,” Pandey says.
The core of the vestibular prosthesis project is to develop a miniaturized motion sensor,” Dong says. “The device will be made of inexpensive, biocompatible polymers such as polydimethylsiloxane and liquids such as water. This is a distinct feature of the device.”

Other components of the apparatus, which will effectively act like a “pacemaker” for the ear, include three angular accelerometers for rotary movements, three linear accelerometers for straightforward movements, and a series of microelectrodes.

According to Dong, in nature the vestibular system has three semicircular canals filled with fluid that flows when an angular acceleration is experienced by the head. The movement of fluid in the canal is sensed by hair cells growing on the canal walls. Nerves connected to the hair cells send a train of neural signals to the brain, which integrates that information with visual signals and other cues to maintain balance and stabilize vision.

To make an artificial system to match Mother Nature’s intricate natural system, one of Dong’s biggest challenges will be to make the motion sensors small enough to fit inside the device, which will be only one millimeter long (about the size of a pinhead), but also sensitive enough to decipher even the slightest movement of fluid in the ear canal.

Dong’s research team is addressing this challenge by using microfluidics technology to develop biomimetic angular and linear accelerometers that use the fluid’s inertia to efficiently achieve high-acceleration sensitivity in a small package. Also, in order to develop multidirectional sensing abilities for the device, they are creating a new self-assembling technology that can accurately assemble multiple components within a liquid environment.

“If we’re successful, we will be the first to develop an all-polymer, implantable vestibular prosthetic device,” Dong says.

“It will be much safer, cheaper, and more bio-friendly than current non-implantable devices available.”

Tortoise meets hare at the nanoscale

Jaeyoun Kim is working to develop very small plasmonic elements that can control the flow of optical waves at the nanoscale for applications in biosensing. Essentially, he is creating a new plasmonic element with two functions: nanoscale sensing and integration with integrated optics.

“Plasmonic elements are excellent in sensing, but interfacing them with optical components is often cumbersome, unstable, and expensive,” Kim says. “We want to do it with pre-aligned, robust optical waveguides. This is not necessarily a new idea, but there are fundamental differences between the two technologies that currently baffle researchers.”

“Plasmonic sensing” includes any sensing technique that uses a surface plasmon—i.e., a lab-generated hybrid of light and electron density fluctuation—to sense phenomena occurring across a range of 200 nanometers or less. Plasmons are used particularly in biomolecular sensing to monitor the interactions between molecules, DNA, and proteins.

To grasp the size of the objects Kim works with, consider this analogy other scientists have made: a nanometer is to a meter what a marble is to Earth. Kim, who works with objects only a couple hundred nanometers in size, says that plasmonic sensing is an extremely sensitive scheme. And while individuals with large laboratories can easily use plasmonic sensing, the technology is expensive and not portable.

“Our research will enable the much-needed miniaturization and integration,” Kim says, “which will bring plasmonic sensing to on-site uses.”

One such use involves going to farms to test and diagnose farm animals for possibly...
contagious diseases, a process that currently takes days because farmers have to take samples and mail them to Iowa State University labs. By miniaturizing the technology, testing and diagnosis could be done on site at the farm, allowing farmers to get test results much faster.

As his research progresses, Kim plans to collaborate with professors from Iowa State’s College of Veterinary Medicine to investigate this specific application of his plasmonic devices. But miniaturizing the technology won’t be easy, he says, as his research requires him to work against the physics of plasmons.

“In setups configured for sensing,” Kim observes, “the surface plasmon-politron—the ‘ammunition’ of plasmonics—is inherently faster than optical waves. That’s physics.

“We are trying to couple the two,” Kim continues. “It’s like coupling a hare and a tortoise. We overcome the difficulty by forcefully slowing down the surface plasmon-politron and syncing it with the optical wave.”

Kim isn’t the first researcher to address this speed mismatch of the surface plasmon-politron and optical waves. However, conventional methods have largely been confined to doing something to the waveguide, often leading to highly complicated structures. Kim, on the other hand, plans to design a new plasmon-supporting structure with which he can modify the characteristics of surface plasmons, simplifying the coupling greatly.

“As an engineer,” Kim says, “it is always exciting to find one element capable of doing more than one thing.”

Electrical Engineering Building Provides Space for Bioengineering Lab

Before the new addition to the ECpE building opened this year, Santosh Pandey, Liang Dong, Jaeyoun Kim, and their bioengineering colleagues didn’t have lab space. But since April, the three researchers have spread their lab across a four-room suite and equipped it with the latest technology and equipment needed for their research.

The trio’s lab has three high-powered microscopes (including an atomic force microscope and high-resolution phase contrast microscope), a furnace, a heater, high-precision electrical instruments, chemical and biological safety hoods, a distilled water tank, a carbon dioxide incubator, and a centrifuge.

“We’ve now brought in almost all the equipment we want, and our graduate students especially enjoy using the new equipment,” Dong says.

Adds Pandey, “Having the new facility and equipment has made me think of research avenues beyond conventional electrical engineering.”
Assistant Professor Soon-Jo Chung is designing a control system to give his robotic bat the same kind of flexibility and maneuverability found in living bats.
Engineers Explore the Biomimetic World in Quest for ‘Killer Apps’

By Mary Jo Glanville

The traffic isn’t all in one direction when biology and engineering converge, as two Iowa State researchers seek to apply principles of nature to advanced technologies.

In the Aerospace Robotics Laboratory in Howe Hall, Soon-Jo Chung is building a micro aerial vehicle (MAV) that utilizes flapping wings and is able to perform acrobatic maneuvers while expending minimal energy. The military uses MAVs for functions such as surveillance and scrutinizing potentially hazardous environments. The ability to avoid obstacles while moving in and around tight spaces is a key requirement.

Across the street in the Developmental Robotics Laboratory in Coover Hall, Alexander Stoytchev is working to make humanoid robots smarter. He wants to build a robot that can learn to adapt to new circumstances as it interacts with tools and its environment.

Both researchers are biomimeticists—that is, they are using ideas from nature to advance the development of new technologies. Nature, after all, has been evolving for millions of years and has come up with some very elegant solutions to perplexing problems.

‘We can learn a lot from bats’

Last fall, Chung, an assistant professor in aerospace engineering, received a three-year, $300,000 grant through the Air Force Young Investigator Research Program. He got the inspiration for his project, “Bio-Inspired Integrated Sensing and Control of Flapping Flight for Micro Aerial Vehicles,” from bats, and while these furry flying mammals won’t win any popularity contests with most people, Chung has nothing but praise for them. “We can learn a lot from bats because they are so agile,” he explains. “They can change directions quickly and easily and do a lot of acrobatic maneuvers. Their membrane wings are very flexible and highly compliant.”

A control and robotics engineer who came to Iowa State in 2007, Chung has turned to biologists for facts about the characteristics of bats that make them so aerodynamic and agile. One of his collaborators is Kenny Breuer, a biologist at Brown University who has collected extensive data from studying bats. “Biologists have learned that regardless of their size, bats are very efficient in flight,” Chung says. “They generate more lift and less drag than airplanes. They can also fly with damaged wings and with more than 50 percent of their proportional weight. These things all have implications for how we design airplanes,” Chung continues. “We’re not looking for strict mimicry, but rather to learn from bats in order to develop new mechanisms.”

A bat’s unique abilities lie in the structure of its membrane wings. Flapping the wings propels the bat through the air, of course, but the wings are also constantly adapting to the environment. Thousands of tiny hairs on the wing membranes provide sensory information that controls the shape and pitch of the wings, enabling the bat’s acrobatic movements. And with a minimum of 24 joints in each wing, there are countless configurations to provide the precise motion required for a particular maneuver.

The challenge of control

Chung’s challenge is to design a control system that will give his MAV, which is essentially a robotic bat, the same flexibility as a living bat. “It needs to work seamlessly,” he explains. “When you walk, you don’t have to think about one foot moving in front of another because signals coming from the brain make sure everything moves in a synchronized way.”

To achieve a similar level of coordination in his MAV, Chung is devising a central sensing and control system that mimics the neuronal networks of bats in order to...
synchronize the wings’ flapping and joint movements, allowing them to respond appropriately to unique environmental conditions—in a word, the controller effectively serves as the MAV’s “brain.”

Chung’s project draws on his previous work on the synchronization of formation-flying satellites. As a graduate student at MIT, he worked extensively in the SHERES lab, a highly sophisticated testbed dedicated to developing autonomous formation-flight and docking-control algorithms. There, Chung was challenged to develop new theories and methods to ensure that the movements of individual satellites were synchronized across entire formations.

Similarly, Chung explains, all of the parts of the bat’s wings must work together in order to achieve the desired motion. “The MAV has to be able to maintain its flight in a robust and sustained fashion,” he says. “With its multiple joints, the wing has many more degrees of freedom than an airplane wing. It makes it very challenging to control. The wings have to flap at the same frequency, more or less, and all of these other parts need to be synchronized in their motion so you have the right pitch angle and face difference.”

Once he has a working model, Chung plans to begin experimental studies with the MAV in Breuer’s wind tunnel at Brown. Yet, while his immediate goal is to achieve highly maneuverable MAVs equipped with intelligent sensors, the work has more far-reaching possibilities.

“The successful reverse-engineering of flapping flight has implications for innovation in aircraft design,” Chung points out. “Aircraft have been dominated by fixed-wing design, but this early work indicates some advantages of flapping wings that should be investigated. This work is also pushing the frontier of our understanding of neurobiological mechanisms underlying animal flight and locomotion.”

Looking beyond R2-D2

Over in his robotics laboratory, Stoytchev, an assistant professor in electrical and computer engineering (ECpE), is taking a developmental approach in his efforts to create intelligent robot behavior, using human behavior as his model.

“Humans, and to some extent higher animals, are the only existing proof we have so far of natural intelligence,” he explains. “To build artificially intelligent robots, we must study how complicated biological systems work and try to emulate them.”

Designing robots with human-like intelligence is something Stoytchev has wanted to do since he was in elementary school. He was nine years old when he first saw the movie Star Wars, whose droids, R2-D2 and C-3PO, captured his interest.

“I remember asking my parents if such robots existed for real, and what would it take to build one,” he says.

Stoytchev’s childhood interests continued, and while robotics clubs weren’t part of the educational scene yet, he was drawn to the next best thing, namely computers. As a college student, Stoytchev majored in computer science and began to specialize in artificial intelligence. Yet it was not until he became a graduate student at Georgia Tech that he worked with robots for the first time.

Joining ECpE in January of 2008, Stoytchev’s work today is centered in developmental robotics, a new field that crosses the disciplinary boundaries of robotics, artificial intelligence, developmental psychology, developmental neuroscience, and even philosophy. The goal of his research, he says, is to build autonomous robots that are more intelligent, adaptable, and useful than traditional robots.

“Today, we have many industrial robots that are very useful for manufacturing tasks such as building cars,” Stoytchev says. “However, their actions are very carefully scripted by human programmers, so they are not truly intelligent. They can use complicated tools to perform cutting, painting, and welding operations, but only as long as their environment—i.e., the conveyor belt—is structured in a predictable way. If somebody replaces their tools, they would not notice the difference.”

Learning from one’s mistakes

Stoytchev wants to create robots that will notice that difference and says that the only way to achieve this goal is for the robots to be able to interact with the tools and learn from their experiences. “It is naïve,” he adds, “to expect that we can pre-program them with all of the knowledge that it takes humans decades to master.”

Stoytchev’s basic hypothesis is that robots must undergo a developmental period similar to that of humans and animals. Tool use, he says, is a prime example. Animals use tools for many different purposes to overcome limitations imposed by their anatomy and over time have learned how to adapt their available resources to meet specific needs—using sticks to reach out for food or to dig a hole, for example.

One long-term project in Stoytchev’s lab addresses the problem of autonomous tool use in robots. Unlike the highly specialized approach used with industrial robots programmed for one specific task, Stoytchev’s robots autonomously interact directly with a tool in order to learn a representation of the tool that is grounded in the robot’s sensorimotor repertoire, thus reducing its dependence on human programmers to tell it what to do.

As with human learning, however, even robots must learn from their mistakes. Last October, for example, Stoytchev and
his students were given the opportunity to design a robot to cut the red ribbon at the dedication of the ECpE building addition. It was a perfect opportunity to showcase his work, Stoytchev says, but the opportunity presented some anxious moments.

“For humans, it is common knowledge that scissors have two handles that form a plane,” he explains, “and pulling on the handles in opposite directions perpendicular to that plane is futile. Well the robot didn’t know that, so a week before the ceremony, it broke three of its fingers trying to do exactly that.”

By the time the ceremony rolled around, however, the fingers had been repaired, and, to the delight of the crowd, the robot had learned how to operate the scissors, successfully cutting the ribbon.

**Windows of opportunity**

In his quest to continually improve the intelligence of robots, Stoytchev is studying the fundamental processes and principles that drive human cognitive development. Language-learning studies conducted with eight-month-old infants, for example, have shown researchers that infants learn to segment the basic units of speech by extracting statistical information from the audio signal. Stoytchev’s team was able to replicate those results in code to apply to robots, work that won the team a best paper award.

One area of particular interest to Stoytchev concerns what are termed “developmental windows of opportunity” during which a given skill must be learned. It is known, for example, that human infants must learn to speak by the age of three, otherwise their language skills and other higher cognitive abilities will be severely affected. Accordingly, Stoytchev wants to understand the significance of the order in which these windows “open”—i.e., what other skills might be affected by a child who doesn’t learn to speak by the age of three?

Since finding the answers to these kinds of questions would disrupt the normal developmental flow in humans and animals, Stoytchev hopes that one day robots themselves may be capable of helping researchers find the answers. That means that the intelligence of robots must definitely increase, and Stoytchev is confident that day may not be so far off.

“Robotics today reminds me of the computer industry in the early 80s,” he says. “There were no standard computer components, and the field was driven by hobbyists and forward-thinking companies and universities. Once Apple unveiled the PC, it did not take long for somebody to invent the first killer app. The rest, as they say, is history.

“Robotics,” Stoytchev adds, “is waiting for its first killer app.”
Iowa State University launched what it hopes will be a long-term initiative in alternative energy technologies by hosting the First ISU Wind Energy Symposium in the College of Engineering’s Howe Hall on December 9, 2008.

More than 220 participants registered for the event, according to symposium organizers. Besides Iowa State faculty, students, and staff, attendees for the daylong program included representatives of state agencies, farmers’ groups interested in leveraging public and private investment in wind farm expansion in Iowa, and venture capitalists exploring opportunities in the burgeoning wind energy industry.

“Wind energy has certainly been on our radar for quite a long time, and we’ve had a good history of faculty working in this area,” says Associate Dean for Research Balaji Narasimhan, who helped organize the symposium. “The wind tunnel in Howe Hall is a pretty unique facility. We have faculty doing research in climate modeling, faculty in the business school working on supply chain—this represented a wonderful opportunity to really bring all of these people together, because they’re all working on the same problem.”

According to the Global Wind Energy Council, the use of wind technologies to produce electricity has grown more than fivefold since the beginning of this decade, with annual worldwide production approaching 100 gigawatts of power by 2008. The United States leads the world in total power generated from wind, and Iowa recently became the second-largest producer of wind energy in the United States, behind only Texas.

The annual symposium, Narasimhan observed, will be an ongoing effort to build and sustain strong profiles for both the university and the state as the nation and world address a host of interrelated environmental, economic, and energy challenges.

“With renewed interest in this area with a new administration coming in, and talk of a green economy,” Narasimhan added, “this was very timely for us to do.”

ISU ASTEROID DEFLECTION RESEARCH CENTER WINS MAJOR GRANT, SPONSORS SYMPOSIUM

Iowa State’s Asteroid Deflection Research Center (ADRC), established in April 2008, has won its first contract to develop technologies to mitigate the threat to Earth posed by asteroids. The Iowa Space Grant Consortium (ISGC), a NASA-supported organization, will award more than $300,000 over three years for the project led by ADRC director and Vance D. Coffman Chair Professor in Aerospace Engineering Bong Wie.

Selected from a field of three finalists, Wie’s proposal, “Development of Integrated System Architectures and Innovative Technologies for Near-Earth Object Surveys and Threat Mitigation,” includes plans for collaborations with other groups and development into a self-sustaining program, one of the criteria for the ISGC grants. The award is the first asteroid mitigation/deflection research project to be funded by NASA, according to Wie.

In addition, the ADRC sponsored an Asteroid Deflection Research Symposium last October in Arlington, Virginia, in order to exchange technical information and develop an integrated multidisciplinary R&D program for asteroid deflection/fragmentation using high-energy as well as low-energy options. Attendees included planetary defense researchers from NASA, the U.S. Air Force, the Air Force Research Laboratory, the Defense Threat Reduction Agency, Sandia National Laboratories, Lawrence Livermore National Laboratory, and the National Research Council, among others.

GOODRICH DONATES ICING WIND TUNNEL TO IOWA STATE

Goodrich Corporation’s Sensors and Integrated Systems team has donated an icing wind tunnel to Iowa State. The tunnel will be the university’s first wind tunnel to be able to perform icing physics research and will be housed in Iowa State’s wind simulation and testing (WIST) laboratory.

The WIST lab is a state-of-the-art experimental facility for conducting research, education, consulting, and outreach for applications in wind engineering, aeronautics, and industrial aerodynamics. The Goodrich icing wind tunnel will be used to study, among other things, icing effects on alternative energy generators such as wind turbines.

Goodrich currently works with Iowa State scientists on other environmentally focused technologies such as optimized gas turbine engine fuel burn for clean combustion. Goodrich Corporation, a Fortune 500 company, is a leading global supplier of systems and services to the aerospace and defense industry.

A NEW WAY TO STAY IN TOUCH WITH THE COLLEGE

The College of Engineering has launched Alumni E-News to provide our stakeholders with brief updates on people and happenings in the college. This electronic newsletter includes links to the College of Engineering Web site and to specific video spotlights or news releases. Alumni E-News is sent out the middle of each month to alumni and friends for whom the Iowa State University Foundation has e-mail addresses. If you have not received Alumni E-News and wish to be on the distribution list, please send your name and e-mail address to alumni@iastate.edu. Questions, comments, and requests to unsubscribe can also be sent to alumni@iastate.edu.
Bioeconomy Institute director Robert Brown has been named to the Gary and Donna Hoover Chair in Mechanical Engineering.

Robert Anex, associate director for research for Iowa State’s Bioeconomy Institute, has been named to the Science and Technology for Sustainability Subcommittee of the U.S. Environmental Protection Agency’s Board of Scientific Counselors.

Surya Mallapragada is one of four Iowa State University researchers recently named an AAAS fellow by the American Association for the Advancement of Science.

The College of Engineering is pleased to announce the receipt by the following faculty members of CAREER awards from the National Science Foundation. Among the most competitive of NSF grants, CAREER awards are given to catalyze innovative research by the profession’s most promising young faculty members at the beginning of their research careers.

Dionysios Aliprantis, Electrical and Computer Engineering, “Sculpting Electric Machines for Unidirectional Motion”

Zhiqun Lin, Materials Science and Engineering, “Evaporation-Driven Self-Assembly of Hierarchically Ordered Structures from Confined Solutions”


NEW ECPE FACILITIES DEDICATED

The College of Engineering dedicated the new Electrical and Computer Engineering Building: Phase I on October 2, 2008. The first of two phases of construction, the new $16.5 million facility provides 23,000 square feet of state-of-the-art classrooms and research and teaching laboratories furnished with the latest equipment and technology for students and faculty.

A robot designed and built by Alexander Stoytchev, assistant professor of electrical and computer engineering, cut the ribbon at the ceremony, demonstrating some of the technology that will be explored in the new facility.

Phase II of construction will add an additional 33,000 square feet to the building and be home for advising and senior design, as well as offices for staff, faculty, and graduate students. Phase II will cost an estimated $22.3 million, with groundbreaking anticipated in 2010.

The building project is funded by private donors and state funds. Private support was made during Campaign Iowa State: With Pride and Purpose, the university’s $800 million fundraising effort launched in October 2007. New classrooms and laboratories for teaching and research allow Iowa State’s electrical and computer engineering program to recruit and retain top students and faculty, positioning the program as one of the best in the nation.

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Iowa Poised to Take the Lead in Wind Energy

BY P. BARRY BULTER

Developing a realistic strategy for U.S. energy independence will require an orchestrated blend of energy technologies. Among alternatives, wind energy is a critical component of national and state plans for achieving energy independence.

Indeed, last year over one-third of all new electric generating capacity installed in the United States was derived from wind. Further, the U.S. Department of Energy recently completed a feasibility study, 20% Wind Energy by 2030, investigating the requirements for producing 20 percent of the nation’s electricity from wind by 2030.

As wind energy continues its upward trajectory, we are likely to see activities clustered around strategic geographical regions. Much like Silicon Valley in the electronics and information technology industries, wind energy’s centers of excellence will demand a nearby supply of highly educated talent, close partnerships between industry and research universities, a bold entrepreneurial spirit, and a welcoming business climate.

Iowa is well suited to take full advantage of opportunities in this rapidly growing industry. Our state has quickly taken a leadership role in wind farm installations as well as the manufacturing of wind turbine components, and today we are positioned to become the Silicon Valley of wind energy technology. In fact, by the end of 2008, Iowa had earned the honor of becoming the number-two producer of wind energy in the United States, second only to Texas.

Eight wind energy companies have already established manufacturing facilities in Iowa because of its strong infrastructure, including community colleges that support manufacturing and operations/maintenance training, world-class research at the universities, supportive renewable energy policies, logistics and supply chain efficiencies, a competitive business climate, and a legacy of manufacturing excellence. Consequently, these industries and their suppliers need state-of-the-art research and development to produce new technologies with greater efficiencies, lower costs, and greater returns on investment; a well-trained workforce for manufacturing and maintenance; improved supply chain management; and testing facilities to evaluate new designs.

To further establish Iowa as a focal point for wind research, education, and industrial innovation, continued growth is needed in both university-industry partnerships in wind energy research and development as well as university and community college education and training programs. Priority areas identified by industry where Iowa’s universities have expertise include

- Meteorology and precise wind monitoring and mapping;
- Electrical conversion and generation, grid management, power converters, and generators;
- Software, control, and sensors for data acquisition and interfacing for system variables;
- Electronics, control devices for reliable and efficient wind turbine/generator operation;
- Mechanical, gearbox, drive train, composites, blades, towers, and nacelle covers;
- Manufacturing, material handling and automation, and electric system operation; and
- Supply chain optimization and logistics.

But to further nourish national leadership, we need to accelerate wind energy research at Iowa’s universities following the model used by the National Science Foundation to stimulate university-industry research partnerships. If successful, wind energy-related research in Iowa will grow significantly, increasing our reputation as a center of excellence for wind energy R&D activities.

In addition to partnering in research, industry has broad workforce development needs in manufacturing, wind turbine maintenance, turbine design and controls, and wind farm operations. It’s clear that students are interested in careers in these areas, so our universities and community colleges have begun to offer wind power and related educational and training activities. Iowa’s public universities have excellent engineering, science, and industrial technology programs that support the workforce needs of wind power and are developing both undergraduate and advanced programs that focus on wind energy. Also, our community colleges offer nationally recognized two-year associate degrees in support of the growing industry.

Iowa is ready to take full advantage of its natural resources, along with an incredible manufacturing base and workforce, to create challenging and rewarding green-collar jobs in every corner of the state, making our state the renewable energy capital of the country. Through research at our universities, innovative public policies, training and education, and expanded testing facilities, Iowa can make a major contribution to the Department of Energy’s goal of generating 20 percent of electricity from renewable sources by 2030.
Starting March 1, Iowa State students began calling engineering alumni to raise merit scholarship dollars. With reduced state support and rising tuition costs, it is imperative that we build this scholarship fund. Many of you have already made a gift—for that we thank you. More of you will be receiving calls in the coming weeks, and we encourage you to support this important initiative. Please take a few minutes to talk to a student about some of the exciting things happening in the College of Engineering and how your support will help attract and retain outstanding students in the college.
Discovery with Purpose

...in education:
- Nation-leading minor in engineering studies
- Engineering Leadership Program for leadership in and beyond the profession
- Nationally ranked learning communities for academic success
- State-of-the-art facilities, including
  - $63 million Engineering Teaching and Research Complex, completed in 2003
  - The C6—first of only three six-sided virtual reality labs in the world, with a $4 million upgrade to world's highest resolution of 100 million pixels
  - The Information Assurance Center, designated a charter “Center of Excellence” by the National Security Agency
  - The Structural Analysis Lab for testing the strength of materials during simulated earthquakes
  - The Mechatronics Lab, with workspace and tools for hands-on experience in integrating mechanical, electrical, and information technologies

...and in research:
- $65 million in annual research expenditures, leading to
  - Timely detection and treatment of diseases
  - Safer highways
  - Biorenewable products, including ethanol
  - A reliable electric power grid
  - Greater Internet security
  - Security of the nation’s food supply
- 2nd in the nation in the prestigious R&D 100 research and development awards
- Home of the National Science Foundation Engineering Research Center for Biorenewable Chemicals
- 5th in the nation in patents awarded, with over 300 patents held by engineering faculty—over half of all patents held by Iowa State researchers
- 12th in the nation in start-up companies launched from research