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Nanosatellite CUSat launches from California

After eight years of planning, submitting, winning, building and waiting, Cornell University’s CUSat—a nanosatellite designed and built by engineering students to help calibrate global positioning systems (GPS) with pinpoint accuracy—launched Sept. 29 from Vandenberg Air Force Base, Lompoc, Calif.

The satellite—which weighs about 90 pounds—was launched on a SpaceX Falcon 9 rocket. Once in space, the satellite moved into low orbit to help calibrate GPS accuracy to within 3 millimeters.

With that precision, future space missions can perform improved close-proximity spacecraft-to-spacecraft maneuvers.

The satellite uses algorithms developed by Mark Ptak, professor of mechanical and aerospace engineering, and Shahnawaz Kohdadi, Ph.D. ’16 EE, “It’s a very exciting and busy time for the team. We’ve been performing weekly mission rehearsals for the past year and a half,” Paul Jackson Jr., the Cornell team’s student project manager, said before the launch.

In 2007 the U.S. Air Force and the American Institute of Aeronautics and Astronautics chose CUSat—from among 11 entries—as the winner of its Nanosat 4 competition. Since 2007, more than 200 engineering students have worked on the project.

The SpaceX Falcon 9 rocket’s primary payload was the Canadian Space Agency’s Cassiope digital broadcast satellite.

To communicate with the satellite in orbit, the team configured ground stations in Aphaca, the Marshall Islands, Colorado Springs, Colo., and Redondo Beach, Calif.

When the CUSat team won the Nanosat 4 competition in 2009 the project was slated for launch in June 2008 from the SpaceX launch complex in the Marshall Islands. But then the launch was postponed to late 2011, early 2012, and postponed again.

— Blaine Friedlander

CUSat nanosatellite launched Sept. 29 from Vandenberg Air Force Base, Lompoc, Calif.

Electric vest to knead away stress

Three Cornell students have developed a garment—embedded with piezoelectric cells and tiny motors—that gently massages the back and shoulders, mimicking a human touch.

“It’s like someone stroking you really lightly, like a mother might when you woke up from a nightmare,” said Marina Gaeta ’14, a biology and society student. Gaeta developed the functional apparel with fiber science and apparel design student Eric Beaudette ’16 and Hadi Hosseinzadegan, Ph.D. ’13, a graduate student in the field of electrical and computer engineering. The team, working with Amit Tal, professor of electrical and computer engineering, and Haiju Park, assistant professor of fiber science and apparel design, filed for a patent for the technology.

The body produces cortisol under stress. Prolonged release of cortisol is linked to serious health problems, including obesity, depression, heart disease, hypertension, and a compromised immune system.

“We find that in our modern way of life a lot of people have unnaturally and chronically elevated levels of cortisol,” Gaeta said, citing one estimated cost of job stress in the United States at $300 billion annually.

The initial impulse for developing the vest came from Mary Maida, a molecular neuroscientist at the company, the Medingen Group in Rochester, NY, seeks to foster medical innovations. Maida approached Gaeta and Hosseinzadegan to make a stress-reducing prototype: a store-bought vest to which they adhered actuators and tiny motors. Welding form and function into an attractive piece of clothing, however, required the expertise of Park and Beaudette.

“Functional apparel design incorporates the latest technologies into layers of fabric to provide more convenient function and a comfortable interface,” Park said.

Beaudette and Park created another prototype using a combination of elastic and rigid fabrics to better accommodate body movement and a wide range of sizes. A built-in neoprene panel muffles motor noise and acts as a buffer against chafing from technical parts.

“This unique design approach ensured a better fit to different body types,” Park said.

Last spring, the team’s invention earned one of two $2,000 Innovation Awards from Cornell’s School of Electrical and Computer Engineering. With the prize money, Hosseinzadegan is working on a flexible circuit that will join more smoothly with the fabric of the vest, into which Beaudette is incorporating lyca spandex for a better fit.

Gaeta, meanwhile, will test the vest’s physiological effects through human trials this fall.

“We’re marketing the vest as a piece of clothing that doesn’t look like a medical device and can just be worn anywhere,” Beaudette said. “And with our small company we’re looking at asking these piezoelectric cells to other products, as well.”

— Blaine Friedlander

At just a molecule thick, it’s a new record. The world’s thinnest sheet of glass, a serendipitous discovery by scientists at Cornell and Germany’s University of Ulm, is recorded for posterity in the Guinness Book of World Records.

The “pane” of glass, so impossibly thin that its individual silicon and oxygen atoms are clearly visible via electron microscopy, was identified in the lab of David A. Muller, professor of applied and engineering physics and co-director of the Kavli Institute at Cornell for Nanoscale Science.

The work that describes direct imaging of this thin glass was published in Nano Letters.

“Making it literally two-dimensional,” Muller said, “is one of the longstanding theoretical questions in physics—looking at the fundamental structure of glass. Scientists, with no way to react with the quartz, also found it strikingly solid but was thought to look impossibly thin that its individual molecule of glass, a serendipitous sheet of carbon atoms in a chicken wire crystal formation, on copper foil in a quartz furnace. They noticed some ‘muck’ on the graphene, and upon further inspection, found it to be composed of the elements of everyday glass—silicon and oxygen.

They concluded that an air leak had caused the copper to react with the quartz, also made of silicon and oxygen. This produced the glass layer on the would-be pure graphene.

Besides its sheer novelty, Muller continued, the work answers an 80-year-old question about the fundamental structure of glass. Scientists, with no way to directly see it, had struggled to understand it: It behaves like a solid but was thought to look like a gas. Muller said, “It’s the first time that anyone has been able to see the arrangement of atoms in a glass.”

What’s more, two-dimensional glass could someday find use in transistors, by providing a defect-free, ultra-thin material that could improve, for example, the performance of processors in computers and smartphones.

The paper, “Direct Imaging of a Two-Dimensional Silica Glass on Graphene,” was published in Nano Letters on Jan. 23, 2012, with first authors Pinshane Huang, professor of applied and engineering physics, and Simon Kurasch, a University of Ulm graduate student. It includes collaborators from the University of Ulm, Germany; the Max Plank Institute for Solid State Research in Germany; University of Vienna; Aalto University in Finland.

Gaeta, meanwhile, will test the vest’s physiological effects through human trials this fall.

“We’re marketing the vest as a piece of clothing that doesn’t look like a medical device and can just be worn anywhere,” Beaudette said. “And with our small company we’re looking at asking these piezoelectric cells to other products, as well.”

— Blaine Friedlander

Graduate student Pinshane Huang and Professor David A. Muller with a model that depicts the atomic structure of glass. They were the first to directly image the world’s thinnest sheet of glass.
As Robinson explained, “The properties of colloidal quantum dots can be tuned by changing their size and composition, and the field has really come a long way over the last decade towards mastering those properties to be ideal for energy applications. We’re really on the forefront of technology. The problem is that there hasn’t been a way to make a massive amount of particles that are all exactly the same size and composition. Scalable methods to manufacture nanoparticles really could change the landscape.”

The key to their project will be the use of a reactive precursor that had previously only been limited to aqueous phase synthesis of nanomaterials. Their method could potentially benefit the application of semiconductors and semi-metal colloidal nanocrystals by providing a non-toxic alternative to metal chalcogenide systems.

The splash from rain hitting a windowpane or printer ink hitting paper all comes down to tiny droplets hitting a surface, and what each of those droplets does. Cornell researchers have produced a high-resolution “photo album” of more than 30 shapes an oscillated droplet of water can take. The results, a fundamental insight into how droplets behave, could have applications in everything from inkjet printing to microfluidics.

The imaging platform, which Chang has named the “Ondreena,” is able to capture the oscillating droplet at different angles at which the droplet can be observed, consists of a glass slide, the droplet sitting on top, and a 50-micron square metal mesh, like a window screen, underneath. A light is shined through the mesh holes, and deflection of the droplet’s surface reflects the tiny droplet which is seen as a deformation of the mesh and captured by a high-speed camera.

The researchers mechanically oscillated the droplets at varying frequencies, and observed and recorded their movements. The oscillation can be likened to when a violin string is plucked, certain natural frequencies correspond to a given length of string, the same way certain frequencies correspond to the shape of a drop of a specific size.

The researchers created a detailed table of droplet shapes according to frequency, as well as observing the results to previous theoretical predictions involving the real-time dynamics of oscillating droplets. Classical theories don’t capture the dynamics entirely, but new predictions, made by collaborators Stein and Bostwick take into account the physical effect of the solid substrate in contact with the droplet and match the images in the photo album.

The researchers also observed that some of the droplets take on multiple shapes when vibrated with a single driving frequency—akin to physicists observing two different energy states simultaneously in an excited molecule.

“Without the high-speed imaging, we wouldn’t have been able to see the drops exhibiting these kinds of mixed behaviors,” Daniel said.

The detailed, clear table of oscillating drop modes could lend insight into further fundamental studies, as well as a host of applications, Daniel said. For example, NASA is interested in understanding how droplets on surfaces move in low gravity. And in high-resolution printing, the spread of a drop as it touches a surface will dictate image resolution. The science chemistry of the roller, printer and ink will have profound effects on the technology.

“The study, ‘Substrate Constraint Modifies the Rayleigh Spectrum of Vibrating Sessile Drops...’ was supported by NASA, the National Science Foundation and Xerox Corp.” —Anne Ju
**NEWS**

**CUAUV wins RoboSub competition**

With their submarine, Ragnarök, the Cornell Autonomous Underwater Vehicle project team won first place for the second consecutive year at the RoboSub student competition, which took place in San Diego July 22-28. It was the team’s fifth win since 2003.

The prize for first place at the competition, hosted by the Association for Unmanned Vehicle Systems International Foundation and the Office of Naval Research, netted $58,000. The students also won a Best Paper Award, which came with an additional $500.

**Cornell named a mentoring center by Sloan Foundation**

Cornell has been awarded a three-year, $1.2 million grant to become one of three new University Centers of Exemplary Mentoring, the Alfred P. Sloan Foundation announced July 9.

The new partnership, which includes Georgia Institute of Technology and Pennsylvania State University, was initiated through the foundation’s Minority Ph.D. Program. The program cited universities with a proven record of educating underrepresented minority graduate students in science, technology, engineering, and math. These universities will be expected to expand, strengthen, and institutionalize minority recruitment, mentoring, educational support, and professional development.

The University Center of Exemplary Mentoring at Cornell has many programs planned, including recruitment and outreach efforts, a one-on-one mentoring program for minority scholars, a three-day leadership development training workshop, and a year-long series of seminars, workshops, lunches, and social events that provide professional development advice and opportunities to minority students.

“The work is very promising and grateful to be recognized by the Sloan Foundation. This new award recognizes the institutional commitment to diversity, allows us to expand the successful Cornell Sloan Scholars program beyond the College of Engineering, and gives Cornell the opportunity to play a larger role in national efforts to diversify the research and leadership ranks of academia, industry, and government,” said Alan Zehnder, associate dean for diversity and faculty development in the College of Engineering.

Cornell’s program, managed by Diversity Programs in Engineering, will provide three years of stipend support and additional support for research and professional development to 22 new, underrepresented, minority Ph.D. students in engineering and applied life science fields.

Cornell was chosen based on such criteria as its historical success recruiting and mentoring doctoral students from underrepresented minorities, the quality of its departments and programs constituting the center, the center’s breadth, and creativity of planned future activities, and the strength of its institutional commitment to furthering education for underrepresented minorities in the natural and physical sciences, mathematics, and engineering.

The University Centers of Exemplary Mentoring represents a change in the direction of the Sloan Foundation’s Minority Ph.D. Program. Founded in 1995, the program initially focused on support at the individual mentor or department level, providing scholarships to students in more than 60 graduate programs across the country. Each center will receive administrative support through the National Action Council for Minority in Engineering. Students supported through these programs will also have the opportunity to participate in the Southern Regional Education Board’s Institute on Teaching and Mentoring, the largest professional development conference for minority scholars.

Cornell’s Sloan grant principal investigator is Zehnder, Sara Hernandez, director of Diversity Programs in Engineering, Marlene van der Meulen, associate dean for research and graduate studies and professor of mechanical and aerospace engineering, and Avery August, professor and chair of microbiology and immunology in the College of Veterinary Medicine.

--- Anna Ju

**Versatile polymer film synthesis method invented**

Forming perfect porous polymer films is not enough; they need both large and small pores, and the process of making them needs to be simple, versatile, and repeatable. Creatively combining already established techniques, Cornell materials researchers have devised a so-called hierarchical porous polymer film synthesis method that may help make these materials useful for applications ranging from catalysis to bioengineering.

The breakthrough was led by Ulrich Wiesner, the Spencer T. Olin Professor of Engineering, and the experiments were completed by graduate student Hiroaki Sai, first author on a paper reporting the results online in the journal Science, Aug. 2. The research collaboration drew on the expertise of other Cornell scientists in materials growth and characterization.

The hierarchically structured polymers are porous at both micron- and nano-length scales. This method of phase separation is known as spinodal decomposition. One of the two phases rich in the block copolymer then phase-separates on the tens of nanometers scale into two domains formed by the two blocks of the copolymer. One of the blocks, a polyethylene oxide block, is swollen with the small molecule additive, which is immiscible—doesn’t mix—with the other block of the polymer. When the additive was washed away, for example with water, what remained was a continuous pattern of pores on two length scales—tens of microns and nanometers. “It’s about as simple as it gets,” Wiesner said. The researchers tried the method with multiple diblock and even triblock polymers, and contend that the method can be generalized for making many versions of this highly sought-after material. What’s more, they were able to easily turn the nanotexture of the resulting polymer by adjusting the temperature at which the original organic solvent was evaporated.

Once made, the material had to be tested for utility. Lara Ettorf, associate professor of materials science and engineering, and her student Emily Asenah-Smith helped the scientists grow calcite crystals on the porous polymers. Electron microscopy confirmed that the calcite infiltrated the entire structure, small and large pores, thus demonstrating transport of calcite precursors through the porous structure.

Researchers including David A. Muller, professor of applied and engineering physics and co-director of the Kavli Institute at Cornell for Nanoscale Science, and his student Marjolein van der Meulen contributed tomography to characterize the nanoporous structure of the polymers. The researchers also used nanoscale computer tomography to quantify the network of micron-sized pores connected throughout the samples. The paper “Hierarchical Porous Polymer Scaffolds from Block Copolymers,” included co-authors Kwan Wee Tan, Kahyun Hur, Yi Jiang, Mark Riccio, Velt Elser, and Sid Graner; the John L. Wetherill Professor of Physics. The research was supported by the National Science Foundation through use of facilities at the Cornell Center for Materials Research.

--- Anna Ju

**Structural hierarchy in the synthesized polymeric scaffolds ranging from micrometer to nanometer length scales.**

**One of the tasks for Ragnarök was to shoot torpedoes through the quadrant of a screen with a specific color.**

--- Anna Ju

**Team leader Markus Burkardt ‘14 helps a volunteer Navy diver get Ragnarök out of the water at the 16th RoboSub competition.**

--- Anna Ju
That typically attracts immune sites, including the lung, liver, and peritoneum, a chemokine, or signaling molecule that stimulates cell migration, which is a step in the metastatic process. The researchers looked at epithelial growth factor (EGF), which is found in blood. Using the device, they found that SDF-1alpha attracts breast tumor cells in a way similar to immune cells, but the addition of EGF to this mix canceled this attraction. The results indicate that in real cancer, different signaling proteins work cooperatively, so understanding these behaviors could be starting points for cancer therapy, Wu said.

The device consists of micron-scale channels patterned into a hard surface. The researchers place cancer cells into one channel and add the chemokines into adjacent channels. The setup is a bit like studying a fish in a fish tank rather than the ocean—isolating one or two factors and observing them specifically, rather than being mired in confounding environmental factors, Wu said. The researchers are interested in chemokines known to be involved in the immune response, because cancer researchers suspect that metastasis uses some of the same immune signals that allow cancer cells to move and invade other parts of the body. “We are trying to understand how cancer cells are borrowing a similar strategy,” Wu said.

In related experiments, Wu hopes to use real tumor cells from human patients in the device, not just cultured cell lines. They are also continuing to use the microfluidic device to look not only at biomarkers for metastasis, but also the physical forces that cells use to move through the body.

The first author of the paper, titled “Cooperative Roles of SDF-1 and EGF-Gradients on Tumor Cell Migration Revealed by a Robust 3D Microfluidic Model,” is B.J. Kim, a research associate in Wu’s lab. The work was a collaboration with Melody Swartz, a cancer researcher at the Swiss Federal Institute of Technology in Lausanne.

— Annie Xu

**BIRDS’ GOOD VIBRATIONS POWER MINI BACKPACKS**

From left, Dorset Torres, Marie Zwetsloot, and Rachel Hestrin show jars of biomass fuel and biochar at the annual National Sustainable Design Expo.

The students developed pyrolysis cookstoves, a low-oxygen environment, to reduce fuel need, decrease indoor air pollution and diminish greenhouse gas emissions. Resultant biochar can be added to soil as a soil-amendment or fertilizer to reduce synthetic fertilizer usage and pollution, to sequester carbon, and to improve soil health for crop growth.


The stacked rapid sand filter is an efficient, inexpensive and fully hydraulic unit process for municipal-scale water treatment. Already, it is a sustainable alternative for developing-world communities where conventional water treatment technology fails. AguaClara develops gravity-powered, electricity-free, sustainable water treatment plants, scalable to fit the needs and size of any community. AguaClara developed plants that now operate in eight Honduran communities, serving more than 70,000 people. Each treatment plant delivers water quality that exceeds World Health Organization guidelines.

— Blaine Friedlander

**TWO STUDENT TEAMS WIN COVETED EPA PRIZE**

Two Cornell student teams—a corkosset fuel/biochar group and the AguaClara water filtration project—won the U.S. Environmental Protection Agency’s prestigious People, Prosperity and the Planet Award June 19. With about 45 teams in the competition, Cornell was the only school with two of the seven winning teams. The competition was held in April at the annual National Sustainable Design Expo in Washington, D.C. Each winning team now qualifies to receive a grant of up to $50,000 to further develop their design. Student projects were designed to protect people’s health, the environment, encourage economic growth and use natural resources efficiently.

The winning project, “Pyrolytic Cook Stoves and Biochar Production in Kenya: A Whole Systems Approach to Sustainable Energy, Environmental Health and Human Prosperity” featured graduate students Dorset Torres, Marie Zwetsloot, Rachael Hestrin and David Guerena, all in the field of crop and soil science, and Jennifer Davis ’15, and ’16man Hsu, M.Eng. ’15, of engineering. Their faculty advisers are Johannes Lehmann, professor of crop and soil science, and Elizabeth Fisher, professor of mechanical engineering.

The students developed pyrolysis cookstoves, a low-oxygen environment, to reduce fuel need, decrease indoor air pollution and diminish greenhouse gas emissions. Resultant biochar can be added to soil as a soil-amendment or fertilizer to reduce synthetic fertilizer usage and pollution, to sequester carbon, and to improve soil health for crop growth.


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— Blaine Friedlander
venture capital. The new students hail from California, different industries, including defense, government and colleges, while others have spent time working in computer science. Some of the Masters students have enrolled in our one-year Masters of Engineering in students on campus, including Ph.D. students and those for our first fall semester, we have approximately 30 (our “beta class”) in January 2013 to a temporary campus help to reduce that friction. Additionally, the Johnson MBA at Cornell Tech, which is currently accepting applications, will fuse business, technology, innovation and entrepreneurship in a fast-paced, hands-on learning environment. The one-year MBA degree program is for those with a degree in science or technology, as well as relevant work experience, who want to enhance their business knowledge and who desire leadership opportunities in the digital economy. Students learn in the vibrant center of New York City’s global tech ecosystem, following a summer session in Ithaca, New York. The first class begins the program in May 2014 in Ithaca, and spends the following two semesters on the Cornell NYC Tech campus. They will graduate in May 2015, with a deep understanding of how technology is changing the way business works, and as leaders ready to start innovative businesses and transformative organizations.

Work is also moving forward on plans for the permanent campus, set to break ground in early 2014 and open its doors on Roosevelt Island in 2017. We completed the public review process for the campus in the spring, and were grateful for the overwhelming support of the entire city and especially our new neighbors on Roosevelt Island. The future campus of Cornell Tech on Roosevelt Island will be an innovative, sustainable academic campus made up of a combination of academic space, corporate research and development facilities, possibly an executive education center/hotel, and housing. Overall, over two million square feet of new space will be located in a series of architecturally dynamic buildings. For the signature academic academic building, being designed by by Pritzker Prize-winning architect Thom Mayne of Morphosis, we are aspiring to “net-zero” energy usage. We have also partnered with Forest City Ratner Companies, the developer of the Barclays Center in Brooklyn, to build the first corporate co-location building, with design by innovative architectural firm WEISS/MANFREDI. The corporate co-location building will be located next to the flagship academic building and will provide space for industry—from start-ups to well-established tech companies—to be located on our campus ensuring frequent and deep connections between industry, students, and faculty.

In the meantime, our temporary campus in Chelsea was redesigned over the summer by award-winning architect David Rockwell, and features an innovative open approach that allows maximum flexibility for all of the activities that take place on campus—from lectures to cocktail parties, private study sessions to hackathons.

The final piece of the puzzle is Cornell Tech’s commitment to the community, consistent with the university’s role as New York’s land grant institution. The campus will be playing a major role in the city, and we are focused especially on innovating K-12 tech education, including adoption of the local public school on Roosevelt Island and partnering with several middle schools across the city as well as some of the outstanding organizations in NYC who are committed to improving education for the 1 million New York schoolchildren. This has been an extremely exciting time, not just for Cornell Tech but for the entire Cornell community. Cornell Tech is truly a graduate school like no other, designed to engage our rapidly evolving global society and ready students, faculty, and partners who want to change the world. As we continue to build this campus and curriculum from scratch, we will be back with periodic updates on our progress. If you want up-to-the-minute campus news follow Cornell Tech on Twitter @cornell_tech.

MESSAGE FROM CORNELL NYCTECH

At Cornell NYC Tech, we have been working non-stop since winning New York City’s applied science bid to rethink graduate tech education and build a new sustainable campus in the heart of the city. It’s hard to believe that less than two years ago Cornell Tech didn’t exist. On December 19, 2011, New York City Mayor Michael Bloomberg selected Cornell and our academic partner—Technion-Israel Institute of Technology—as the winner of the city’s applied sciences campus competition. Since then, we have made enormous strides in building an innovative new academic program and planning our campus on Roosevelt Island.

Cornell Tech is designed to address two significant issues slowing innovation and economic development in New York and around the country. The first issue is that the enormous growth of New York’s tech sector is being held back by a shortage of top-level tech talent. The second, broader challenge is that the way we innovate and commercialize research ideas in this country is changing, and universities and companies both need to adapt to remain at the forefront of technology innovation. It is time for new thinking about how industry and academia work together. Cornell Tech will help to reduce that friction.

We’re off to a flying start. Just over a year after winning the competition, Cornell Tech welcomed its first students (our “beta class”) in January 2013 to a temporary campus in space donated by Google in its Chelsea headquarters. For our first fall semester, we have approximately 30 students on campus, including Ph.D. students and those enrolled in our one-year Masters of Engineering in computer science. Some of the Masters students have come to Cornell Tech straight from their undergraduate colleges, while others have spent time working in different industries, including defense, government and venture capital. The new students hail from California, Texas, Israel, China and everywhere in between. They are a highly talented, entrepreneurial and diverse group of students, and they have already begun interacting with industry. We look forward to sharing news of their innovative projects and work at the end of the semester.

Earlier this year we announced two new degrees that will launch in the fall of 2014—a one-year MBA in partnership with the Johnson School, and a groundbreaking two-year program that offers students both Cornell and Technion degrees. The dual degree program will be offered by the Joan and Irwin Jacobs Technion-Cornell Innovation Institute (JTCI), named in honor of a $153 million gift from Joan and Irwin Jacobs. The Jacobses are both Cornell alumni who have a long history of supporting Cornell and Technion, and the JTCI is a key component of Cornell Tech. This degree program will allow students to specialize in applied information-based sciences in one of three hubs focused around leading New York City industries—Connective Media, Healthier Life and the Built Environment. The first area of specialization will be in Connective Media and is slated to begin in the fall of 2014. We recently announced at an event with Mayor Michael Bloomberg and several industry partners that applications for the Connective Media program are now open.

Additionally, the Johnson MBA at Cornell Tech, which is currently accepting applications, will fuse business, technology, innovation and entrepreneurship in a fast-paced, hands-on learning environment. The one-year MBA degree program is for those with a degree in science or technology, as well as relevant work experience, who want to enhance their business knowledge and who desire leadership opportunities in the digital economy. Students learn in the vibrant center of New York City’s global tech ecosystem, following a summer session in Ithaca, New York. The first class begins the program in May 2014 in Ithaca, and spends the
Craig Fennie is deeply skeptical of the word “genius,” especially when applied to him. “I have always hated the word,” he says, while sitting cross-legged and shoeless on a couch in his office. “I have always hated standardized tests. I have done badly compared to how people thought I should do on them.” Presumably, the selection committee, president, and board of directors of the MacArthur Foundation did not look at Fennie’s SAT or GRE scores before giving him a 2013 MacArthur Fellowship, known as the “genius award.”

“When you look at my life I don’t really know how I am here. I feel so lucky—I feel like I need to give something back,” says Fennie, clearly still trying to make sense of his award. MacArthur Fellows represent an eclectic mix of fields. This year’s roster of 24 winners includes a jazz musician, an immigration lawyer, a paleobotanist, a medieval historian, a choreographer, a neuroscientist, a photographer, and several writers. The thread that ties this diverse group together and runs through the work of all the winners is extraordinary creativity. The MacArthur Foundation seeks out individuals who “actively make something or find something new, or connect the seemingly unconnected in significant ways.” Fennie’s work fits this description perfectly.

“Fennie, a materials scientist and assistant professor in the School of Applied and Engineering Physics at Cornell, was cited for his work combining theoretical physics with solid state chemistry. Sit with Fennie for even just ten minutes and you start to catch glimpses of a creative fire. His work is a ground-breaking combination of deeply theoretical physics and completely practical solid state chemistry. Physicists love to find the simplest model that describes the properties of known materials,” says Fennie. “Solid-state chemists, often driven by intuition, discover new materials irrespective of their properties. They’ll say ‘Hey, let’s figure out how to make these things and then see what happens.’” Fennie and his collaborators have turned that approach on its head, starting with a property in mind, they work out a model, which they then combine with quantum mechanical simulations to search for a real material with that property. “We are trying to move away from serendipity and into a more rational approach.”

Fennie uses this approach to identify previously unknown materials that should, if his calculations are correct, have desirable optical, magnetic, and electrical properties. He works with others in the College of Engineering to then build these materials, atom by atom. Listening to Fennie talk about his work, it quickly becomes apparent that he always uses the plural “we” instead of the singular “I.” “We are looking at things in a physics-y way. We have had to learn a lot of chemistry, but we can do this,” says Fennie. “We have been incredibly lucky—we have had more than one success lately.”

There are six Ph. D. students, eight post-doctoral fellows, and at least six faculty collaborators in Fennie’s lab group at Cornell. “Cornell Engineering is phenomenal. Some of the best scientists in the world are here,” says Fennie. “It is strong across the board in physical sciences and engineering like nowhere else. It covers the full spectrum of engineering from purely fundamental and a bit abstract to fully functional and practical.”

This breadth of expertise makes Fennie’s work possible. Professor Darrell Schlom is the grower and Professor David A. Muller is his eyes. Darrell makes just about everything I have worked on, while David, using his powerful electron microscopes, is able to see where Darrell is putting the atoms. I could not do what I do without them,” says Fennie. “We really need to push the field’s current understanding of fundamental solid
Fennie and his collaborators have created materials that allow for the synthesis of such materials that do not otherwise appear in nature. Fennie and his group are particularly interested in understanding how the composition, symmetry, and professional inclinations. They may use their fellowship to advance their expertise, engage in bold new work, or, if they wish, to change fields or alter the direction of their careers. Some of the materials Fennie and his collaborators have created may end up as the basis for a new way of storing digital information. Others may be the foundation for a new generation of solar collectors that can more efficiently harvest photons from the sun and turn them into a power source here on Earth. Beyond these admittedly very useful and exciting applications, Fennie is clearly thrilled by the more fundamental repercussions his work may have. “We are creating new materials based on ‘first principles’ approach and this is different than it has been done before,” says Fennie. “This is a new way of approaching things.”

In the end, whether he sees himself as a genius or not seems totally irrelevant to Fennie. “If I can’t have it all, I don’t want any of it. I need to be doing what I love,” says Fennie. “I have always done what I have loved to do, and when I wasn’t, I made changes. I am in the best place now; I love what I am doing here and I am going to be at Cornell for a long time.”
Cornell Engineering received a record number of applications this year (10,084) – more than at any time in the college’s history.

Early decision application volume increased by 18% this year and 36% of the enrolling class were offered admission in early decision. SAT scores improved again this year.

Thirty-nine states are represented in the first-year class, including Hawaii, Alabama, Louisiana, Arizona, Colorado, Iowa, Idaho, Kentucky, Maine, Michigan, Missouri, Oregon, Tennessee, and Vermont. The majority of enrolling students hail from New York, New Jersey, California, and Florida.

Legacies represent 14% of the incoming class, which mirrors last year's class.

Compiled 9/24/13 SMC (Source - OAR various reports)
AERIAL MASTERY

CORNELL STUDENTS TAKE FIRST IN AUTONOMOUS AIRCRAFT COMPETITION

The judges at this year’s Student Unmanned Air Systems Competition certainly had a flair for the dramatic. Each year, the three-day competition ends with an awards dinner attended by all of the teams, parents, and judges. This year, that meant 35 teams sitting around tables at the Patuxent Naval Air Station in Maryland enjoying a buffet dinner, and waiting to be called to the podium for their awards. The judges started with the team that came in thirty-fifth. Then they called up the team that came in thirty-fourth. And so on. And so on. And so on. Eventually, there were two teams that had not yet been honored: North Carolina State and Cornell Engineering’s CUAir team. Rather than put an end to the tension, the judge at the podium took a few moments to give a short history lesson. He recalled the very first competition in 2003. Just two teams entered that year: North Carolina State and Cornell. NC State’s plane was unable to fly autonomously. Cornell’s plane flew—right into the ground. Despite the crash, Cornell was named the winner of that first competition.

After recounting the first place crash of CUAir in 2003, the judge went on to announce that the second place finisher in 2013 was…North Carolina State. As the words were leaving his mouth, members of CUAir knew that they were the winners. “It was kind of a nail-biter,” says electrical sub-team leader Joel Heck ’14 EE. “It was very exciting.”

The win came as vindication for Phill Tischler ’13 CS. Under his leadership, the team decided to ditch the kit-built planes they had been using and instead design and build a custom composite aircraft of their own. “It was a great victory not just for the team members, but also for everyone involved—our sponsors, the Cornell community, and friends and family. Without their support, we would not be where we are today,” he says. “We have been working hard all year to achieve this...
For the Student Unmanned Air Competition, remote control systems are turned off, leaving the model-sized aircraft to autonomously locate, identify, and classify targets on the ground using their own on-board imaging systems. They must connect to a directional Wi-Fi network and obtain mission data.

The competition in Patuxent is organized by the Association for Unmanned Vehicles Systems International. According to its website, this non-profit organization exists “to advance the unmanned and robotics community through education, advocacy, and leadership.” Their sponsored competitions give students opportunities to participate in hands-on robotics activities so they can apply their science, technology, engineering, and math skills outside of the classroom. The association has awarded more than $1.3 million in prize money over the years. For their first-place showing in June, CUAir brought home $7,450.

Back in 2003, the year of their crash victory, Cornell’s team took home a first prize of $3,000. Karl Schulze ’05 CS, a founding member of the CUAir team in 2002, remembers it this way: “The first competition was actually a disaster; it was the first year the competition was run, and there were only two teams,” he says. “We ran the first test flight as a remote control plane so that we could capture aerial images to tune our vision algorithms. Shortly after takeoff the plane flew through a radar beam they had either forgotten (or not realized they needed) to turn off, and lost all remote control reception. The plane promptly nose-dived into the ground, totaling the aircraft. As a result neither team completed the course, and we won for having a better journal paper/technical design and entry.”

Ironically, for a team that creates and flies autonomous vehicles, that first CUAir team was not autonomous. It was a branch of the Cornell team competing in the association’s autonomous submarine competition. As a high school student, Schulze had competed against Cornell’s underwater team and so he joined them when he got to Ithaca as a freshman. When the association launched the Unmanned Air Systems competition that same year, Schulze convinced team captain James Buescher ’03 ME and team adviser Kevin Kornegay to launch an unmanned air vehicle for the competition. “The first year was really run as CU Autonomous Underwater Vehicle team running two robots, one in the water and the other in the air,” he says.

After winning the inaugural event in 2003, CUAir suffered through an eight-year drought, not once finishing in the top three. Tischler was on the team in some of the lean years and he was part of the group that finally put everything together. In 2012 the Aeolus II, a plane Tischler worked on as the software team leader, took first in mission and second overall at Patuxent. Then, by taking the systems that had performed so well in Aeolus II and putting them in a self-built plane, named Hyperion, CUAir finally managed to reclaim the crown in 2013. Hyperion found all ten targets—four better than the next best entrant, was the only system to image a target located off to the side in the no-fly zone, and was one of only a handful of vehicles to connect to the Wi-Fi signal successfully.
Despite the intense competition for talented undergraduates among Cornell Engineering’s 20 project teams, CUAir has more than 30 members this year. All the teams give young engineers meaningful experience as part of a collaborative effort to address and solve tough engineering problems. Student teams work to provide clean water for communities in the Global South; to design, test, and build a Mars Rover; to design, build, and test genetically engineered machines; and to design, build, and race concrete canoes, among other challenges. In the teams, students take leadership roles and learn both basic and high level engineering concepts and skills. They also learn about effective communication, collaboration, and compromise.

To join CUAir, students apply, interview, and then wait to hear if they have made the cut. Those who are accepted join one of five sub-teams: Airframe, Software, Electrical, Autopilot, or Business. In practice, the members of CUAir take a systems approach to the design of their aircraft since all systems must work together to accomplish the mission. Toward this end, mechanical engineers, aerospace engineers, electrical engineers, computer engineers, and chemical engineers all work together.

Heck is in his fourth year with CUAir. “I applied to join CUAir because at the time it was one of the smaller teams. I had high interest in aviation and aircraft, so my decision was driven by my interest,” he says. “You can take your project team work and get class credit for it, but I don’t. I do it because I love it.”

Heck says that this year’s plane “will look similar to last year’s, but we want to make it fifteen pounds lighter.” He is a firm believer in learning by doing, so in the redesign of the airframe he has separated the plane into its constituent parts. “Last year the airframe was mostly designed by a senior for a senior design project. Other airframe members were involved, especially with the fuselage,” he says. “This year the design has been broken up and assigned to sophomores and juniors. One team is working on the wings, others are working on the body and the tail. It’s a great way to get younger team members involved with some real responsibility.”

“Rather than toss out the winning design and start from scratch, says Heck, “We will make some tweaks this year. Our goal is to improve our infrastructure and our design process.”

Members of CUAir don’t learn just from each other. Both Heck and Tischler value the opportunity the competition in Maryland gives them to see the designs other teams come up with. “Even though we came in first this year, NC State really had a great design and we had a lot of questions for them,” says Heck. Tischler says that as team lead he encouraged team members to get out and talk to the other teams to learn from them as well as to share some of what CUAir has learned over the years.

Heck has some clear ideas about where CUAir will go next, but he is a bit reluctant to tell other teams just what is coming. “Over the past 11 years we have continually been building up and we have finally understood the winning formula,” he says. “So now it’s a matter of doing it. We will experiment with other things off to the side and then bring them in as we perfect them. The future looks good.”
When an engineer uses the term “matriarch” to describe nature, you know you’re not talking to a typical nuts and bolts person. And when she elaborates on her philosophy of creating a built environment that flexes with the weather and land, rather than trying to control them, you know you’re in the presence of someone who is working in a shifted paradigm.

Abena Sackey Ojetayo ’07 M. Eng. ’09 is that person. And that paradigm—one which prioritizes sustainable infrastructure that allows humans to live in concert with their environment—is informing the path of her already remarkable career.

Ojetayo, who was named to the 2013 list of New Faces of Civil Engineering by the American Society of Civil Engineers and was singled out as a “Notable Black in Energy” by the U.S. Black Engineering & Information Technology Magazine in 2012, is a senior project coordinator in the Energy and Environmental Engineering section of Cornell University Facilities Engineering.

She provides project management support for Cornell NYC Tech’s Roosevelt Island campus, as well as helps to monitor Cornell’s progress toward meeting the goals of its 2009 Climate Action Plan. Her path to this position and her enthusiasm for sustainable infrastructure began with her supportive family.

Ojetayo was born in Ghana, and her family immigrated to Maryland when she was nine. Her mother, a financial analyst, and her father, an informatics pharmacist, recognized her math and science talent early on.

They fostered her interest and encouraged her to attend Eleanor Roosevelt High School in Greenbelt, Md., a science and technology magnet school. Her teachers suggested she consider engineering. It appealed to her, especially because during family visits back to Ghana, she witnessed the need for vital infrastructure.

“I went into engineering thinking ‘How do I use this to solve problems?’” says Ojetayo. “I wasn’t wild about equations. I just wanted to learn how to get things built and elevate people’s living conditions.”

She first visited Cornell during a Diversity Hosting Weekend, and even though the weather was unusually awful for Ithaca, she knew it was the place for her. “I went to visit MIT and I was seriously considering Carnegie Mellon, but they both felt narrow,” says Ojetayo. “I wanted the flexibility to be able to also take hotel classes if I wanted to, which I did.”

Classes she particularly enjoyed in the College of Engineering
Cornell's first significant step was its 2010 decision to phase out the on-campus coal burning power plant. The new combined heating and power plant burns natural gas. Before it was brought on-line, the university burned about 60,000 tons of coal per year. This move, supplemented by cleaner grid-purchased electricity and other energy equipment upgrades, reduced Cornell's greenhouse gas emissions by more than 20 percent between fiscal years 2010 and 2012.

Another key action is intensive energy conservation work being done on campus, such as weather-proofing leaky old windows in Rockefeller Hall. “The energy management group is identifying opportunities to conserve and use energy better within buildings across campus and implementing these measures” Ojetayo says. “We’ve seen tremendous decrease in the energy use. This is one program that works.”

The Snyder Hill Solar Farm is another important component of the plan. This array of 6,766 solar photovoltaic panels on a 10-acre site owned by Cornell, adjacent to the Ithaca Tompkins Regional Airport, will produce about one percent of Cornell’s electricity when it is completed in winter 2014. It will reduce carbon pollution by an estimated 750 tons per year.

One aspect of the plan Ojetayo is especially excited about is the prospect of an enhanced geothermal system hybridized with a biogas facility, a project in the concept stage. The system is being developed by facilities staff and faculty in the Colleges of Engineering and Agriculture and Life Sciences. The biomass-to-biogas facility, dubbed Cornell University Renewable Bioenergy Initiative (CURBI), would feature demonstration-scale research projects.

“CURBI is a neat partnership with several benefits across stakeholders,” says Ojetayo. “In addition to being used for research, the facility would also generate a significant amount of energy that can be used by facilities immediately.” Together with the existing lake source cooling system, these actions could allow Cornell to heat and cool the campus using only natural, renewable resources and stored heat energy from the earth.

In all, Ojetayo feels optimistic about the climate plan’s progress and thrilled to be working on it. “I was never the type who really wanted to just crunch numbers,” she says. “I’m really more energized when I get to translate a vision into actionable plans and make it make sense for other people.”

Part of making it make sense for other people is sharing her vision. And as she talks about that vision, Ojetayo is not shy about using language that might seem unexpected from an engineer’s lips. “We don’t want to fight the matriarch,” she says, laughing. “We have to stop building structures that are so firm and rigid, that are lip service. “We don’t want to fight the matriarch,” she says, laughing. “We have to stop building structures that are so firm and rigid, that are

Ojetayo works with her supervisor, Steve Beyers, on Cornell NYC Tech site development.
Citing research that has transformed our scientific view of the heavens, the American Astronomical Society (Division of Dynamical Astronomy) will give Joseph A. Burns, Ph.D. ’66 ME, the Irving P. Church Professor of Applied Science and professor of astronomy, the prestigious 2013 Dink Bower Award. The presentation will take place in Philadelphia in May. 2014.

The society cited Burns’ fundamental contributions in planetary dynamics and exceptional record of scientific achievement. With Victor Safonov in 1973, Burns wrote a seminal paper that quantified how collisions affect the rotational properties of asteroids. Burns’ 1979 paper, “Radiation Forces on Small Particles in the Solar System,” illuminated the importance of radiation forces in the dynamics of small bodies, and changed the understanding of the motion of interplanetary dust and asteroids. This work is the foundation for the Yarkovsky and YORP effects that explain the rotation and shapes of small, icy bodies. According to his second most highly cited paper in the journal, “Massive Comets in the Solar System,” Burns’ work has more than 900 citations to date.

The society said that he “made impressive contributions to the interpretations of planetary ring structures,” about Jupiter and Saturn using Voyager.

For heavenly radiation, Burns wins Bower Award

Galileo and Cassini spacecraft observations, and clarifying the role of magnetic fields and resonance dynamics. Beyond his scientific achievements, Burns edited the texts planetary satellites (1977) and satellites (1986), and was the editor of kurios for almost 20 years. At Cornell, Burns has served as chair of Theoretical and Applied Mechanics (1987-1992), vice provost for physical sciences and engineering (2002-2007), he is currently dean of the university faculty (2013-present).

Cornell Engineering hires student director

Rebecca Macdonald has been named the first Swanson Director of Engineering Student Project Teams. The position was made possible by a generous endowment from John A. Swanson ’61, M ’69. Macdonald will be responsible for leading the project teams program that provides opportunities for students across all colleges and engineering and related disciplines to participate in hands-on interdisciplinary design, development, and construction. Students utilize their technical knowledge, creativity, enterprising, and leadership skills to engage in national and international competitions and service projects. Macdonald will work closely with an advisory group to develop a strategic direction and provide much-needed management support to the student project teams.

Macdonald is a graduate of the Georgia Institute of Technology and has completed two master’s degrees—in civil engineering and economics. Macdonald was previously an engineer designing high voltage transmission lines by computer optimization and a senior pricing and structuring analyst for Dominion Power in Virginia. Most recently she was a professor in the department of Construction Management at East Carolina University. Her Ph.D. in civil engineering with an emphasis on construction management was awarded by the University of Alabama in early August.

“Professor Macdonald brings both industry and academic perspective to the leadership of our student project teams. We have more than 600 students involved in our project teams and we are excited to have attracted someone with her combination of credentials to be the first Swanson Director of Engineering Student Project Teams,” said Lance Lucks, the new Joan Dean of Engineering.

Hod Lipson briefs Congress on 3-D printing

Hod Lipson, associate professor of mechanical and aerospace engineering, briefed Congress on the impact of 3-D printing technology on manufacturing on April 24. Lipson spoke at the National Network for Manufacturing Innovation congressional briefing hosted by the American Society of Mechanical Engineers, the Society of Manufacturing Engineers and Land Grant Universities, and Rep. Tim Ryan (D-Ohio) and Rep. Tom Reed (R-N.Y.), co-chairs of the Congressional Caucus on 3-D Printing. The House Manufacturing Caucus has identified 3-D printing as an emerging technology that is affecting almost every field, from aerospace and medicine to art and architecture, and even food and fashion.

“Though the 3-D printing market was only $2 billion in 2012 compared to over $2 trillion in 2013 in the U.S., the market share of 3-D printing is growing rapidly,” said Lipson. “The technology also has broader impact on new business models, when you can quickly prototype a new intellectual property, and new safety, as well as positive and negative environmental impacts.”

3-D printing tools can remove barriers for any size enterprise, according to Lipson, who recently co-authored with Melba Kurman the book Fabricated: The New World of 3-D Printing. “The technology allows large corporations to innovate faster, and medium corporations can use it to integrate into the supply chain with smaller investment,” he said.

“The technology also reduces the upfront cost of starting new businesses, allowing people to ‘scale up from one’ without quitting their day job.”

While the United States appears to lead in some areas of the technology, Lipson warned that the rest of the world is catching up. “Europe is leading in metal 3-D printing, and Asia appears to lead in some areas of the technology,” he said.

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Hod Lipson testifies before Congress April 24.
information,” Schneider said. “I am looking at new ways of using the same fast problem-solving system that aerosols, which are an excellent example of an earth system process. They both respond to climate and force climate to change. She has also studied fire, the carbon cycle, and, more recently, understanding natural emissions of methane and nitrous oxide.

One of the strands that pulls her work together is the interaction of different components of the earth system and how they modify climate. An example is her recent paper in the journal Science identifying aerosol carbon cycle (biogeochemistry) interactions as a source of significant climate forcing. Mahowald pointed out that aerosols related to human activity reduced carbon dioxide concentrations and also offset the emissions of carbon dioxide.

For their prior achievement and exceptional promise, three Cornell faculty members have been awarded Guggenheim fellowships. They are Brian Crane, professor of chemistry and chemical biology, Gary Faris, the Elizabeth Lee Vincent Professor of Human Ecology; and Natalie Mahowald, associate professor of atmospheric sciences.

Mahowald, a Cornell faculty member since 2003, studies natural feedbacks in the climate system, how they responded in the past to natural forces that change the climate, and how they are likely to respond in the future. Much of her work focuses on mineral aerosols, which are an excellent example of an earth system process. They both respond to climate and force climate to change. She has also studied fire, the carbon cycle, and, more recently, understanding natural emissions of methane and nitrous oxide.

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Going Green

Green-painted engineering students prepare for Dragon Day on the Pew Engineering Quad. Every year around St. Patrick’s Day, in a tradition whose origins go back more than 100 years, an enormous dragon created by the first-year architecture students parades across the campus. Accompanied by Architecture, Art, and Planning students in outrageous costumes and heckled by rival engineering students, the dragon lumbers to the Arts Quad to be consumed by a bonfire. This rite of spring is one of Cornell’s best-known traditions.
Aerial Mastery:
Cornell Students Take First in Autonomous Aircraft Competition.
By Chris Dawson