EAS Prof. Natalie Mahowald studies the complex impact of atmospheric aerosols on climate
Life Achievements: Cornell at the frontier of biomolecular engineering from its very beginnings. By Robert Emro

Engineering Entrepreneurs: Three alumni entrepreneurs talk about going into business and the technical skills that helped them get there. By Dan Tuohy

Intel in Everything: Cornell and chipmaker launch national embedded systems competition. By Sherrie Negrea

Dust in the Wind: EAS Prof. Natalie Mahowald studies the complex impact of atmospheric aerosols on climate. By Lauren Cahoon

Engineering Entrepreneurs: Three alumni entrepreneurs talk about going into business and the technical skills that helped them get there. By Dan Tuohy

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Technion-Cornell Innovation Institute brings a number of initiatives to Roosevelt Island:
- For creating the next generation of high-tech entrepreneurs to exemplifying the highest standards of sustainable building, the Technion-Cornell Innovation Institute will bring a number of transformative initiatives to Roosevelt Island.

Hubs: The campus will be organized initially around three interdisciplinary hubs: Connective Media, Healthier Life and the Built Environment—connected to one another to create a wide range of disciplines and designed to evolve over time. The school will immediately offer master’s and doctoral degrees in such areas as computer science, electrical and computer engineering, and information science and engineering. After proposal, Bloomberg said, was the boldest and most ambitious, as it included an enrollment of 2,500 students, approximately 280 faculty and a 10-acre stretch of state-of-the-art classroom and research space. He talked about the dynamic partnership between Cornell and Technion and the establishment in New York City with its Weill Cornell Medical College, the College of Engineering and extension programs, and its active alumni base.

The campus is expected to generate nearly $600 million over the project period, which could create up to an additional 30,000 permanent jobs. Finally, Bloomberg said, the aggressive schedule to which Cornell has pledged to get the campus up and running will also be financially self-sufficient, Fuchs said. The $350 million gift from philanthropies will help support the entire initiative. A digital rendering of the proposed NYC tech campus on Roosevelt Island. (Such today, the campus’s 1.6 million-square-foot academic building would be the largest net-zero energy building in the eastern United States and among the top four largest such buildings in the United States.

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**Multiple spaces are connected and designed around flexifying ideas creation. All public spaces are designed with the understanding that many of the most innovative ideas are a result of chance encounters.**

**The great green roof system will capture and retain up to 100 percent of rainwater to support the campus's lush green plant life and the natural habitat, and reduce cooling loads and the heat island effect.**

The Cornell-Technion campus is scheduled to break ground on New York City’s Roosevelt Island in early 2013. The first students will start in temporary off-site space in fall 2013. The partnership with Technion-Israel Institute of Technology was announced by New York City Mayor Michael Bloomberg as the “game-changing” project promises to spur economic growth, job creation, and high tech entrepreneurship.

The announcement came just as Cornell announced a $350 million gift—later revealed to be from Chuck Feeney’s 56 Atlantic Philanthropies—in support of the tech campus.

Fuchs went on to predict that having the tech campus in New York City will create a symbiotic flow of ideas and talent that will end up attracting people and philanthropy—to Cornell in Ithaca, not just New York City. “It elevates the visibility of Ithaca as a tech town,” said Fuchs, as well as Tompkins County and all of this region we love, and puts us on a worldwide stage that we’ve never had before as a community,” Fuchs said.

He noted, for example, the inaugural tech startup fair held that weekend, attended by more than a thousand people, “many of whom have never been to Ithaca,” said Fuchs, adding that that’s a sign of things to come.

Until approximately the end of March, the leadership team planned to “take a step back” to approach many people in the process of ironing out the details of bringing the campus from the ground up, said Cathy Dove, associate dean of administration in the College of Engineering, who was later named vice president of CornellNYC Tech. Fuchs added that an email address—cornellnyctech@cornell.edu—was being created through which people can ask questions about anything from aesthetics to programming.

The year 2012 will bring work on environmental reviews of the site, master planning and opening a satellite campus in leased space, which is to be occupied by the incoming Ithaca-based students.

AguaClara students visiting Honduras Jan. 6–20 toured existing water plants and helped improve others, including one in Maculca, where they installed a new inlet manifold. From left, AguaClara students visiting Honduras Jan. 6–20, Adam Corro, professor of applied and engineering physics, and colleagues optical work in the Jan. 5 issue of the Journal of Nature. The researchers created what they call a time lens, which can manipulate and focus signals in time, analogous to the way a glass lens focuses light in space. They use a technique called four-wave mixing, in which two beams of light, a “signal” and a “pump,” are sent together through an optical fiber. The two beams interact and change the wavelength of the signal. To begin creating a time gap, the researchers first bump the wavelength of the signal up, then by flipping the wavelength of the pump beam, bump it down. The beam then passes through another, very long, stretch of optical fiber. Light passing through a transparent material can be scaled to fit individual communities. On site, the students can deal with many unknowns, many of which cannot be solved from an arm’s length distance in space.

In Honduras, the students also get to see the policies, fundraising and technical challenges that sometimes derail project. But Weber-Shirk maintains that AguaClara’s plants for scalability, cost reduction and expansion are on the right track. “Every one of the AguaClara facilities continues to provide safe drinking water,” she said. “This is an amazing accomplishment in a world of failed development projects.”

That AguaClara works so well is due to its partners on the ground. Antonio Elvir, A’10, is the crown jewels without anyone noticing. The gap created in the experiment was 15 picoseconds long, and might be increased up to 10 nanoseconds. But the technique could have applications in fiber-optic data transmission and data processing. He added, for example, it might allow inserting an emergency message without interrupting the main data stream, or multitasking operations in a phone or computer, where light beams on a chip replace wires.

The experiment was inspired, Gaeta said, by a theoretical proposal for a space-time cloak or “history editor” published by Martin McCall, professor of physics at Imperial College in London, in the Journal of Optics in November 2010. “But his method required an optical response from a material that does not exist,” Gaeta said. “Now we’ve done it in one spatial dimension. Extending it to two (that is, happening in a moment in an entire scene) is not out of the realm of possibility. AI advances have to start from somewhere.”

The research was funded by the Defense Advanced Research Project Agency and by Cornell’s Center for Nanoscale Systems, which is supported by the National Science Foundation and the New York State Division of Science, Technology and Innovation (NYSTAR).

—Bill Strele
A biosensor may improve disease detection, water monitoring

A biography of how single-stranded DNA is immobilized and hybridized on the sensor.

**BIOSensor MAY IMPROVE DISEASE DETECTION, WATER MONITORING**

A quick, inexpensive and highly sensitive test that identifies disease markers or other molecules in low-concentration solutions could be the result of a Cornell-developed nanomechanical biosensor, which could potentially help with early stage disease detection.

The biosensor, based on a photonic-crystal nanowire array, was developed by Yuemu Lu, a graduate student in the lab of Amit Lal, professor of electrical and computer engineering. Their research was published online Dec. 6 in the journal Nano Letters.

The sensor’s operation was confirmed in collaboration with Dan Luo, professor of biological and environmental engineering, and his graduate student Songming Peng.

The experimental device is a mechanical resonator 50 microns in diameter made of a thin silicon-silicon dioxide membrane, ordered, tightly packed vertical nanowires on top. The design achieves a high surface-to-volume ratio for biomolecule detection, which means it can detect molecules at very low—down to femtomolar—concentrations.

The sensor could be useful, for example, for finding just a few molecules in a glass of water. The sensor works by attaching single-stranded probe DNA molecules onto the nanowires. When those molecules come into contact with a target single-stranded DNA, the relevant molecules bind together, changing the mass detected by the device. The mass change causes a change in the resonance frequency of the device.

A laser beam is shot on the device, and the nanowires’ innovative design allows for more than 90 percent absorption of the light, resulting in an efficient opto-thermo-mechanical excitation of the resonator. An optical readout of the resonance frequency change can be accomplished remotely, quickly and without electrical wires, making the device convenient and inexpensive to make, the researchers said.

Lal said he imagines doctors could use such a device in a clinical analysis, for example, in DNA testing. Typically today, DNA in drawn blood is compared against standard DNA sequences.

The new device could instead be coded with particular DNA sequences of relevance, and those specific molecules could be detected in early stages when concentrations are low.

“You could have a cartridge with any array of the membrane sensors, and you could quickly scan to see what DNA imperfection you might have,” he said. “Today’s tests take time and are expensive.”

**DEVICE WILL QUICKLY DETECT PATHOGENS**

Two Cornell professors will combine their inventions to develop a handheld pathogen detector that will give health care workers in the developing world results to identify in the field such pathogens as tuberculosis, cholera, gonorrhea, and HIV.

Combining biological and environmental engineering, has devised a method of “amplifying” very small samples of pathogen DNA, RNA, or proteins. Edwin Kan, professor of electrical and computer engineering, has developed a computer chip that quickly responds to the amplified samples targeted by Luo’s method. They will combine these into a handheld device, capable of testing under harsh field conditions, that can report in about 30 minutes what would ordinarily require transporting samples to a laboratory and waiting days for results.

The research was supported by the Bill & Melinda Gates Foundation as part of the Grand Challenge program to develop “point-of-care diagnostics” for developing countries. The foundation has distributed $5 million to 10 teams, selected from more than 500 applicants. Various teams are working on different aspects of the technology, and eventually their work will be integrated to make a practical, low-cost testing kit, Luo said.

Luo’s research group has found that DNA can be used for the molecular-level Lego blocks. A single strand of DNA will lock onto another single strand that has a complementary genetic code. By synthesizing DNA strands that match over just part of their length, his team can assemble unusual shapes—in this case, a switch. Attached to the base of the Y is a DNA strand or antibody designed to lock onto a pathogen. Attached to one of the upper arms is a molecule that will polymerize—chain up with other similar molecules—when exposed to ultraviolet light.

When a pathogen is added to a solution of these Y-DNA molecules, the matching receptors on the stem of the Y will lock onto pathogen molecules, but only onto part of them; the mix will contain two different Y structures, each tagged to lock onto a different part of the pathogen molecule. The result, when the targeted pathogen is present, is the formation of many double-Ys linked together by a pathogen molecule, each assembly carrying two molecules capable of polymerizing.

When the mixture is exposed to a portable ultraviolet light, the polymer molecules at the ends of each double-Y link to those on other double-Y molecules, forming long chains that clump up into larger masses. Without polymerization won’t happen, the researchers emphasize, unless a target pathogen is present to link two Ys together. A single Y with only one polymer molecule attached can link only to one single Y, and no chain will form.

Kan’s new chip measures both the mass and charge of molecules that fall on it. The large clumps of DNA’s much larger mass and charge than single molecules, and trigger the detector. The chip uses the popular and inexpensive CMOS technology compatible with other common electronic devices. A detector might, for example, be controlled and powered by a mobile phone, Luo suggested.

All this can be combined to make a robust battery-operated testing kit, the researchers said. After further development they plan to conduct tests simulating field conditions in the developing world. Along with surviving hot or cold weathers Luo said, “it has to work in dirty water.”

**UNDERGRAD SYNTHETIC BIOLOGY TEAM TAKES A TOP PRIZE AT WORLD CHAMPIONSHIP**

With today’s most pressing problems ranging from the environment to healthcare, it’s clear that life scientists and engineers need to work together. A Cornell undergraduate project team, only three years old but already winning international accolades, is getting in on the ground floor.

CUGEM (Cornell University Genetically Engineered Machines), a mostly undergraduate, highly interdisciplinary project team that started in 2008, achieved its highest honor yet at the GEM 2012 World Championship. Presenting their testing and working “Biofactory”—a series of microfluidic chips that use a biosynthetic pathway to produce a useful chemical—the students beat out 100 other teams to take the “Best Manufacturing Project” prize. CUGEM had previously won a gold medal at the GEM Americas regional competition in October, and ultimately placed among 16 others to the worlds.

“At Cornell, our goal is to foster future Leeds Leutwyler, team leader assistant professor of electrical and computer engineering and team adviser,” said, “We are not trying to have research superhumans who can do it all, but to learn how to harness people’s expertise.”

The new device could instead “amplify” a pathogen sample, two different Y-shaped DNA structures are linked to one of the pathogen molecule. The result, when the targeted pathogen is present, is the formation of many double-Ys linked together by a pathogen molecule, each assembly carrying two molecules capable of polymerizing.

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With the projects were scrutinized on technical details as well as ethical considerations. Teams were also judged by their commitment to outreach and helping public school students, for example, gain access to science. In its short duration, CUGEM has hosted outreach events at both the Ithaca Scienticenter and at Cornell's CUREA Academy, and has already sparked an alumni network.

Shen pointed out that Cornell's relatively young team beat out more established teams from other top institutions. They were one of the few who came with an entire world system, rather than staying on a conceptual level. The team’s interdisciplinary nature is evident through its growing list of sponsors. The College of Engineering, Department of Electrical and Computer Engineering, Weill Institute for Cell and Molecular Biology, and Biotechnology and Life Sciences, and Cornell NanoScale Science and Technology Facility. They have also garnered corporate sponsorship from Corning Inc., New England Biolabs, Integrated DNA Technologies and Mologic.

CU GEM is breaking into a relatively new field called synthetic biology, said Shen, who teaches the course introduction to Systems and Synthetic Biology, which has doubled as a recruiting ground for CUGEM.

The team hopes to pique the interest of freshmen and sophomores especially. Their next information session will be Dec. 3-5 p.m. at 120 Physical Sciences Building.

**DNA Monomer Assembly and Target Recognition**

To “amplify” a pathogen sample, two different Y-shaped DNA structures are linked to one of the target molecule. When two Y’s are linked, polymer molecules attached to the ends of the double-Y can chain together to form a large, easily detected clump.
Mae demonstrates her understanding of structured-English commands during a demo in Rhodes Hall. Background from left, graduate students Jia Raman, Jia Jing and Cameron Finucane stand with Hadas Kress-Gazit.

Mae, a 2-foot robot NAO, was developed by Aldebaran Robotics, to simulate looking for missing items in a grocery store while also avoiding spills in the aisles. Depending on what she finds, the robot takes action based on the specifications that were given to her.

The "store" is located in the Rhodes Hall Autonomous Systems Lab. Mae knows how to react in certain situations—for example, if a "missing item" is encountered, she alerts a manager if she sees a "spill," she'll avoid the area.

Traditionally, a controller for robots which carry out complex tasks requires programming the robot to react in every conceivable state it may find itself in. This is the tedious and error-prone nature of robotics today, the researchers say. There's no guarantee that the code has accounted for every situation, and that it will work. There's also no guarantee the behavior is even possible.

For their work, the Cornell researchers are looking at how to provide explanations to the user when, for whatever reason, a task cannot be done. That kind of feedback from the robot does not exist in robotics today, Kress-Gazit says.

In LTLMo, a high-level specification can be written in structured English. For example, Mae's understanding of "spill," she'll avoid the area.

"Instead of giving it a list of things to do in order, you give it a specification of the sort of behavior it should exhibit at all times," said graduate student Cameron Finucane, who works on the LTLMo platform.

Kress-Gazit's research is supported by the National Science Foundation CAREER program.

Structured English brings robots closer to everyday users

In LTLMo, tools such as "between" and conditional prepositional statements, such as "if-then," can be written concisely because the robot understands breaking down the specification of the sort of behavior.

Mae demonstrates her understanding of structured-English commands during a demo in Rhodes Hall. Background from left, graduate students Jia Raman, Jia Jing and Cameron Finucane stand with Hadas Kress-Gazit.

Mae is told to visit all the corners of the "store" and to look side to side while walking through the aisles. The commands can be written concisely because the robot understands breaking the store into "regions," and prepositional statements, such as "between" and conditional statements like "if-then.

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The ability to manipulate light and fluids on a single chip, broadly called “optofluidics,” has led to new technologies as liquid-crystal displays and liquid-filled optical fibers for fast data transfer. Optofluidics is now also on the cusp of improving such green technologies as solar-powered bioreactors, say Cornell researchers.

The biggest challenge, says Cornell’s David Erickson, associate professor of biomedical engineering and lead author of the paper, is “to envision using optofluidic technologies, such as plasmonic nanoparticles or photonic waveguides, could more directly target the microorganisms and lead to greater energy output.” Similarly, the paper also describes how optofluidic technologies could be used to create photoactive systems, in which light energy splits water into the hydrogen and oxygen, or converts carbon dioxide and water into hydrocarbon fuels. Other applications include optofluidic chips in solar collectors.

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Diversity Programs Honored by President Obama

President Barak Obama cited Cornell’s Diversity Programs in Engineering among the four individuals and four other organizations to highlight the 2011 Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring. The announcement was made Nov. 18.

The mentors received their awards at a White House ceremony Dec. 1. The award recipients received $25,000 from the National Science Foundation to advance their mentoring and other efforts.

“Through their commitment to education and innovation, these individuals and organizations are helping to envision themselves as Cornell engineers.”

Rick Almendinger, associate dean for diversity faculty development and mentoring for the College of Engineering, said: “Here at Cornell, we are always looking to do things differently, not an obligation. We have to leverage an increasingly diverse pipeline of students if the university—and the country—is to remain competitive, and as engineers we firmly believe that diversity and excellence go hand-in-hand.”

The Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring recognizes the crucial role that mentoring plays in the academic and personal development of students studying science and engineering—particularly those who belong to underrepresented groups in these fields. By offering their expertise and encouragement, mentors help prepare the next generation of scientists and engineers.

Says Almendinger, “Diversity Programs in Engineering, explains the importance of mentoring. For science, technology engineering and mathematics, engaging students from a diversity of backgrounds is a national imperative. At Cornell, we take that imperative seriously and mentorship is an integral component of the pipeline.”

Reinforcing diversity within the College of Engineering is central to our profession, our priority as a profession to decades to come. I could not be more pleased with their success,” he said.

Color, women and others historically underrepresented in engineering have the opportunity to realize their aspirations and also contributing their ideas, skills and talent. Through various initiatives, Diversity Programs in Engineering is providing students with access to tiers of role models and mentors. High school students participating in engineering programs gain access to undergraduates and graduate student role models—a critical element to envisioning themselves as Cornell engineers. Said Hernandez, “Role models for our undergraduate and graduate students include other more advanced students as well as faculty.”

“Through our mentoring and other programs, we are helping our engineering students to define and fulfill their aspirations as well as to achieve success at Cornell and beyond.”

George Lowery
That background proved quite useful to Finn after he graduated in 1942 and went to work at Merck. The United States had recently entered World War II and the pharmaceutical company was part of an unprecedented collaboration between government, industry, and academia to quickly ramp up production of penicillin. The new drug, discovered by British researchers, had the potential to save millions of lives, but first it had to be mass-produced—from a mold grown in fermentation tanks.

It was the dawn of a new era in chemical engineering, one in which the production of biomolecules would increasingly be done by microorganisms, and later tissue cultures of living cells. “The world was turned upside down by antibiotics,” says Finn. “It made true believers that there are some things that chemists cannot do. Living organisms can do it cheaper.”

Finn was paired up with a microbiologist for the penicillin project. While his biology coursework at Cornell gave him a leg up on some of the other engineers, Merck still wouldn’t let him near the fermentation tanks. “They knew we’d contaminate the whole doggone business,” says Finn. “It was a touchy business in those days. It wasn’t at all sure that anybody could so change the fermentation industry as to allow pure cultures of aerobic bacteria or molds or yeast.”

Instead, Finn worked on purifying the “gunk” that was harvested from the tanks using liquid-liquid extraction. “You got this penicillin in a broth and you want a crystalline product in the end,” he explains. “Merck was still working on the purification problem when Finn decided to enroll in graduate school at the University of Minnesota in 1946, where he minored in microbiology. “Most of us engineers at Merck realized that there were engineering problems in the fermentation,” say Finn.

By the time Finn had his Ph.D., the Korean War had just ended and the U.S. economy was in recession, so he followed his professor who went to head the biology department at the University of Illinois. “I couldn’t get a job in industry. I wanted to work; I wasn’t planning to be a professor,” says Finn. “I went down there and spent six years as assistant professor. And this is where I started teaching a course. We called it ‘Biochemical Engineering.’”

At the time, Finn was one of just a handful of academic chemical engineers in the country doing this kind of work, but he soon had company. “Biotechnology was a brand new thing,” he says. “All of a sudden we found out that, ‘Hey, these bugs could not only make penicillin and streptomycin, but they could make a whole lot of other products.’”

By 1955, Finn had investigated continuous fermentation techniques and was finishing up a critical review of aeration and agitation that was published in Microbiological Reviews when he got a call from Rhodes’ successor, Chuck Winding.

Emeritus professor Bob Finn began his professional career at Cornell in 1955, marking the beginning of more than 50 years of continuous research in what would become known as biomolecular engineering.
The world was turned upside down by antibiotics. It made true believers that there are some things that chemists cannot do. Living organisms can do it cheaper.

BOB FINN

“He said to me, ‘Would you like to come back to Cornell and be a teacher here?’” says Finn. “I accepted the job on the phone.”

Finn’s return marked the beginning of more than 50 years of continuous research at Cornell in what, with the discovery of DNA, would become known as biomolecular engineering. One area Finn explored was measuring the cell damage caused by aeration. “We made it more quantitative to characterize the shear damage that was caused by various types of impellers,” he says. “That still is more of an art than a science. It’s so complex.”

Finn also branched off into waste treatment, especially chemical waste. He developed a patented process for treating wastes low in nitrogen with bacteria that fix nitrogen from the atmosphere. “My process has been used in Belgium for this. It’s used to treat certain types of food waste, even from the beer industry,” he says. “You can discharge the whole thing, you don’t have any sludge. It’s a highly aerobic process for special waste.”

On the hunt for useful microbes, Finn sampled soil all over campus. “We found some strange behavior in two Staphylococcus that would give rise to a highly liquid product—what chemists call shear-sensitive cells,” he says. “We were looking for useful microbes to push the last recoverable oil from wells. Finn figured his biopolymer could be used the same way. This was a cell line which became very, very popular and was used extensively by a lot of people called the High-Five cell line,” he says. “One of the things that’s good about Cornell is you have such a diversity of people working on a wide variety of different topics, it’s possible for someone in engineering to interact with people that have real expertise with other systems. The graduate field system kind of promotes that.”

Over time, Shuler’s interest turned toward biomedical engineering, such as treating brain tumors, investigating cancer metastasis through blood cells, and using the techniques of nanofabrication to build scaffolds for tissue engineering. “We’ve invented a body on a chip which is to try to predict the response of the body to new drugs or combinations of drugs or potentially to chemicals which might be toxic,” he says. “But the distinctions between biochemical, bioprocess, and biomedical engineering have blurred, says Shuler, in part because many of the same techniques are used. If I’m interested in tissue engineering, I can use it in the context of making a chemical, whereas in the past that was going to be added to the chemical, or to potentially make replacement parts for the body. So it’s a spectrum,” he says. “The term biomolecular engineering really

As scientists fill in the picture of how molecules interact to perform the functions of life, engineers are manipulating them more rationally and effectively. For Associate Professor Matt DeLisa, cells are filled with useful molecular machines all with millions of moving parts known as proteins. By swapping in parts from other organisms, he is working to engineer supercharged cells that can produce treatments for Alzheimer’s, cancer, and autoimmune diseases. “One of the most important types of therapeutic proteins that we have an eye toward making are glycoproteins,” he says. “A glycoprotein, just like a regular protein, is made of amino acids but it’s further modified with complex sugar structures. These sugars are attached to many proteins and this attachment turns out to be very important in terms of drug development.”

By inserting human genes into E. coli, DeLisa can give this simple organism the machinery to attach different sugars to proteins, giving them specific biological actions. He has co-founded Glycobia, Inc. to commercialize the process. “We bring in the entire protein machinery for sugar biosynthesis and attachment and give E. coli the ability to perform glycosylation, something it does not normally do,” he says. “It’s a very bottom-up engineering approach that is made possible by a deep understanding of the underlying biological mechanism.”

Such a mechanistic understanding of biomolecules raises the prospect of computational models that can not only show how to make a protein that might not exist in nature, but also predict its effect. Assistant Professor Jeffrey Lanczyk is already developing such tools to rationally reprogram cell machinery. “Our ability to make accurate predictions is still in its infancy,” says Shuler. “In 40 years we’ll be able to make much more accurate predictions.”

It may one day even be possible to tailor make entire microorganisms from scratch. “That’s not an impossible and in fact in some sense is probably closer than many people realize,” says Shuler. “The idea in both of these cases is to have a human-designed organism fulfill a predetermined task as efficiently and effectively as possible.”

Creating such artificial life forms presents a host of technical challenges, not to mention philosophical questions, so most chemical engineers will continue to work with modified cells for the foreseeable future. What biomolecules they will create is anyone’s guess. “There are still all sorts of things to be learned. It’s hard to imagine what the next use of living organisms will be,” says Finn. “So you know, we’ve just started getting there.”
We all know dust can be a pain; it makes you sneeze, collects under your bed, and then there’s the way it can mess with geological climate change patterns and models. Didn’t know about that last one? You’re not alone. “Even people in the scientific community overlook it,” says Natalie Mahowald, an associate professor in Cornell Engineering’s Earth and Atmospheric Sciences department. She studies how dust—both man-made and natural—affects the planet’s ecosystems and climate, revealing multilayered feedback systems that, despite their broad-ranging effects, have largely been ignored.

Carbon dioxide is the primary culprit when it comes to climate change, but, thanks to Mahowald and her collaborator’s, dust and aerosols are beginning to get attention. In fact, Mahowald will serve as a lead author on the next edition of the International Panel on Climate Change (IPCC) report. She will work with 250 other experts in Working Group I, which assesses the physical, scientific aspects of the climate system and climate change. Mahowald will write the introduction and contribute to chapters on paleoclimate and the impacts of clouds and aerosols—a topic that didn’t get much play in the last report.

“That was one of the big uncertainties that came from the 4th assessment report,” says Pauline Midgley, head of the technical support unit for IPCC Working Group I. For this iteration, Midgley noted, there was a “large enough nucleus of work” for an entire chapter to be dedicated to clouds and aerosols.

Dust’s role in climate change is “really complicated,” Mahowald says. In fact, one of its most significant effects on the climate is actually a cooling one. Dust affects the “radiative budget,” or the ratio of incoming solar radiation to the radiation that is reflected from the earth. CO2, for example, traps only outgoing radiation—thus the term “greenhouse effect.” Dust, however, can alter the heat that both enters and leaves the planet’s atmosphere. “Dust acts like a greenhouse gas,” says Mahowald, “but it reflects solar energy too. We think that in the net, it actually cools.”
A dramatic example of this effect is illustrated in global climate data from the 1950s to the 1980s, a period in which North Africa experienced massive droughts, turning once-lush regions into parched desert. With deserts came the dust, so much that by 1980, there was four times as much dust pouring into the atmosphere as there was in the ’50s. The climate turned cooler by 0.1 degrees Celsius—a seemingly small change, but a significant one. More important, Mahowald says, is that many scientists don’t understand that the change was due to dust. “It’s important to understand what’s going on,” she says. “Even people in the scientific community are ignoring mineral dust, especially when looking at what’s happened in the past.”

While a cooling effect sounds like a good thing when it comes to droughts, Mahowald and her colleagues argue that the ’80s drought was partly due to the dust. As the tiny particles reflect back heat and cool the air, the air sinks, preventing precipitation (warm, rising air is the kind that breeds rain clouds) and exacerbating the drought. It’s subtle phenomena like this that drive Mahowald to increase awareness and understanding of desert dust’s effects on climate change.

In an effort to do this, Mahowald and her collaborators have compiled a series of data sets that aggregate dust-relevant information—including data from satellites, wind observations, deposition data, as well as paleoarcheologies such as ice cores and marine, terrestrial, and lake sediments. This information is combined to create climate models that simulate atmospheric dust’s effect on the climate for every year between 1870 and 2000. These datasets, and similar datasets for paleoclimate time periods (e.g., last glacial maximum), are “available to anyone who wants to use them,” Mahowald says. As a result, the model data have been the gold standard of dust data for climate researchers worldwide. “That’s our claim to fame,” says Mahowald. A key finding from this wealth of data is a stunning one: the amount of atmospheric dust has doubled over the 20th century.

Mahowald clearly enjoys being a teacher as well. She raves about a climate change class that she co-taught at Cornell with a philosophy professor, and is looking forward to teaching classes on climate change and how it impacts humans. “Teaching is really hard, a whole lot of work,” she says, “but students make you think so much more creatively.”

“Whenver I’m meeting with Natalie to discuss research, she will often come up with entirely new ideas and directions for science,” says Daniel Ward, a postdoc in Mahowald’s lab. “This makes her a scientist that many people want to collaborate with...she shifts people’s viewpoints.”

**Effects on Ecosystems**

Part of Mahowald’s view-shifting work has looked at how dust’s effects can go beyond the atmosphere and affect other ecosystems, such as the oceans. Mahowald first began to unravel this connection more than a decade ago while working as an assistant professor at the University of California Santa Barbara’s Bren School of Environmental Science and Management. There, she collaborated with oceanographers such as Dave Siegel, now director of the Earth Research Institute at U.C.S.B. He recalls Mahowald’s novel perspective toward the relationship between dust and the living planet. “So much of our planning on how aerosols work has been on their roles in [the atmosphere],” says Siegel. And what Natalie did was to say, wait a minute, there are ecosystem-based systems...that are playing a role.”

Siegel says that her ability to think outside the box has earned Mahowald significant recognition within the scientific community. “She is one of the most productive young scientists in this area,” says Siegel. “The work that she does is the best in the field.”

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As Mahowald and her collaborators found, when desert dust lands in the ocean, it deposits key nutrients and minerals, such as iron. The iron is consumed by phytoplankton, the base of the ocean food chain. A higher abundance of iron yields greater blooms of phytoplankton, which then pull more CO2 out of the air as they photosynthesize, a phenomenon known as a biological pump. This effect, which reduces CO2, adds yet another complicated layer to dust’s impact on the climate. Adding to the complexity is the fact that man-made aerosols given off by pollution can chemically react with desert dust, making the iron more soluble, thus increasing the amount that enters the ocean. “We showed that humans have probably doubled the amount of soluble iron going into the oceans,” says Mahowald. Overall, she says that the iron deposition from desert dust since 1870 has resulted in the uptake of roughly 4 parts per million (ppm) of CO2. Mahowald has also studied how aerosols affect terrestrial ecosystems. Desert dust can carry phosphorus, a limiting nutrient for many tropical forests. “These forests use all the phosphorus they can,” says Mahowald. Thus, she says any that comes via mineral dust is eagerly absorbed. As it turns out, “North Africa is probably fertilizing the Amazon, and Asian dust is fertilizing Hawaii.”

Even anthropogenic aerosols, typically viewed as having a negative impact on the environment, have a more nuanced role. These man-made pollutants can often carry nitrogen—another necessary nutrient for plant growth, a fact that has led to more interdisciplinary collaboration between Mahowald and other scientists. At Cornell, Mahowald has collaborated with Christine Goodale, a forest ecosystem ecologist in the Department of Ecology and Evolutionary Biology. “She’s greatly expanded the opportunities for me and my lab group,” Goodale says of Mahowald. While Goodale’s group typically looks at how nitrogen affects one particular section of land, Mahowald and her group have helped put that phenomenon into a larger, more comprehensive context. “She’s provided a door opening for people who work on plot scale to look at things on the global scale,” Goodale adds. “She’s amazingly collaborative and productive—I was at a conference last week and three colleagues and I were just saying how we wish we could be more like her,” she adds with a laugh.

As with ocean ecosystems, the overall effect of aerosols on forest ecosystems seems to also create a cooling effect on the climate, thanks to nutrient-rich aerosols that enhance plant growth and CO2 uptake.

Mahowald has summed up the myriad climate effects of aerosols, both natural and man-made, in a paper published this last November in Science, with a cautioning message: reducing aerosols, which has long been an environmental goal due to public health reasons, could exacerbate warming global temperatures. Mahowald estimates that this cooling effect is enabling the land and the ocean to take up an extra one to 50 ppm of CO2. As humans reduce aerosols for health reasons, they will also reduce the cooling and carbon uptake these aerosols indirectly provide.

“I’m thinking about the uncertainties,” says Mahowald. “Right now 50 percent of CO2 that humans are emitting is being taken up by land and ocean, which is unlikely to continue. That’s a huge negative feedback on the climate system and we poorly understand it. If we cut aerosols, that’s going to impact the carbon cycle—it will make things tougher.”

For more information, visit mae.cornell.edu.

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Intel in Everything

Cornell and chipmaker launch national embedded systems competition

BY Sherrie Negrea

YOU ARE ABOUT TO LEAVE YOUR OFFICE FOR HOME. With a couple last keystrokes on your computer, you turn up the thermostat inside your house and turn on the oven. Driving home, you pass through an “intelligent” intersection where the traffic light automatically changes as it senses your car approaching. It begins to rain, and without your noticing it, your car reacts by adjusting the power to your wheels.

Embedded systems make it all happen. Devices containing microprocessors that monitor information and react to it are already prevalent in our lives: it’s what makes your smart phone “smart,” and it’s what allows more and more consumer electronics to communicate with other devices. The rapid growth of such devices is creating an “Internet of Things” expected to include more than 15 billion devices within the next four years.

The top three entries will be awarded prizes of $10,000, $5,000, and $2,500. The competition grew out of the success of an Intel Cup embedded technology competition in China—which now includes over 26,000 students—and one started more recently in India. The company that introduced the world’s first microprocessor asked Cornell systems engineering lecturer David Schneider M.S. ’06 ME, Ph.D. ’07, how he would create a U.S. competition. Schneider was given just a month to craft his proposal. Intel approved it last spring and work began on a competition that would give a new generation of innovators the chance to showcase their own “world’s first.”

“We know and we’ve seen through the participants that these hands-on projects give students a very rich learning environment,” says Kimberly Hills, Intel university relations manager. “They get to do everything they’ve been working on in their classes. They get to test it and put it together and see if it works.”

Schneider says one of the aspects that makes this competition unique is its attention to what he calls professional design: defining the challenge you’re trying to solve, how your solution meets that challenge’s needs, and how to measure how well your solution has met its goals. Add in a bit of risk management and planning, some objective decision justification, and attention to communicating your ideas effectively, and you have many of the skills that are targeted by this competition, but that industry says are often lacking in college graduates from even the nation’s top colleges.

“So we wanted to try to provide this very exciting and very empowering experience that would bring these skills to the forefront,” Schneider says. “And at the same time, allow the students to express their creativity.”

“The competition is open to any invention using an embedded system. Teams can consist of three to five undergraduate or master’s degree students. By October, teams from schools will challenge college students across the country to invent the next generation of embedded systems.

May 4–5, the Cornell Cup USA Presented by Intel finals are slated to kick off at Walt Disney World’s Contemporary Resort in Lake Buena Vista, Fla., with 24 teams from 19 American colleges and universities competing. Equipped with donated Intel Atom boards, Tektronix test equipment, MathWorks software, and $2,500 in development and travel funds, the teams will present a wide array of inventions: solar-powered unmanned aircraft, belts that allow the visually impaired to detect obstacles, home energy control systems, and robots that pick up stray tennis balls.

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Industry expects 24 billion connected smart devices by 2020. Intel partners with Cornell and see if it works. A rich learning environment. They on projects give students a very "We know and we've seen through competition—that's great and like Cornell University Sustainable Design (CUrED) David Schneider shows that this new competition will bring in sponsors of all sorts," says Abby Westervelt, Cornell Engineering's director of Corporate and Foundation Relations. Having Cornell create and develop the competition presented a quandary to Schneider if Cornell sponsored a team and won the competition, he says design was not a focus of the curriculum, since most of the courses are based on textbooks, problem sets, and exams. Yet while working on the modular platform, Schneider had submitted a diverse range of ideas. The finalists' concepts can have developed with the additional functionality on top of that, most teams wouldn't be able to fully accomplish that over the course of just one year, which is the time frame for the competition. Schneider says this flexibility is empowering. "It will aid students in learning the basics while providing a robust framework to build their own unique aspects," he said, estimating that at least half of the competing teams' entries would have benefited from this modular platform, and he hopes that future entries will be even more amazing as a result of it. "The fact that we're delivering a complete starter system for other teams is really important," says Jim Kehoe '12 ME, a mechanical engineering team leader for the robot. "To create just the core system in a robotic platform takes a lot of time and effort. And to be able to have the time to create additional functionality on top of that, most teams wouldn't be able to fully accomplish that over the course of just one year, which is the time frame for the competition." Besides the modular platform, the Cornell team has another project to exhibit at the competition at Disney World—a human-size robot rock band. With a guitar, drum, and bass, the human-size robots, running on an Intel Atom board, will perform RockBand and Guitar Hero video game songs on an Xbox as background music to welcome each speaker on stage. "Just like Saturday Night Live has a band, this is our band for the competition," Schneider says. "Beyond learning how to create an embedded technology project, the students say preparing for the competition has given them valuable skills that will help them in the job market. "Working with a team that has 11 people in our subgroup and 30 people overall, you really have to learn just how to do project management and work in groups and teams and learn how to motivate people," says Chad Mess M.Eng. '12 EE, an electrical engineering team leader. "I think it's pushed all of us in a lot of different ways, not necessarily just engineering." As an undergraduate engineering student at Cornell, Kehoe says design was not a focus of the curriculum, since most of the courses are based on textbooks, problem sets, and exams. Yet while working on the modular platform, Kehoe also helped with a range of tasks, including monitoring the budget, working with vendors, and controlling costs, all while justifying the team's decisions to better help them obtain their technical goals. "It's a really powerful experience in terms of just managing the product," Kehoe says. "We're giving the plans up to other teams and this needs to be as cost effective as possible. So it's given the students on this team a great perspective on how to keep costs in mind and overall just how to execute a successful engineering project. It's really an experience on a scale that you just don't get in the undergraduate curriculum."
Three alumni entrepreneurs talk about going into business and the technical skills that helped them get there.

Steve Haas had an ear for music and a nose for business. He knew what he wanted to do during his years at Cornell University. Gavin McKay applied his expertise in a more traditional milieu before he had a professional epiphany and pursued a less conventional, more personal path. Cheryl Yeoh and pursued a less conventional, more personal path. She was interested in a more traditional milieu before he had a professional epiphany and pursued a less conventional, more personal path.

Steve Haas '89 ME
Founder and President, SH Acoustics

Sh Haas has dedicated his life to making concert halls, museum spaces, home theaters, and private residences sound better. He has designed hundreds of acoustic spaces.

Haas has a major role in the acoustic and audio design for a wide variety of prestigious facilities, including the U.S. Holocaust Museum and the Newseum, both in Washington, D.C., and Carnegie Hall's Zankel Hall in New York City.

It can be unsung work, and Haas is fine with that. “I often tell people that when I do my job well, nobody notices.” It helped really introduce me to the industry and I never looked back from there, “he said. “I did not want to transfer out of Cornell to look for another opportunity to study sound at the time, so with the help of Professor Al George, he made his own. He basically created his own curriculum. His senior thesis was designing a recording studio for Cornell’s Music Department.

By Dan Tuohy

SH Acoustics has a proprietary “Concertino” system, which changes the acoustics of a place electronically. It is not a sound system, but more of an enhancement system, Haas explains.

“If you bring a musician, a cellist, or a pianist into a small space and you play naturally, it’s not going to sound like much. It’s going to sound like a small room. But by integrating our technology and our system in this space we can actually turn it into a virtual Carnegie Hall.”

The Newseum remains one of his signature projects. It was handed to him only two months after he launched his firm in 2003—after 14 years of working for a major consultancy. Completed in 2008, the Newseum may be the biggest project he may ever work on, and most complicated, given the size and number of technological exhibits.

“It was a challenging project but everything turned out incredibly well.” Haas, a pianist, saxophonist, and electronic musician, does not often play professional gigs; but he does play in connection with his work. It’s very handy, he notes, to be able to sit down at a grand piano in a private studio to demonstrate the acoustics of an environment.

Haas has challenged himself since his days at Cornell Engineering. There was not a lot opportunity to study sound at the time, so with the help of Professor Al George, he made his own. He basically created his own curriculum. His senior thesis was designing a recording studio for Cornell’s Music Department.

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Steve Haas worked with architects and engineers, and other project members, to make sure that whatever solution is implemented works from a functional and technical standpoint, as well as from an aesthetic standpoint. Haas and his team also work in audio system design to make sure the way that sound is delivered is appropriate. They are often involved with a project early on, and can be among the last on site to tweak and calibrate systems.

Annenberg Theater – Newseum, Washington D.C.

Annenberg Theater – Newseum, Washington D.C.

Gavin McKay ’99 OR
Owner/Manager Fusion Cross-Training

“Basically what we look at is the quality of sound in a space, but also controlling the sound so that it’s not noisy or that sound doesn’t get from one space to another and interfere with any kind of functionality.”

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It courses through his fitness company, Fusion Cross-Training: Heart, Muscle, Mind. “It’s the core of everything we do.”

One friend went to Sonoma to become a winemaker. Another went to a startup. Another became a Bain investment strategist. And Gavin McKay proceeded to work in consulting and marketing.

So there he was, in New York, a young man in love with the idea of getting ahead, when he realized his job was not stirring his creative energies. He applied to business school, having felt the pull of climbing the corporate ladder and on a trip to California he got a taste of working for a start-up.

B-school would have to wait. His creative energies were firing, and he set out traveling the world. The farther abroad he went, the closer he came to purpose and meaningful living. “Getting so lost that you are kind of coming back to your core,” McKay describes it.

He made his way back home with a singular focus, an understanding that...
“The story there is to really put yourself out there, never give up, and don’t let anybody discourage you from realizing your passions.”

Cheryl Yeoh '05 OR, M.Eng. ’07 CE and Co-Founder, CityPockets

The Geometry of Sailing

Geometry puzzle

You are given \( u > 0, \theta < \pi/2 \) and \( \theta = \pi/2 \). Find the biggest \( v = |v| \) for a given \( \theta \), where \( \theta \) is the angle between \( \beta \), and \( \theta > 0 \).

1. What is the range of values of \( \theta \) for which you can find some \( K \) and \( \delta \) so you can find \( v > 0 \)?

2. What is the biggest possible value of \( \theta \) and in what direction does \( \theta \) change?

3. If you draw all possible \( v \) vectors with the tail of the vectors at the origin, what is the shape of the boundary of the region that encloses all possible tips of the arrows?

Hints

a) Try a special case first, like \( \theta = \pi/2 \), \( a = \pi/3 \), and the answer to Question 2 depends on whether \( \theta > \pi/2 \) or \( \theta < \pi/2 \).

b) It may help to use the angles \( \alpha > \pi/2 \), \( \beta = \pi/2 \), \( \beta > \pi/2 \), and \( \alpha > \pi/2 \). The best boats have \( \alpha \) and \( \beta \) as close to \( \pi/2 \) as possible.

c) The set of answers is called X’s theorem, where X is a mildly famous person.

Please give concise answers in terms of \( u, \alpha, \beta, \) and \( \theta \).

Sailing interpretation

The wind speed is \( u \), going South. The boat velocity is \( v \) making angle \( \theta \) from North. The force of the wind on the sail is \( K \) and has to make less than an angle of \( a \) with the motion of the water relative to the boat (tan \( \alpha \) = the best lift-to-drag ratio of the sail). The force of the air on the sail is \( S \) and has to make less than an angle of \( \beta \) with the velocity of the wind relative to the boat (tan \( \beta \) = the best lift-to-drag ratio of the sail). The net force on the boat must be zero. The shapes of the keel and sail determine \( \alpha \) and \( \beta \) and the sizes of \( K \) and \( S \) can be adjusted by changing the size of the boat and sail. Assuming given shapes for the keel and sail:

1. What directions can a sailboat sail?

2. What is the fastest a sailboat can go in what direction is that?

3. What is the set of all possible speeds and directions for a sailboat?

Solve this to win CORNELL ENGINEERING GEAR

We will draw three winners from correct entries submitted by July 1. They will receive a Gariah gift pen, a stainless steel water bottle, or a Cornell Engineering car decal. Congratulations to Jerod Green ‘10 EE, Jeffrey Hart ‘05 EE, and Yakov Shkolnikov ‘99 EP for correctly solving the Fall Brainteaser! You can see the solution, and submit your answer at www.engineering.cornell.edu/brain teaser.

The exhilaration that comes with sense of place and purpose is one thing. Getting to launch is another. McKay still marvels at the challenge he took head-on.

McKay is an entrepreneur, but an engineer at heart. That is the story there.”
The program, administered by the Air Force Office of Scientific Research, is open to U.S. scientists and engineers who have received a Ph.D. or equivalent in the last five years and who have shown “exceptional ability and promise for conducting fundamental research.” The objective of the program is to foster creative basic research in science and engineering, enhance early career development of outstanding young investigators, and increase opportunities for the young investigator to recognize the Air Force mission and related challenges in science and engineering. Fuhs, assistant professor of applied and engineering physics, has been awarded $357,000 over three years to support his research into optical methods of probing magnetization with nanoscale spatial resolution and picosecond time resolution. He plans to use these techniques to study the dynamics of magnetic oscillators and memory.

Tang, assistant professor of electrical and computer engineering, has been awarded $357,000 over three years to conduct a research project to help monitor such large-scale networks as the Internet and power grids to avoid possible system failure and to optimize performance. The scale and complexity of such systems raise the need to quickly infer system characteristics from limited and distributed monitoring. Tang’s project aims at providing fundamental understanding and constructing algorithms for such measurements.

This year the Air Force received 260 proposals on such areas as aerospace, chemical and materials sciences; physics and electronics; and mathematical, computational, and life sciences.

**NASA Chief**

Mason Peck, associate professor of mechanical and aerospace engineering, has been named NASA chief, effective January 2012. Peck will serve as the agency’s principal advisor and advocate on matters of technology and policy programs.

Peck leads several Cornell spacecraft research programs including CIUSAT, an orbit inspection system consisting of a pair of twin satellites designed and built at Cornell CIUSAT is scheduled to launch in 2013 on a Falcon 9 rocket through the U.S. Air Force Research Laboratory’s University Nanosatellite Program. Peck also is principal investigator of the Voilet satellite experiment, also a Cornell built system that will provide an orbiting test bed for investigating better commercial Earth imaging satellites. Voilet carries an ultraviolet spectrometer that will be used as a precursor to understanding exoplanet atmospheres.

In his NASA role, Peck will help communicate how NASA technologies benefit space missions and the day-to-day lives of Americans. The office coordinates, tracks, and integrates technology investments across the agency and works to infuse innovative discoveries into future missions.

In addition, Peck will lead NASA technology transfer and technology commercialization efforts, facilitate internal innovation and creativity, and work directly with other government agencies, the commercial aerospace community, and academia. Peck also will serve on the executive board of the intergovernmental personnel agreement with Cornell and will continue as a faculty member.

At Cornell, Peck’s work focuses on spacecraft dynamics, control and mission architectures. His research includes innovative flight dynamics, gyroscopic, robotic technologies, and computationally controlled spacecraft, most of which have been demonstrated on NASA microgravity flights. Peck has worked with NASA as an engineer on a variety of technology programs, including the Tracking and Data Relay Satellite System and Cassini Equatorial Operational Experimental Satellites. The NASA Institute for Advanced Concepts, sponsored his academic research in modular spacecraft architectures and propelled-particle propulsion, and the International Space Station currently hosts his research group’s flight experiment in microgravity-class spacecraft. As an engineer and consultant in the aerospace industry, he has worked with organizations including Boeing, Honeywell, Northrop Grumman, Goodrich, and Lockheed Martin. He has authored 85 academic articles and holds 17 patents in the United States and European Union. Peck earned a doctorate in aerospace engineering from the University of California Los Angeles as a Howard Hughes Fellow and a master’s degree in English literature from the University of Chicago.

—Anne Ju

**SWE Success**

Mason Peck, chief of Cornell’s Society of Women Engineers (SWE), has been recognized as a top collegiate section by the national organization whose mission is to empower women to succeed and advance in engineering fields.

At the SWE annual conference, held Oct. 15–19 in Chicago, Cornell SWE took home a Gold Award for Outstanding Collegiate Section. The award is the highest honor to be bestowed on a collegiate section.

Collegiate awards are determined by such activities as openness of communications among chapter members, the chapter’s relationship with member recruitment activities, and regional and national participation. In addition, two Cornell SWE alumnae were recognized with top awards for professional achievement.

Alison Goodman ’99 received the Distinguished Alumni Award for creative and effective team leadership in her career and in her contributions to SWE and the community. She received her bachelor’s degree in electrical and computer engineering from Cornell, and is now senior engineer and validation program manager in the Non-Volatile Memory Solutions Group at Intel. Goodman serves on the Cornell SWE advisory board and is also former president of Cornell SWE.

Stephanie Jackson ’99 received the Emerging Leader Award for “strong personal leadership that balances governmental stewardship, professional accomplishments and dedication to community.” Jackson received her bachelor’s degree in civil and environmental engineering from Cornell and is an environmental engineer in the environmental health and safety department at Intel Corp.

—Anne Ju
**Frontiersmen**
Cornell faculty members Rajesh Bhaskaran and Jonathan Butcher were among 65 researchers selected to take part in the National Academy of Engineering’s third Frontiers of Engineering Education (FOEE) symposium, Nov 15–16.

The conference, held in Irvine, Calif, invites early-career faculty members who are “developing and implementing innovative educational approaches” in their engineering disciplines to share ideas, learn from research and best practice in education, and leave with a charter to bring about improvement in their home institutions.

Bhaskaran, senior lecturer in mechanical and aerospace engineering, is interested in integrating modern computer-based simulation technology into the mechanical and aerospace engineering curriculum. His efforts are directed not only at providing students with a solid foundation in the use of simulation technology but also at enhancing the learning experience through this technology.

Butcher, assistant professor of biomedical engineering, conducts a research program on understanding the roles of mechanical forces in shaping cardiovascular morphogenesis and adult disease with an emphasis on heart valves. His long-term objectives include discovery of novel disease paradigms and using them to develop therapeutic strategies.

The attendees were nominated by fellow engineers or deans and chosen from a highly competitive pool of applicants.

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**PRESIDENT’S MEN**
Cornell engineer, Salman Avestimehr, and John C. March are recipients of this year’s Presidential Early Career Awards for Scientists and Engineers (PECASE)—the highest honor bestowed by the U.S. government on early-career science and engineering professionals.

Avestimehr, assistant professor of mechanical and aerospace engineering, was awarded through the Department of Energy for his work in directed assembly of hybrid nanomaterials. His research deals with self-assembling nanomaterials with optical and energy conversion properties, and he has recently demonstrated how electromagnetic fields in nanophotonic devices are strong enough to physically manipulate biological and nanobiological materials that are just a few nanometers in size. He proposes studies that aim to elucidate the underlying physics behind this new assembly process. Specifically, he uses optically resonant “nanowireless” and kinetic motors to determine conditions under which static nanoparticle manipulation can take place. Efforts will extend to such complex materials systems as gold nanoparticles, quantum dots, and carbon nanotubes.

March, assistant professor of biological and environmental engineering, was awarded through the Department of Health and Human Services to support his research into human intestinal bacteria. He proposes examining the use of these bacteria called commensal bacteria for the controlled expression of an insulin-stimulating peptide in the intestinal epithelial cell space, which could mediate a glucose regulatory mechanism through reprogramming of intestinal stem cells. March hopes these results will translate to safely dosed treatments for type 1 diabetes that cost just pennies a day to potentially modulate the long-term effects of the disease.

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**FRONTIERSMEN**
Rajesh Bhaskaran
Jonathan Butcher
Salman Avestimehr
John C. March

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**Dynamic Modeler**
From football to ambulance deployment, Matt Maxwell Ph.D. ’11 OR predicts the future.

When you call for an ambulance, you want it ASAP. But how can an ambulance company ensure the fastest possible response time when previous calls have sent ambulances all over town?

This is the question Matt Maxwell Ph.D. ’11 OR answered in his thesis. “As the day progresses, and ambulances are called out, that creates holes in coverage,” he explains, “so you want to move them around dynamically so they can serve calls rapidly.” Maxwell used approximate dynamic programming to improve a simulation-based algorithm developed by a previous student. “I was able to boil it down to a very simple algorithm so you don’t need a lot of additional complexity to run it,” says Maxwell. “I was able to speed up running the simulations by up to 100 times.

With that speed, Maxwell could run many weeks’ worth of simulations, giving him the data he needed to fine-tune the algorithm, cutting response times by a small, but significant amount. “These performance increases are a big deal for ambulance companies,” says Maxwell. “If they can take one ambulance and crew off the road they can save about a million dollars a year.”

Maxwell has co-authored several papers on the work with his advisers Professor Shane Henderson and Associate Professor Huseyin Topaloglu. One was a finalist for best paper at the 2009 Winter Simulation Conference. And he says he has two more in the works.

No ambulance company has yet to implement Maxwell’s work, but there has been some interest, and fire and police redeployment present similar problems.

Maxwell’s skill with algorithms caught the attention of Andrew Daines ’10, an undergrad philosophy major and Cornell Daily Sun columnist Maxwell knew from Cornell. Daines and Maxwell, ’10, a communications major and Sun editor, were working on a social app, but they needed help.

Daines came up with the ideal at a New York Yankees game in June of 2009. By the eighth inning, the score was heavily lopsided in the Washington National’s favor and he wondered how to keep fans interested in the game: When he looked around, he saw that many were on their smart phones checking stats and scores. If fans could use them to compete with their friends, predict the outcome of the next play, he thought, they would remain engaged no matter how bad the blowout.

Daines sought out Maxwell and PrePay Sports was born. “He needed someone to come up with a probability-based scoring algorithm,” says Maxwell. “That’s how I got involved. And because of my computer science background, I said I could do it.”

The company also has expansion plans. “Our company has attracted interest from sports and entertainment companies and we are currently building technology for them,” says Maxwell.

But for now, PrePay Sports remains a sideline for Maxwell, whose day job at the SAS Institute, the North Carolina based business analytics services and software company, working on a revenue management product for hotels.

Maxwell still finds time to play the app, though he says he’s not the best at predicting plays. “I think the most fun part of it is actually playing it in my hand and watching the game and saying ‘hey, that number is there because of something I did’, and that’s a pretty neat experience,” he says.

—Robert Emro
Space Weather

A NASA-funded collaborative research team led by Steven Powell, Cornell senior engineer in electrical and computer engineering, launched a sounding rocket Feb. 18 from Alaska’s Poker Flat Research Range to collect data straight from the heart of the aurora borealis.

The project — the Magnetosphere-Ionosphere Coupling in the Alfven resonator (MICA) mission — involves 60 scientists, engineers, technicians and graduate students from several institutions. From Cornell they include Powell, principal investigator for the mission; David Hysell, co-investigator and professor of earth and atmospheric sciences; Robert Miceli and Brady o’Hanlon, graduate students in the fields of electrical and computer engineering; and Mark psaki, professor of mechanical and aerospace engineering. One of the scientists is Manhattanville College physics professor Christopher Haggard.

The project, in its third and final year, was initiated by the late Paul Kintner, Cornell professor of electrical and computer engineering, who served as the mission’s principal investigator during its proposal and early development phases.
Industry expects 24 billion connected smart devices by 2020. Intel partners with Cornell Systems Engineering to inspire students to harness the power of this “Internet of Things.”