ENGINEERS with a TOEHOLD in the arts

Things that Think
Passionate about Paper
Space Food
Cornell University is pleased to announce the W. M. Keck Program in Nanobiotechnology, focusing on the development of micro-miniature devices and machines for use in biological research.

W.M. KECK PROGRAM IN NANOBIOENGINEERING

Life scientists, physical scientists, and engineers across three colleges have entered into a collaborative, interdisciplinary program for the micro-exploration and micromanipulation of biological systems. The Keck Program in Nanobiotechnology will generate substantial new insights into biological function, provide new approaches to biological manipulation, and lead to the design of new classes of nanofabricated devices based upon biomimetic principles.

FACULTY OF THE W.M. KECK PROGRAM IN NANOBIOENGINEERING

Michael Isaacson
School of Applied and Engineering Physics

Carl Batt
Department of Food Science

Harold Craighead
School of Applied and Engineering Physics

Ronald Hoy
Department of Neurobiology and Behavior

Carlo Montemagno
Department of Agricultural and Biological Engineering

Mark Saltzman
School of Chemical Engineering

Norman Tien
School of Electrical and Computer Engineering

The W.M. Keck Program in Nanobiotechnology will take advantage of several of Cornell’s specialized research facilities such as the NSF-funded Cornell Nanofabrication Facility, the NSF-funded Cornell Center for Materials Research, the Institute for Biotechnology and Life Sciences Technologies, and the Nanobiotechnology Center, a newly funded NSF Science and Technology Center.

RESEARCH AREAS

The seven faculty members of the Keck Program in Nanobiotechnology are applied physicists, engineers, and biologists who are collaborating across various areas of research that push the frontiers of fabrication science and technology in pursuit of tools needed to address significant biological problems. These include:

• Nanopatterned Surfaces for Control of Cell Growth and Assembly
  Development of nanofabrication technology for the chemical and topographical modification of surfaces. We will not only develop the technology for multilayer chemical patterning, but also use this technology to apply to various aspects of tissue and cellular engineering.

• Microdiagnostics
  Utilization of nanofabrication technology to create miniaturized tools able to probe events from the subcellular to organismal level.

• Integrating Life Processes into Nanofabricated Devices
  Integration of biocompatible nanodevices with biological motors in order to create a transparent interface between living and inorganic systems.

• Biomimicry for Microsensors
  Utilization of nanofabricated devices to explore the sensory and locomotive systems of living systems and using the knowledge gained to create novel devices.

For further information about graduate fellowships contact:

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Features

Striking a Balance/6
BY MEREDITH F. SMALL

Three engineers become artists for a week in a rare opportunity to work with sculptor Andy Goldsworthy. A sidebar by Jay Wrolstad describes Prof. Frank Moon’s course, where engineers get in touch with their inner artists.

Bits and Atoms/12
BY DANA NIGRO

Juggling his wide-ranging interests, Neil Gershenfeld found the perfect job at MIT’s Media Lab, where tossing around ideas from projects as far-flung as magic and music results in amazing discoveries.

The Paper Paradox/16
BY K. A. MAJOR

Whatever happened to the paperless office? Who needs paper in the digital age and what do they do with it? Six engineering profs share their stories.

Eat Well and Prosper/22
BY BETH SAULNIER

For long-term space exploration, astronauts will need to grow crops. But you can’t just eat a head of wheat! Prof. Jean Hunter’s work, taste-tested on Cornell volunteers, will take space cadets from farming to feasting on the final frontier.

Hometown Hero/32
BY JAY WROLSTAD

Four years ago, Prof. Mike Kelley found a way to give his advisees roots; they graduated in May with wings.

News/2

A new nano device speeds up DNA separation; Cornell collaborates in bio research; the BRAIN team takes on MIT at the autonomous sub competition; Big Red robo-team gets ready to defend their international soccer title; and CS students go wireless in a campus test.

People/26

Engineers gathered on campus in April for the CSE conference, in May for graduation, in June for reunion; students build and race cars and concrete canoes; the engineering community says goodbye to new grads and an old friend.
Lab on a Chip

Nano-researchers create component to speed up DNA sequencing.

Researchers have long sought to create a “laboratory on a chip” that could greatly speed up the process of DNA sequencing. That goal has come a step closer with the announcement that Cornell University researchers have built and tested a nanofabricated device that can separate DNA fragments by length.

The silicon-based device performs the same function as the cumbersome gel electrophoresis process biologists now use but in as little as 15 to 30 minutes, rather than the 12 to 24 hours the gel process typically requires. It also can be more precisely controlled, the researchers say.

Harold Craighead, director of the Cornell Nanobiotechnology Center and professor of applied and engineering physics, and graduate student Jongyoon Han built on their previous research on the behavior of DNA in microscopic passageways to make the device, which fits on a silicon chip 15 millimeters (about three-quarters of an inch) long.

A nanofabricated device such as this could be incorporated into a complete analysis system on a single chip, the researchers say. In addition, they believe, it could be modified to separate various proteins and other molecules, such as inorganic polymers, in addition to DNA.

Separating DNA fragments by length is a fundamental part of the process of DNA sequencing to read out the genetic code of a sample, and is used in DNA “fingerprinting” to identify a person from a tissue sample or determine whether or not one person is related to another.

—Bill Steele, Cornell News Service

$160 MILLION FOR BIO RESEARCH

Three of New York’s leading research institutions announced the creation of a $160 million collaborative program in basic biological research sparked by a private donor who will contribute half the total investment.

The collaboration among Cornell University, its Weill Medical College, Memorial Sloan-Kettering Cancer Center, and The Rockefeller University will include the joint recruitment of a dozen new faculty members, reflecting the level of investment demanded by the technological demands of science today.

“This new and unique institutional collaboration of these outstanding research centers will allow us to take on the most exciting intellectual challenges of the 21st century: how to utilize the full knowledge of the human genome and how to apply new technologies in structural biology and nanotechnology to advance human health,” Cornell President Hunter Rawlings said.

The three areas targeted for development are:

Chemical biology: Spearheading this research will be Cornell professors of chemistry and chemical biology. A new generation of drugs will be precisely targeted to block or reverse disease processes at the molecular level. Development of these new therapies will depend on collaborations among chemists, cell biologists, and biophysicists who study protein structure.

Computational biology: Leading this research will be Ron Elber, Cornell professor of computer science. Collaboration among computer scientists, mathematicians, physicists, engineers, and biologists is needed to identify functional connections among genes and to work toward eventual applications in the diagnosis, treatment and prevention of human disease.

Cancer biology: Under the cooperative venture, cell and developmental biologists will invent and apply new technologies to understand how healthy cells grow and differentiate and how the disruption of normal...
processes can lead to tumor formation.

Also involved in the collaboration will be Harold Craighead, director of the Nanobiotechnology Center (NBTC), a national science and technology center at Cornell. The professor of applied and engineering physics is involved in collaborative projects on new molecular species for microfabrication and cell growth and in developing the use of microfabrication in biology.

The partner institutions will create core facilities for fundamental technologies such as high-performance computing, physical analysis of molecular structure, light and electron microscopy, DNA sequencing and other tools for genetic analysis and the broad range of chemical techniques that are applied to biology. One aspect of the partnership will be its group governance by the leaders of each institution. Laboratory space also will be shared.

—Linda Grace-Kobas, Cornell News Service

**POOL PARTY FOR BRAIN**

Cornell Big Red Artificial Intelligence Navigator (BRAIN) team won second place at the third annual International Autonomous Underwater Vehicle Competition held on the grounds of Disney's Coronado Springs resort in Orlando, Florida. Cornell's submarine took first place in the safety of design, technical merit, and craftsmanship categories, and tied for second place overall with the competition favorite and two-time defending winner, MIT. This is the first year Cornell students have participated.

Organized by sophomores Walter Chang, Jack Chuang, Nidhi Kalra, and Serguei Vasilvitskii in September of 1999, and advised by Asst. Prof. Kevin Kornegay of electrical and computer engineering, the BRAIN team is Cornell's newest interdisciplinary engineering project, providing students with an opportunity to apply the knowledge learned in classroom studies. This year's team consisted of 42 students, with the majority coming from computer science, electrical engineering, and mechanical engineering. Also represented were engineering physics, operations research and engineering, and the College of Arts and Sciences.

The competition, sponsored by the Office of Naval Research and the Association for Unmanned Vehicle Systems International, is in its third year and is rapidly growing, with 12 teams entering in 2000. Although many of the teams, including MIT, University of Florida, and University of Rhode Island, receive technical support from local oceanography and robotics centers, all work is completed by the student members of the teams.

The goal of this year's competition was to locate and retrieve an orange ring (12 inches in diameter) from a murky lake (350 feet in diameter). A flashing light and an acoustic pinger were placed next to the target and served as navigational guides to the ring. Points were also awarded for gathering aural and visual information about the beacons. The main challenge of the competition was to perform the task completely autonomously, without any communication between the submarine and any person or computer on shore once the vessel entered the water.

None of the teams retrieved the ring. Cornell's team experienced technical difficulties stemming in part from central Florida's extreme heat and humidity but was nonetheless able to complete a fully autonomous run. The sub hovered directly over the target and recorded information from the beacon but was unable to pick up the ring.

Having won first place in static judging in three categories, the Cornell team earned enough points with the autonomous run to tie for second place with two-time winner MIT. Both teams were edged out by the University of Rhode Island, whose submarine came closest to the marker.

“This has been an incredible trip,” said the team caption, Serguei Vasilvitskii. “What we have learned surpasses anything that could have been taught to us in the classroom.”

“We are already considering improvements to this year’s design and we hope to position ourselves to win next year,” added team member Brian Dunstan.

Above, left to right: Members of the BRAIN team are performing final adjustments on the submarine before it goes in the water, left to right: James Buescher, Serguei Vasilvitskii, James Barabas, Lisa Ong, Brian Dunstan, Asst. Prof. Kevin Kornegay, Sean Welch; James Buescher assists the US Navy Divers team in lowering the submarine into the competition lake; Nidhi Kalra and Serguei Vasilvitskii pose with the sub after the competition. Photographs courtesy of the BRAIN team.
The other team came up with an innovative wheel design that allows the robots to scoot sideways or diagonally just as easily as forward and back, a definite advantage on defense.

ROBOCUP II: THE DEFENDERS

A lot of engineering is trial and error. You build it, you test it, and if it doesn’t work, you build it again.

The audience that came to watch the Cornell robot soccer playoffs in May got a practical demonstration of that principle. They learned how soccer-playing robots work and met the students who designed and built them, but due to a technical glitch, they didn’t get to see an actual game.

“It could have been a lot worse,” said Raffaello D’Andrea, assistant professor of mechanical and aerospace engineering and adviser to the teams. “It might not have worked at all.”

What was supposed to have happened was a competition between two teams of soccer-playing robots built over the past school year by two teams of engineering students. The results would determine, in part, which robots would go on to the World Cup of robot soccer, familiarly known as RoboCup, where some two dozen teams will meet in Melbourne, Australia, in late August.

“We will probably take both sets of robots to RoboCup,” D’Andrea said. One of the two teams worked with the robots that won RoboCup for last year’s Cornell team, making a few improvements. The other team started from scratch, and came up with an innovative wheel design that allows the robots to scoot sideways or diagonally just as easily as forward and back, a definite advantage on defense. A few of each type of robot may be fielded as a single team, D’Andrea said.

The event was moved to the Flexible Theatre of the Cornell Center for Theatre Arts to accommodate a larger audience than was able to fit into the Upson Hall lounge last year. Unfortunately, without adequate set-up time in the new location, the vision system wasn’t properly calibrated. As a result, the computer thought everything was seven centimeters away from where it actually was. Robots frequently bumped into the wall around the field and attempted to kick empty air next to the ball. Nevertheless the students were able to explain some of the principles of the game strategy and show the audience how the robots could avoid obstacles and seek out the ball.

Several students will stay on campus over the summer perfecting the system and preparing for the World Cup.

While the Big Red team hopes to win again, D’Andrea said, cautiously, that he expects the team to place in the top four. Last year Cornell literally walked away with the championship, previously held for two years by Carnegie Mellon University. D’Andrea said he believes this was because other teams were made up entirely of computer scientists, while Cornell combined the talents of mechanical and electrical engineers with those of programmers.

—Bill Steele, Cornell News Service

WHAT'S IN A NAME

The faculty in electrical engineering has voted to change the name of their organization to School of Electrical and Computer Engineering. EE Director James S. Thorp, the Charles N. Mellowes Professor of Engineering, explained in the Spring 2000 issue of Connections, the EE alumni newsletter, that the school’s advisory committee recommended the name change to attract students who may be unaware that the school was active in the computer field. After some debate, the faculty voted in favor of the change, and engineering dean John Hopcroft subsequently approved the request. Final approval from the state is expected this summer, and a name-change ceremony will be slated for the fall.

Class of ’00 career stats

- Interview Statistics
  Number of interviews: 7,070
  Number of interview schedules: 830
  Number of Employers Recruiting: 398
  Number of Non-Duplicated Employers: 320

- Average starting salaries (preliminary report)
  B.A./B.S. $51,976
  M.Eng./M.S. $63,245
  Ph.D. $72,375
  (Given the low survey response at the Ph.D. level, the corrected figure is likely to be closer to $80,000.)

- Firms hiring the most CU Engineers (alphabetical)
Big red romance

Under partly cloudy skies on May 28, some 34,000 family members and friends gathered to watch 5,000 graduates participate in Cornell’s 132nd Commencement at Schoellkopf Field. Cornell President Hunter Rawlings challenged members of the Class of 2000 “to continue your work, with great skill, broad knowledge, and the insights gained from both reason and moral conviction, in the world beyond Cornell.”

As delighted classmates look on, Delcia Rawlings ’00 (A&S) hugs fellow graduate Felix Mendez ’00 ME, who has just proposed marriage to her during the commencement ceremony. (She accepted.) Mendez was among 509 engineers who graduated in May. He is now a project development engineer with Ford Motor Company.

The pilot project, called “Nomad,” was funded with a $300,000 grant from Intel Corp. The money bought the base stations and 150 Dell laptops equipped with Aironet wireless networking cards. Base stations have been installed in Olin Hall, Carpenter Library, Upson Hall, Kennedy Hall, Mann Library, Uris Library, Olin Library, Willard Straight Hall, and the Center for Theatre Arts, forming what Hallgren calls a “campus corridor” although there’s still a wide gap between Kennedy/Roberts and Olin Library.

The base stations automatically assign addresses to linked computers, and in theory users can move from one base to another without interrupting the connection, rather like using a cell phone.

It won’t be a replacement for the wired network, Hallgren said, pointing out that the speed won’t be adequate for things like large graphics files, but, she said, “It’s a technology that’s very attractive. It’s a great idea that you can take your laptop and sit under a tree on the quad on a sunny day.”

—Bill Steele, Cornell News Service

GOING WIRELESS

Assignments in CS 502, Computing Methods for Digital Libraries, were due to be filed “by e-mail only” at midnight. At 11:55 p.m., a car pulled up to the curb on Tower Road, in front of the entrance to Kennedy Hall. The student in the car opened his laptop, fired it up, logged onto the network, and turned in his assignment, with maybe a minute to spare.

The story may be apocryphal—none of the witnesses could name the student—but it’s certainly possible, because students in CS 502, as well as COMM 440, Computer Mediated Communication: Theory and Practice, were all issued Dell laptops equipped with wireless networking cards, and Kennedy/Roberts is one of eight buildings on campus equipped with wireless transceivers linked to the campus network. The range of the base station inside Kennedy/Roberts is officially about 150 feet, but there’s enough spread to allow connections from outside the building. (The base station in the Center for Theatre Arts spills over far enough to permit logging in from Collegetown Bagels on College Avenue.)

Once logged in, a wireless user has the same connection to the campus network as any user on an office desktop or in a computer lab.

“My hope is that Cornell will provide campus-wide coverage,” said William Arms, professor of computer science, who teaches CS 502. But for now, it’s a pilot project. “It’s not a campus service; it’s a CIT experiment,” said Martyne Hallgren, assistant director of Cornell Information Technologies. “We’re not encouraging access beyond the class.”

Campus-wide access is certainly the long-range plan, Hallgren said. But, she said, “We have to learn how to support the technology and make decisions on how to roll out a service. We’re trying to be very aggressive, and it will happen sooner rather than later.”

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http://www.nomad.cornell.edu/

things like large graphics files, but, she said, “It’s a technology that’s very attractive. It’s a great idea that you can take your laptop and sit under a tree on the quad on a sunny day.”

—Prof. William Arms, CS

“My hope is that Cornell will provide campus-wide coverage.”

—Bill Steele, Cornell News Service
Wall that went for a walk at the Storm King Art Center by Andy Goldsworthy; Andy Goldsworthy p. 7. Photographs by Alison Sheets '00 ME.
EONARDO DA VINCI was an artist and an engineer; admittedly, he is better remembered for the Mona Lisa than for his various designs of catapults, turnspits, and that flying machine. But in fact, during the prime of his life, da Vinci received just as many commissions for engineering as he did for art. And he wasn’t the odd man out, but one of a group of artist/engineers that flourished during the Renaissance. Back then, a person needed to have many skills, and contemporary masters recognized that art could not exist without engineering—how else could one build giant monuments or construct the dome of a church? These days, of course, careers tend to be more narrowly focused—engineering students rarely have time to venture outside the Engineering Quad, and art students aren’t exactly sure what engineering is. And that’s why a recent collaboration between artist Andy Goldsworthy, a sculptor who works outside with natural materials, and a group of engineering students sounds like a page ripped out of one of da Vinci’s notebooks.

It all started when Andy Goldsworthy visited Cornell in the fall of 1999. Cornell alumni and art patrons Sherry (HumEc) and Joel Mallin (ChE) ’55 are great supporters of Goldsworthy’s work and knew that Ithaca would be just the place where he could find the right combination of scenic beauty and natural materials to create some interesting installations.
During that fall, Goldsworthy produced a series of works in Fall Creek, the magnificent gorge that delineates north campus. Photographs of the work, on display at the Johnson Art Museum, show that Goldsworthy took advantage of the fall color. In one, several thick sticks are joined in a line and then wrapped with leaves that blend from dark russet to yellow to green. In another, a cone-shaped hill of flat river stones seemingly floats in Fall Creek on a bed of bright orange leaves. The hand of man simply reorganizes nature and makes it even more lovely.

Goldsworthy's connection to Cornell was established further when he was nominated as an Andrew D. White Professor-at-Large, a position that entails various visits to campus over a six-year period. More interesting, Professors-at-Large are supposed to find ways to interact with students in an intimate, non-classroom setting. And that's when Goldsworthy and Professor-at-Large administrator Gerri Jones cooked up an unusual way for Cornell students to be part of his work—they could spend time with Goldsworthy during his residence at Storm King Art Center, an outdoor sculpture park in eastern New York. But how to pick the lucky students?

Art majors would be the obvious choice. And then art history, architecture, landscape architecture, and ecology. Goldsworthy specifically asked that engineering students also be invited. Prof. Frank Moon, a faculty member in the Sibley School of Mechanical and Aerospace Engineering who teaches a kinetic sculpture class (see sidebar), was asked to point out the best candidates.

Three students, all senior mechanical engineering majors, signed up to go. Margaret Middleton and Emily Winston had taken Moon's class, and Alison Sheets had built models in the robotics course—surely little works of art. Surprisingly, the students all felt a connection with Goldsworthy's type of work, or art in general, from those and other engineering courses. They know material commonly used in sculpture and comprehend the importance of design. "You say to yourself, here is a steel rod, and it won't torque. You know it," said Middleton, musing on how she built several pieces for the kinetic sculpture class. "In our design course, you have to do a zillion calculations, but not in the kinetic class. But after years of doing designs, you also have a feel for the material," explained Winston.

The engineers were all excited about the visit and felt privileged by the opportunity. They also knew there was work ahead. Obviously, Goldsworthy doesn't pick up all those leaves and sticks and stones by himself; other people comb the woods and help build the structures according to his vision. "It will probably ruin some romantic notions we have of Goldsworthy in the woods with a bunch of leaves," quipped Middleton. "We're going to be slaves to art." But they knew it would allow them to get at the heart of how some of his work is made, and that's what mechanical engineering is often about.

On May 12, Winston, Middleton, and Sheets boarded a bus along with 27 other students and four professors—including Moon—for the trip to Storm King. The sculpture park is 55 miles north of New York City in the Hudson River Valley. Monumental works of art dot their outdoor "green galleries" spread across 500 acres of fields, hills, and forest. The open areas are mowed grass interspersed with large patches of alfalfa; standing on one hill, a visitor looks over groomed fairways dotted with massive sculptures shown as they should be, open and free.

Storm King was founded in 1960 and now owns works by David Smith, Alexander Calder, Isamu Noguchi, and Richard Serra, among many others; there are works from 79 artists currently on exhibit. Andy Goldsworthy completed his first contribution to the center, Wall that went for a walk, in 1998. Like most of his stone walls, it's not just a fence, but a statement. The wall at first follows the line of an ancient stone wall that was in disrepair but the sculpture soon weaves around several trees, dips into a pond, and then rises out of the other side of the water only to head for the New York State Thruway. Built by master stone masons, the 2,378 feet of stacked stone is a testament to both their traditional craft and to Goldsworthy's imagination.

When the Cornell group first
Students apply engineering principles to create kinetic sculptures.

That. The creative process starts with a preliminary design and includes a trip to Rock Stream Studio in Ithaca, where Rhoads does his work (which includes the massive kinetic sculpture at Ithaca’s Sciencenter).

With thumb and forefinger on his chin, studio owner Bob McGuire examines each piece in the exhibition, asking students how they incorporated movement with design. Almost invariably, the answer is “trial and error.” “I didn’t know what they would come up with,” McGuire says. “It’s good to see all of the different directions they have taken, based on the assignment’s narrow focus. Some of this welding is very fine, as is the woodworking. The kids will take this experience as one of their best memories of school. They will learn something that they don’t get from other courses—that ideas have come out of their heads, not out of a book.”

One reason the class is attractive to the students is because it’s non-competitive, says Moon. “There are national and international engineering competitions, but the motivation here is to have some fun, find some beauty in the work, and make it interesting. The only prize is creating a piece of artwork. There is some internal motivation as well; I think two or three of the students could have this as an avocation—they could be sculptors.”
All true sciences are the result of experience which has passed through our senses.

Leonardo da Vinci

Top: Goldsworthy began working in the United States with a piece commissioned by Sherry (HumEc) and Joel Mallin (ChE) ’55 for a sculpture garden at their home. The Mallins invited the Cornell group to view their collection while the students were in residence at the Storm King Art Center; Center: Students talk with Goldsworthy about “Wall that went for a walk.” Photographs by Emily Winston ’00 ME; Bottom: Sculptures created by Goldsworthy and the Cornell students at Storm King. Photograph by Prof. Francis C. Moon.
arrived, they followed the plan of most tourists. There was a mini-bus tour of the grounds and some time to walk around and get up close and personal with some of the larger works. Everyone gravitated to his or her favorites, and for the engineers, those made of metal seemed to hold special attraction. “It was as if the metal was a magnetic field pulling us over. And there was lots and lots of metal,” said Sheets. They were particularly drawn to a structure of metal rods by Kenneth Snelson that looked like a giant group of pick-up sticks thrown into the air. The students marveled at the way Snelson had balanced the rods and strung them together. They also loved the floating squares—made of steel, of course—which were outlines of boxes that in the right light seem to be floating above their own shadows. Between the patches of alfalfa, Sheets fell in love with two huge squares of rusted red metal, oblong blocks tipped into each other. She wanted to run down the field and stand beneath the sculpture, feel the weight, and imagine that she could tip it all back into place.

They also followed the lead of Prof. Moon in crawling into the center of cement bowls made by Isamu Noguchi. Inside, the acoustics were wild. Among works on a much smaller scale, Sheets and others liked the metal stick man that lounged on a wall. “I thought he conveyed a lot of personality for a stick man,” she commented.

In general, the students all gained an appreciation for the work. “I hadn’t taken an art class in school, but now I know it’s OK to like something and not know why,” commented Sheets. This trip validated that non-artists can have opinions about art.

All three students felt the mix of disciplines made for a much more valuable experience. “We could have gone with twenty engineers and it would have been fun, but this was so interesting, to see how other people from other majors react to the sculpture and the land,” explained Winston. “This work involves all kinds of knowledge,” added Middleton.

And the engineers added their particular perspective to the discussions. For example, a metal mobile by George Rickey moved in the breeze. Looking closely, Sheets was impressed by the bearings that Rickey had used to make this sculpture work: “He had the greatest bearings, I don’t know where he gets them.” Not your average art critic comment. Middleton in particular was impressed by how the massive pieces were constructed: “I couldn’t figure out how they fabricated these things. Were they welded or cast?”

The next day, the students were scheduled to work directly with Goldsworthy, rain or shine, and it was raining. This proved a major stumbling block, because the original plan was to have them help mold wavy clay lines down the face of rocks. The dripping water made this assignment impossible, so they switched to sticks. Goldsworthy sent them into the woods to gather wood and then began to construct “stonehouses,” five igloos of interwoven sticks with a stone for the single resident. Dressed in a yellow rain suit and a bush hat, Goldsworthy spoke quietly to the students, directing them to put sticks here or there. Emily Winston soon joined Goldsworthy in placing the sticks. Everyone was covered in dirt and leaves and water, and they loved it. They also felt involved with both the art process and the artist. “I felt very comfortable around him [Goldsworthy]. He was not the kind of person who would ask our names, maybe he’s shy, but I really felt comfortable around him, as if I now know him well,” commented Sheets. Goldsworthy felt the same about his band of students: “This is really quite different. I’m so used to people wanting me to do things for them, and with Cornell, there are all these folks wanting to share their abilities with me.”

Later in the day, the students participated in negotiations on a new commission that Goldsworthy had received from a couple from Santa Fe—he would be working in a desert ecology and with an architect. This meeting, they knew, would teach them about the business of art. The next day, the group visited several private homes in the area with works by Goldsworthy and others. Seeing great art in a private setting had an unexpected effect: “It made me wonder what art is about,” questioned Middleton. “This was a weird glimpse into the world of art and money.”

But Middleton was also heartened by the experience: “I’ve felt that if I put my mind to it, I could be an artist. It’s not inconceivable.” Winston felt the same: “If I work on this [art] and it goes somewhere other than my garage, how cool that would be. Now I know there are people who buy these pieces and support artists and you don’t have to be a slave for art.” But still, that knowledge hasn’t compelled Winston to give up her impending job at General Motors after graduation, and Middleton is still working for Hewlett Packard this summer.

Eventually, it was time for a group photo—everyone in rain gear posing in front of a pile of sticks. But Sheets and Winston don’t appear in the photo because they were off making mischief. Drawn to metal once again, they hung out at the base of an 8-foot-long, 2.5-inch-wide slab of wall rammed into the ground by Richard Serra. Sheets, it turns out, is an accomplished gymnast; she held the Cornell record for the balance beam from 1998 until this year. How could she resist?

Sheets slipped off her shoes and hopped onto the short end of the wall. Arms out, she placed one foot in front of the other, balancing like a ballerina on a million-dollar sculpture as she walked toward the high end. She could feel the welding that held the metal plates together and appreciate the design of the sculpture that balanced not so precariously on the earth. Spread around her in the field she could also see other testimonies to human imagination as well as Nature’s grace. Leonardo da Vinci, fellow artist and fellow engineer, surely would have been pleased.

—Meredith F. Small is a writer and professor of anthropology at Cornell.
Neil Gershenfeld’s workday reality is still science fiction to most people. Even famed sci-fi writer and futurist Arthur Clarke wrote in a postlude to *3001: The Final Odyssey* that he was mortified to discover that his idea of exchanging data through a handshake is being done now—as part of the research that Gershenfeld, Ph.D. ’90 AP, oversees at MIT’s Media Lab.

In the not-too-distant future, according to Gershenfeld, computers will become almost invisible, incorporated into everything from our coffee cups to our clothes. Our own bodies will be transformed into the ultimate Local Area Networks (call them Personal Area Networks), which can transmit data from our shoes to our wristwatches, or to another human being.

Gershenfeld—who has detailed his vision in a book called *When Things Start to Think* (Henry Holt and Company)—works on merging the old physical world of atoms with the new digital world of bits, combining the best of both and making technology easier to use.

“...we are at a very difficult, transitional stage where the technology is like an early adolescent, good enough to be intrusive everywhere, but not particularly helpful,” he says. “Right now, we meet the needs of the machine.” He wants to create objects that meet our individual needs without demanding much attention, such as computers that deliver information at a rate suited to your mood or a coffee cup that can tell the coffeemaker how and when you like your coffee.

As head of the Media Lab’s Physics and Media Group and director of the Things that Think research consortium, Gershenfeld may spend his days devising a quantum computer. Or developing interactive furniture for the Museum of Modern Art. Or helping to create a sensor system that...
can deploy a car’s airbag based on the size of the person in the front seat.

“Some days I like to wake up and behave like a traditional scientist and do research and publish papers,” he says. “Some days I like to do fun things like developing a smart stage for the Flying Karamazov Brothers, and some days I like to work on things that have a global human impact. I appreciate an environment in which I don’t have to decide which of those I am.”

One could say that Gershenfeld’s divergence from a traditional path in the physics profession started at Cornell, where he was a graduate student in applied physics. “At Cornell, I had a wonderful time; it was the healthiest, liveliest physics community I’ve been around,” he said. He also spent time in the electrical engineering and materials science departments making things, time in the math department working on models, and time in the music department playing his bassoon as a diversion. “At the time, I didn’t understand how all these things I was doing were related, even though I saw them as being connected,” he says.

In the music department, Gershenfeld got to know David Borden, a composer who had worked with Bob Moog—the inventor of the modern synthesizer—when he too was a physics grad student at Cornell. “With electronic music, I could push a button and out would come great sounds,” he said. “That was wonderfully liberating until I noticed that the same sound came out every time. I had lost the nuance.”

Gershenfeld almost gave up on the new technology until, one day, he had a revelation. “I began to realize that if I bring to bear the critical skills in the music department that I apply in the physics department, I could ask, ‘What are the effective specifications of a Stradivarius? How much does it measure? How quickly does it compute?’” he said. “And I came to the surprising conclusion that new technology is passing the performance of nature at the level of classical mechanics, so we can hope to start to generalize mature instruments without sacrificing anything.”

But before bringing this idea to fruition, Gershenfeld left to become a Junior Fellow at Harvard University. There, he met Marvin Minsky, one of the fathers of the field of artificial intelligence, who brought him to the Media Lab and introduced him to composer Tod Machover and cellist Yo-Yo Ma. “Yo-Yo wanted to control more sounds in more ways; Tod was thinking about writing for smart instruments; and I was thinking about generalizing instruments,” said Gershenfeld. “We were all really asking the same question from different directions. I stayed and made a cello for Yo-Yo that measured everything he did and could map it into sounds and generalize his performance.”

In creating this unconventional cello, Gershenfeld used sensors to determine where the bow was in relation to the cello, what bowing technique the cellist was using, and where his fingers were on the strings. These sensors were connected to a computer that used the incoming data to determine what kind of sound should be produced by each action. The computer then controlled the collection of synthesizers and signal processors that produced the sound.

Machover wrote new music that not only specified the notes, but also the rules for how the computer generated sound in response to what Ma did; for example, the location and velocity of the bow could control the volume and tempo of a sequence of notes, rather than an individual note, turning the experience with Yo-Yo Ma into a virtual ensemble. “We’re trying to let great players do more,” said Gershenfeld. “But even better is letting more players get access to great instruments. The deepest reason of all is that it used to be that to make music you had to play it. But then mass media split society into a small number of people who were artistically creative and everybody else was a passive consumer. This eliminated that distinction. One object can be anywhere between a Stradivarius, a CD player, and a PC, so that you can let it play music, you can start to control tempo and phrasing, you can take over more and more, blurring the boundaries between passive reception and active control.”

The experience with Yo-Yo Ma changed Gershenfeld’s direction. He realized that all his varied, seemingly unrelated activities revolved around the boundary between bits and atoms, or how the physical properties of a system relate to the information in that system. Instead of heading on to IBM as planned, “I made what I thought was a radical leap to leave the familiar confines of a physics department and do physics in the Media Lab,” he said.

Gershenfeld’s lab brings high-vacuum chambers and advanced machine tools next to musical instruments, sewing machines, and toys. Next door is the Media Lab’s “Cube,” home of Lego’s Mindstorms robotic kit. The Cube is full of parts and pieces and gizmos: touch sensors, light sensors, temperature sensors, radio-fre-

quency chips, gears, motors, and wires. And of course Legos—bins and bins of little plastic blocks carefully sorted by color and shape, boxes of Mindstorms, even a whole cityscape built of Legos.

In this environment, Gershenfeld and his colleagues work on everything from short-term, commercial-driven enterprises to long-term projects that address fundamental issues in physics. The lab members' constant interactions with the consortium's corporate sponsors and other visitors often lead to new, unexpected connections. "Every day I come in thinking I know what we should do next, and every day my students show me that I'm wrong," quips Gershenfeld. One day, trying to get sensors on a violin to measure the position of the bow, Gershenfeld was stymied because the sensors kept reading the position of the violinist's hand instead. After playing around a while, one of his former students, Tom Zimmerman (inventor of the Data Glove), realized that the body was conducting the electrical field away from the receiver. He also realized that this part of the field could be detected by using a circuit matched to the pattern being transmitted. In other words, the human body could be used to transmit data.

Gershenfeld and Zimmerman created a transmitting device that, when placed near a person, changed the body's average voltage by a very small amount. A receiving unit on another part of the body measured this voltage change, allowing messages to be sent. This technique could let a computer incorporated into a piece of clothing, such as the sole of a shoe, send data to a wristwatch display through the body's own natural network. It's only another step further to people exchanging business cards simply by shaking hands.

Meanwhile, Tod Machover was creating an opera piece with magicians Penn & Teller. The group came up with idea of a magic trick—a modern-day version of a "spirit cabinet," which psychic mediums would enter to contact lost souls who would communicate through sounds. They created a seat that radiates a field through the "medium's" body and can measure and respond to the smallest gestures; the performers could then create an entire symphony of sounds just by moving.

One of the Media Lab's sponsors, NEC, which makes the controllers for airbags, saw the spirit-cabinet demo and wanted to know if the seat could be used to solve a major problem for them: the much-publicized deaths of infants caused by airbags. Could a smart car seat be made to recognize the size of passenger and respond accordingly in an accident? The Media Lab quickly developed a seat that uses electrical fields to create a three-dimensional configuration of the occupant, which then determines how the airbag is fired. It is now in production by NEC and first appeared in the 1999 Acura automobiles.

Another project that has many wide-ranging applications is the physics group's work on low-cost tagging, building digital devices into everyday products without adding significantly to their cost. "For a range of reasons, we want to develop computers that cost a penny," says Gershenfeld. "You can’t get there through [expensive] silicon fabrication, so we are studying ways to sense materials so we can replace chips." Low-cost tags are most familiar to us in the form of retailers' shoplifting tags, such as the white strips placed on compact disks. Becton Dickinson and the Media Lab are using the tags to create a smart medicine cabinet. The shelf will read the identity of tags in pill bottles and remind people to take their medication by lighting up the bottle. The whole thing must only add a penny to the cost of each bottle. "To compute for a penny, you have to think deeply about how nature works," says Gershenfeld. The search to find ways to store more data in smart material tags has led Gershenfeld to work on computing with nuclei. "This is using quantum mechanics to make computers that go beyond classical limits," he explains, demonstrating an early version of a quantum computer. A liquid sample is placed in a small, strong uniform magnet. A radio pulse is sent into the fluid, exciting the atomic nuclei, which radio back out a signal that gives the answer to a computation done by the molecules. "This is perhaps the purest notion of the blurring of bits and atoms," says Gershenfeld. "This system is computing, processing information, but it’s doing it by the physical structure of the nuclei. You can’t separate it into the hardware and the software because their workings are so intimately connected."

These and other projects detailed in When Things Start to Think have generated a largely enthusiastic response from a diverse audience. Gershenfeld has heard from officials in developing countries who need to bring technology to remote areas with few resources, older people who are concerned about their ability to live autonomously, and even an eight-year-old kid who shared his dream of the future. "It’s a passionate reaction from the kinds of people that don’t now use computers—they want to know how quickly this stuff can get out of the lab and into their hands," he said. It’s already trickling out now, and Gershenfeld believes the day is not far off when there will be a new digital revolution—one for the people instead of the computers—when the world is full of technology that is sensible, individualized, and hardly noticed. As he wrote in his book, "I will have succeeded if a shoe computer comes to be seen as a great idea and not just a joke, if it becomes natural to recognize that people and things have relative rights that are now routinely being infringed, if computers disappear and the world becomes our interface.”

—Dana Nigro ’93 is news editor of Wine Spectator Online.
Sandip Tiwari remembers the moment well. It was 1982, and he was working at an IBM research center. One day the CFO gathered employees to announce the beginning of a new era: the paperless office. Everyone would have a computer, information would be stored and transferred electronically, and paper would be obsolete, gone, kaput! Offices of the future would be paper-free.

Tiwari, director of the Cornell Nanofabrication Facility, repeats this story now 20 years later, smiling. It is a weak sunned Ithaca late afternoon, and Tiwari sits in his Cornell office talking about the future. He is working on binary systems that are small enough to show single and few electron effects. His computer sits in a corner; there is a supercomputer at his disposal one building away; and upstairs his graduate students minister to
"The paperless office is by now such a failed concept it's become a joke. All you need to do to shoot down someone else's idea is to say, 'Yeah, and they said we'd all work in a paperless office one day.' "

—Gus Venditto, Internet World, November 2, 1998
microscopic projects using computers. But his office is full of paper. Really full. As he speaks of his research, he selects drawings from the piles on his conference table, from piles on his desks, from two banks of filing cabinets.

Tiwari is poised at the tip of a paradox so exquisite it seems almost the stuff of poetry. His research is directed at making computers ever smaller. Yet in this search for more efficient means of storing data, his office is overflowing with paper—articles, sketches, presentation materials. The smaller he wants to go, the more space he takes up.

So what ever happened to the paperless office? Is Tiwari’s conundrum the rule or the exception? Six members of the engineering faculty talk about the paper in their offices, how they harmonize it with available technology, why they use paper or don’t, and what might happen in the future.

Albert R. George, Ph.D. ’64, John F. Carr Professor of Mechanical and Aerospace Engineering

The piles around here used to be a lot worse than what you are seeing now. I had a few more on the floor and on my credenza. And the piles were growing. Even the stuff that is still in here used to be twice as high. I finally had enough: I decided earlier this year that I wanted to get rid of all the paper accumulating in my office.

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I’ll also have hard copy. This is important because of disk life and in case there are future incompatibilities with software—I already have problems with things I had on an old Apple II. If I put the diskette into a modern computer, chances are it won’t even be able to read the document nor even be able to open the diskette.

You still need hard copies. I think everyone will agree that people use more paper now that they have computers.

Mark Heinrich, Ph.D. ’98, assistant professor, School of Electrical and Computer Engineering

You can’t argue that there is more paper than before. I’m sure 20 years ago the department sent everything out via paper. Now we communicate paper-free with e-mail. The days of FedExing documents are gone. You attach things to an e-mail.

For archival purposes, I have things on redundant systems. Hard drives do crash; it’s happened to me. In fact, my hard drive crashed when it had my Ph.D. thesis on it, and I had no hard copy.
But I had a copy on a Zip disk so there was no problem. As long as you have backup, you don’t need paper. When I travel or work at home, I use my laptop. I used to do a lot of programming and had a huge computer screen. But I love having something smaller and mobile that does not dominate my work area. I take my laptop everywhere.

When I go to class, I have everything on PowerPoint so I just bring my laptop and plug it in. The basics are all there, though I leave graphs blank and other things that students have to fill in themselves.

I think the move away from paper is starting to happen, but it’s slow. This is not going to move at the rate of the computer evolution; it’s going to move at the rate of human evolution. People have certain social customs that computers defy. I can be at a talk and be reading a paper, and that is more socially acceptable than bringing a laptop. We’ve had the technology to vote electronically for 30 years, but people are so nervous. They are sure computers are going to do something strange to the ballots.

There are some things for which the use of paper has never ended. I don’t see computers generating tests, or people taking tests on a computer. It takes ten seconds to jot down a question with integrals, but with a computer you have to use a menu and find keys. It’s a nightmare. Likewise with taking a test, we need to see the students’ equations and thinking. It would take hours on a computer.

The stuff I keep in paper form are old student tests, homework, exams, grading sheets, and accounts of grant money balances.

I aggressively control what I bring into my office. When I go to the mailroom, I spend 10 minutes going through my mail. Ninety-five percent of what I get is recycled there—if it’s a schedule or agenda, I’ve already gotten it online.

Once I’ve acted on something, I toss away the paper. I have e-mail and a calendar online that my wife can also see where I’m going to be, and [she can] add things, like if I need to take our child to a doctor’s appointment. I have no printer. Someone has to work hard to get paper into my office.

I’m not a zealot. It is just that there is little influx of paper into my office and I don’t generate any.

Arnim Meyburg, Ph.D. ’71, professor, School of Civil and Environmental Engineering

The fact is, the inflow of paper far exceeds the ability to make the outflow just as big. We get so much information—campus mail, journals, notices, outside mail—and now with computers we get more.

When I moved offices, I threw out an enormous amount of paper—this whole credenza surface was empty. But I just keep getting stuff, and I can’t throw all of it away. There is no time—with research, teaching, and administrative and committee work—for recovery, for filing everything away. I occasionally get fed up with myself and all this clutter, but I cannot spend my whole day making everything neat.

My set-up at home is identical to that here, so I just pick up my disk drive and can take it with me. It improves the quality of my life—at home I have my family, and a refrigerator and couch nearby.
nearby. I can be more mobile with my Zip drive. But I can’t move around in my office. If I were to have a meeting at my conference table, I’d have to print any documents we’d need.

Everything is stored on a computer. There is lots of it that is replicated in hard copy, but there is a lot of it that is not. There are things like lecture notes, transparencies that are replicated, and having them on the computer means I can go back and amend and not start from scratch. We develop everything on the computer, and so it makes sense to leave it there. We have not yet developed a protocol or etiquette about e-mail. If we write a letter or phone someone, we don’t expect to hear back in the same day, but we expect an immediate answer on e-mail. You feel compelled to answer everyone’s e-mail immediately, and that is not the best use of time.

E-mail has increased interaction tremendously—we get many more inquiries from prospective graduate students because they can send us materials at the press of a button, when they might not have been able to afford the postage to send their materials to all the schools they can now. As for current students, I perceive a reduction in the amount of time we talk to students outside class. Our e-mail is replacing our office hours to a great extent. … The current student population has grown up more comfortable with computers which are backed up by the illustrations and well developed, the illustrations are not writing better just because they can print out a document a hundred times. I don’t get the feeling that books or paper will ever be replaced.

Sandip Tiwari, Ph.D. ’80, professor, School of Electrical and Computer Engineering, and Lester B. Knight Director, Cornell Nanofabrication Facility

It used to take discipline and effort to write paper documents (typewritten). That is not the case anymore, with computers spitting out paper at the push of a button. And this has made for bad writing and spurious publications. People use paper poorly. People are not writing better just because they can print out a document a hundred times. I do not get the feeling that books or paper will ever be replaced.

In many developing countries, such as China and India, you still walk into government offices and see how everything is done with piles of paper. … Replacing the forms-type paperwork is a task that computers are particularly suitable for. … All societies, including here, do have a number of occupations—tellers, checkout clerks—that automation can replace. … These are hardworking people; their unemployment would lead to systemic problems in their societies.

Transparencies encourage interaction.

E-mail and communications are cases where computers have solved more problems than they created. As faculty, we are more productive because we are able to generate documents on our own where [before] we were totally dependent on secretaries. … I’ve become much more efficient.

Sandip Tiwari, Ph.D. ’80, professor, School of Electrical and Computer Engineering, and Lester B. Knight Director, Cornell Nanofabrication Facility

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Computers and disks are do have value. When my parents visited from India, they went to the Kroch library and were able to read a number of out-of-print commentaries by Max Muller, Wilson, etc. on old Indian writings—the Vedas and Upanishad—that they didn’t have access to in India. … If they could get this on diskette or off the Web, great.

The future is going to change how much people still end up wedded to old technology. I know of places that are still using these old Wang systems from twenty years ago, and they can’t change or upgrade them because of all the information that is already stored there—it’s unreadable on other systems. … In the future, people will not be replacing computers every two to three years. The hard drive will stay the same. The method of transfer will be what changes, such as Zip disks, CD-ROMs, and DVDs. I do wish at least some reduction would take place in the use of paper as a result of use of computing, for the sake of the forests. Unfortunately, that just doesn’t seem to be happening.

My drafting takes place on the computer, but at least a few of the intermediate editing steps take place on the paper. Paper leaves on me a more lasting impression, so makes it easier for me to make connections. This may be because written books have had much more effort put into them. The writing is succinct and well developed, the illustrations appealing—a more developed form. And then there is the feel of the paper. I keep copies of papers that have been particularly appealing to me. So, it is natural that they are the ones I am subconsciously making connections from. I do carry a lot of information on computer—my final papers, etc.—and I do not have to print them to look at them. But papers by others, if I have found them useful, I keep them in paper version for reference. I don’t want to have to go look for it, and then print it out. It’s easier to keep those things on paper.

Yuri Suzuki, Ph.D. ’95, assistant professor, Department of Materials Science and Engineering

I have paper files, but after a while I can’t find things in my filing cabinet, so I usually end up just going back to the Web and finding the article again and printing it out, or printing it from my hard drive. It’s easier.

Things do pile up but I purge them regularly. We purposely keep our data-taking computers off of the network. When we take data from experiments, we transfer them by Zip disks to other computers which are backed up by the Cornell Center for Materials Research computing facility, so we always have a second way of backing up things. Research data is paperless, so that doesn’t accumulate. Student papers and journal articles do. …

From a technology point of view, to
get rid of paper we’d need something that is just as bright and inexpensive as paper and just as light and portable. Prof. Thompson in the materials science and engineering department is working on a flexible display—something that you can just roll up and take with you.

For my class I started putting my problems on the Web, but ... it is a burden for students to leave class and go find their homework on the Web and print it out. It makes sense to give it to them in class, and it uses paper all the same. Students like to have paper that they can take with them anywhere.

I will not trust a laptop in class—you could have your whole lesson planned around PowerPoint and then it won’t work at the last minute—this has happened to someone I know.

When the American Physical Society had their convention, we got a meeting listing the size of a phone book. I went to the Web and searched the listing for the talks I wanted because it was easier to find. But when I was actually at the conference, I had to drag the book with me just in case I missed something in my Web search. The Materials Research Society has now arranged it so that you can download the meeting listing onto your Palm Pilot!

I only send things electronically.... When I go to a conference, I take printouts of papers for reading. Paper is so much lighter than my laptop. I prefer to leave it at home if I can.

The Palm Pilot replaces and organizes paper. I like it, but I don’t carry it with me everywhere. I don’t use the alarm or to-do lists.

Every day when I get mail I throw a lot away. A lot of paper and dead trees result from this. I hope as people get more and more environmentally conscious there will be less paper.

I just stopped my paper subscription for a physics journal newsletter, and I’m going to see how good I am about going to the website. ... Because I have so much work, I tend to postpone reading journals. If it’s cluttering my office, it forces the issue.

Every few weeks, I decide I have too much paper, and I purge. ... I have piles, but they do not grow.

Teresa Jordan, Ph.D. ’79, professor, Department of Geological Sciences

I have so many papers my file cabinets don’t close properly. I just added new file boxes to the top of my file cabinets.

Now that we have computers, we as a group can accomplish things we could not before. We can unite data sets. But computers have also increased the pace at which we fall behind. Everyone is generating things, and we cannot keep up with what we are all putting out there. I have no doubt computers cause us not to keep up with the literature. Everyone I speak to is so far behind. I have no doubt computers cause us not to keep up with the literature. Everyone I speak to is so far behind. Everyone is generating things, and we cannot keep up with what we are all putting out there. I have no doubt computers cause us not to keep up with the literature. Everyone I speak to is so far behind.

We create so much but we don’t evaluate one another’s results and don’t know what endless creation is doing.

I have many more things on the burner, many more projects. In the absence of computers, I’d have two or three major projects. Now I am juggling seven or eight. And of course, all of them create paper.

I don’t trust the computer not to crash. I know from experience that today’s files won’t necessarily be readable on the software of ten years from now. Pieces of paper are the only reliable way of archiving.

I’m not a Palm Pilot person. You can store things in it, but you can’t read documents. With paper I can read on the bus, at home, anywhere. It’s not the weight. I walk around with sample rocks in my backpack all the time, so weight is not that big a deal. You can’t make rocks any smaller, so I’m not concerned or going to be won over by lightness.

I could be more systematic with my computer, but I don’t want to deal with it. I do my best thinking when I am nowhere near a computer screen. I don’t feel that concerned about the office of the future. I think that things are going to stay pretty much the same for me.

If the problem computers were meant to solve was the use of paper, then they are a miserable failure. But if the problem they were meant to solve was to generate more meaningful data, I think they have been an astounding success. And I do think that was their main goal, not the saving of paper.

S o computer technology didn’t produce the paperless office. We thought it would; we even collectively desired that it would. Instead, it gave us new tools that we can use according to our needs. And while we may have feared that technological progress would escape our control and destroy our individuality, we underestimated our own idiosyncrasies. Rather than obscure our authentic selves, technology allows us to be that much more expressive.

—K.A. Major is a freelance writer living in Ithaca and New York City. She can be reached at kam9@cornell.edu.

WHEN THE AMERICAN PHYSICAL SOCIETY HAD THEIR CONVENTION, WE GOT A MEETING LISTING THE SIZE OF A PHONE BOOK.
EAT W
Jean Hunter plucks the space food from a cardboard box on her bookshelf and lays it on her desk. It’s dehydrated, pale, wrapped in thickish plastic. Each vacuum-sealed package has spots of blue Velcro on the corners, so you can stick it to your spacesuit—lest your dinner float away in zero gravity. Some have valves for sucking the contents through a straw; all are bar-coded and labeled in both in English and Russian, relics of the Mir era. There’s a bag of Tang, some creamed spinach, a few dozen cashews clumped together, a chalky-looking portion of beef stroganoff, a sad little beef patty, crumbling into its constituent parts.

The food didn’t always look this unappetizing, the agricultural and biological engineering professor says with a grin. NASA sent it to her several years ago, and it’s been manhandled by countless visitors. “I’ve talked to a number of astronauts,” she says, “and they all say it’s really pretty good.”

But Hunter wants space food to be more than just pretty good. She wants it to be tasty, nurturing—a comforting slice of Mother Earth for people working as far from home as humans can get. It’s been her passion since 1997, when the space agency awarded her a three-year $500,000 grant to develop recipes and menus for long-term missions and planetary colonies. Previous efforts had focused on growing the crops that would provide the necessary nutrients. But as Hunter puts it, “no one had ever really looked at converting those plants into food. And you can’t just eat a head of wheat.”

With an interdisciplinary team of experts—crop specialists and food scientists, chefs, operations researchers, nutritionists—
Hunter set about studying every aspect of food production in space, from farm to table. “Ultimately, we’ve drawn in people from all over campus, because it’s just so much fun,” says Hunter, who holds a bachelor’s degree in chemical engineering from MIT and a Ph.D. in engineering science from Columbia. “Working on space is a noble mission. It’s exciting to be part of exploring new worlds.”

Hunter and her team weren’t aiming to replace the vacuum-sealed packages, which are designed for a weightless environment where cooking isn’t possible. Rather, the project was geared toward long-term exploration planned to begin in the next 15 to 20 years—colonies on the Moon or Mars, or missions on ships equipped with artificial gravity. The goal was to figure out which crops to grow in space, develop efficient cooking techniques, and plan menus that would meet a host of financial, biological, and technical constraints. Oh, and it all had to taste good, too.

When Hotel School senior lecturer Rupert Spies joined the project, he was reminded of stories he’d heard about polar expeditions, where meals were one of the only sources of consolation. “The chef was held in high esteem, because when you’re in the dark, in the cold, food becomes very, very important,” says the German-trained chef. “We thought if you’re on the Moon or on Mars, and you have the same lack of visual stimuli, food in the greenhouse and on the plate is a very important part of your everyday life.”

So why not just pack it all to go? “When you eat in space, you have sort of a forkie-spoonie thing and a pair of scissors,” Hunter says. “But there are problems with doing that on a thousand-day mission.” Never mind that eating reconstituted spinach with a spork for three years straight would drive the most dedicated space jockey insane. There’s another major issue: money. It’s phenomenally expensive to blast anything out of the atmosphere. The weight of the plastic packaging alone means that “Earth-lifting” all the food is out of the question.

Instead, future astronauts will be limited to the ingredients they can produce themselves—crops grown under artificially lit, temperature-controlled conditions—plus a precious cache of extras from home like spices, vegetable oil, coffee, tea, vanilla extract, black pepper, chocolate, and parmesan cheese. The Cornell study set a target that these treats would make up no more than 10 percent of the total diet. The other 90 percent could be farmed on the final frontier: wheat, potatoes, rice, soy, peanuts, lettuce, tomatoes, carrots, onions, fresh herbs, chard, kale, cabbage, and beets. “We used a lot of bell pepper,” Hunter says. “And mushrooms. I wouldn’t go to Mars without mushrooms.”

“Narrowing down the ingredients was fairly straightforward. Meat was out, since there’s no such thing as a hydroponic chicken. (Except for the occasional sprinkling of parmesan, the diet is almost entirely vegan, or non-dairy vegetarian.) No fruit grown on trees. Nothing high in sodium; it exacerbates bone loss and creates a waste-disposal problem. And since astronauts are busy people, nothing too labor-intensive. “When we first started, we thought the energy to grow crops was the limiting factor in having a farm on Mars,” Hunter says. “But now we’re seeing that crew time is at least as limiting.”

For the recipe development she tapped Adriana Rovers, a former Cornell staff photographer with an extensive background in vegetarian cuisine—she’d run her own natural food store and bakery in nearby Auburn and taught cooking classes at the local community college. In addition to being limited by the list of some 30 ingredients, she also had to stick to just a few cooking techniques: the oven, the stovetop, and a bread machine. Rovers came up with more than 200 dishes, both her own recipes and some adapted from vegetarian cookbooks. They included sweet potato pancakes, seitan tacos, carrot drumsticks, pasta primavera, basil pesto with soy nuts, seitan stroganoff with shiitake mushrooms and soy milk over brown rice, barbecued seitan, pasta with vegetarian bolognese sauce, carrot muffins, tofu cheesecake, and chocolate soy candy. “The desserts were tough,” she says. “There wasn’t a lot of fresh fruit to work with, no sugar, and no honey.” Her solution: amazake, a sweetener made from fermented rice. Other alternatives included a combination of starch-derived sweetener (wheat starch syrup, which is very similar to corn syrup) and artificial sweeteners such as sucralose.

But was the food any good? Once a week over the course of two years, some five dozen volunteer taste-testers reported to a classroom attached to a kitchen in Human Ecology’s Martha Van Rensselaer (MVR) Hall. There, they sat in individual carrels and sampled six of Rovers’s creations, then filled out elaborate surveys on each. “I’ve got to tell you, some of the stuff was just plain odd,” says taster Roger Jagoda, who’s in charge of information technology for the Department of Agricultural and Biological Engineering (ABEN). “They even had this thing called ‘lentil loaf.’ I got to like it, though.”

The criteria for the testers were nearly as stringent as for the food itself. Volunteers had to be grad students or staff, aged 30 to 55, in good health, with stable weight, no major dislikes, and no food allergies. And although vegetarians would have lined up for a plateful of Rovers’s potato and fresh coriander stir-fry, they were out of luck; no veggies allowed. “We wanted people who eat meat on a regular basis, to get as much fidelity as we could toward the astronaut corps,” Hunter says. “Vegetarians wouldn’t have to cross any adaptive hurdles to enjoy the food.”

Hurdles notwithstanding, the tasting team liked many of the foods, though they also dished out a fair amount of criticism. Among the most common: that the recipes were a bit boring, had too many herbs, or were too spicy. Some people didn’t go for the texture of tofu or the flavor of milk alternatives. “One thing that surprised me,” says Hunter, “was how critical people
can be and still give something a passing grade." The single biggest complaint was the lack of salt—something that Spies says bedeviled the chefs, who tried to compensate with seasonings, soy sauce, and hot spices. "Adriana would say, 'What's missing?'" he remembers. "And I'd say, 'You know what's missing.'"

Those two years of tastings helped refine the recipes, but researchers had no idea if the dishes would hold up to long-term scrutiny. So they recruited 16 of the tasters to live on the space food—and only the space food—for 30 days. The tasters called themselves The Cooler Club, after the little boxes Rovers and her cadre of grad student and Hotel School volunteers filled with their dinners and weekend meals. On weekdays, breakfast and lunch were served at MVR. The participants took vitamin supplements and were allowed calorie-free drinks like coffee and Diet Snapple, but all other Earth food was verboten.

"Definitely, in the beginning, I had to get used to the fact that if I was cooking, I couldn't lick my fingers," says Elizabeth Babcock Woodring, a lab technician in the horticulture department who got married during the study and had to freeze a piece of her wedding cake to eat later. "My family was very supportive. They didn't shove food in my face, and they understood when I didn't want to cook something for them that might tempt me too much." As for Jagoda: he once had a dream in which he was eating chicken, and he chewed so loudly he woke up his wife.

Although the subjects could take as much food as they wanted, Jagoda says, "most people felt hungry a lot, because it really wouldn't fill you up." A fan of Tang and "Space Food Sticks" as a child, Jagoda found the diet didn't give him enough energy for his running and weightlifting regimen; he also discovered an antipathy for soymilk. "I just couldn't stand it," he says with a laugh. "Soymilk should be used to lubricate engine parts."

Like many of his fellow tasters, Jagoda lost weight on the diet, mostly due to the lack of sodium. "I lost six and a half pounds," he says. "Then I gained it all back, plus a pound." Another reason for the weight loss, Hunter says, is a phenomenon called "sensory-specific satiety": people get tired of eating the same type of thing, so they eat less—which is why you can feel full at dinner, but still have room for dessert.

In general, though, the tasters enjoyed the food; none of the 16 dropped out, and they’ve even been pressing Hunter and Rovers to publish a cookbook. Not that they weren’t relieved when the 30 days were over; at the end-of-study party, the volunteers consumed seven pizzas, two ice cream cakes, and a whole lot of candy.

Hunter’s department, ABEN, is a hybrid between the agriculture and engineering colleges. But her space food project had yet another engineering angle: she and Spies collaborated with Prof. Peter Jackson in the School of Operations Research and Industrial Engineering to develop a course titled “What shall we eat on Mars.”

Students and faculty conducted a two-year work-factor analysis. First they videotaped Rovers in the kitchen, then defined and timed the various tasks of meal preparation, such as mixing, chopping, stirring, measuring, and interacting with stove and worktable. In an effort to make the best possible use of cooking facilities and reduce downtime, they also studied the kitchen equipment, the use of oven space, and the order in which ingredients are added. "It’s classic industrial engineering, analyzing what a worker is doing," says Jackson. "Some things can be automated, but putting a meal together is still quite a manual operation."

The independent study course gave students hands-on experience in database techniques, statistics, optimization, and PowerPoint presentation. On top of the basic research, the students conducted their own optimization projects, on such topics as coordinating the menu to the farm’s harvest cycles, and studying how the system would be affected by letting the crew choose 20 percent of the meals. The optimization angle jibes well with Hunter’s original concept for the study. To make her findings as widely applicable as possible, she looked at space cuisine as an optimization problem, with variables including advances in technology, budgetary constraints, and NASA’s evolving priorities. If strawberries and melons are nixed due to cost, for instance, they can be removed from the menu at the click of a mouse. Constraints like power and labor can wax and wane; the role of cheaper, more productive crops (such as potatoes and wheat) can become more or less dominant in the diet as needed.

Now Hunter is deep into data-crunching, NASA has extended the term of the study by a few months, and she expects to deliver her findings this fall. Plus, her volunteer taste-testers are still clamoring for that cookbook—call it Diet for No Planet at All. "I'll consider it a success," Hunter says of her guide to galactic cuisine, "if it inspires people to eat their veggies."

Beth Saulnier is associate editor of Cornell Magazine and recently published her second novel, Distemper (Warner Books).
If you stayed away from Ithaca during the Cornell Society of Engineer’s annual conference April 13–15, here is what you missed:

- A priceless overview of the “broadband revolution,” the revolution in the communications industry made possible by new broadband technology. Industry leaders from equipment, content, and service companies discussed the technologies and business models underlying the “new economy” based on this revolution.

- A transcontinental Q-and-A session at the distance learning center, where Jeff Hawkins ’79, inventor of the Palm Pilot, and an audience in Silicon Valley interacted with the audience in Ithaca.

- A memorable banquet evening that unfolded with inspiring tales behind this year’s teaching awards, an expose of the communication peculiarities of the ruffed grouse by Jack Bradbury, Robert G. Engel Professor of Ornithology and director of the Library of Natural Sounds at the Cornell Laboratory of Ornithology, and the piano stylings of Tom Foulkes ’52.

Conference chair Robert Maroney ’72, president of Sigma Optics, extended the scope of the presentations this year and drew an exceptionally large attendance.

Jay Walker ’77, founder of Priceline.com, launched the conference Thursday evening with a sweeping and thought-provoking review of civilization’s great networking revolutions—those of electric power, transportation, and telephone, broadcast, and Internet communications. The great challenge of our age, he said, is to understand the special, powerful properties of the broadband network, which he predicted will soon connect everything and everyone. He warned, “If you think things are disorienting now, you ain’t seen nothing yet! We as consumers, parents, citizens, and individuals will be totally changed.”

Later that evening, conference participants followed Jeff Hawkins’s humorous account of the early days of the personal digital assistant. His biggest challenge, he said in response to a question from an engineering undergraduate in Ithaca, was to resist the prodding of his marketing staff to add ever more features. “There are no bad features,” he explained, but adding even 10 lines of code to an already complex system invariably causes problems out of proportion to the benefits of the added feature.

Friday’s sessions provided examples of successful businesses founded on new technology and new regulatory environments. Irwin Jacobs ’54, CEO of Qualcomm, showed how his company succeeded by pioneering the use of code-division multiple access, or CDMA, for wireless and...
Internet applications. CDMA is a scheme to permit multiple users to share the same bandwidth and time interval; each user or telephone conversation is tagged with a code so it can be isolated from others on the receiving end of the communication.

Jack Scanlon MS ’65, CEO of Asia Global Crossing and vice chair of the board of Global Crossing, described the challenges of connecting the continents with optical fiber. These included raising $12 billion in two years, buying 40 percent of the world’s cable-laying ships, and learning how to bury cable so that French fishing trawlers specifically don’t dig it up.

C. Jay Abbe ’63, president and CEO of Optical Coating Laboratory Inc., described wavelength-division multiplexing, the technical underpinning of the broadband revolution, emphasizing that the components that make it possible, such as amplifiers that operate in the optical wavelengths, are key.

Mike Malaga ’86, chair and CEO of Northpoint Communications, emphasized the so-called “last mile” problem of connecting millions of individuals to the broadband networks crisscrossing the country and the globe. “The real story of the last mile is not one of technology but of regulation,” he said. His efforts to learn about the regulations governing rights-of-way and the needs of medium and small businesses helped bring about the success of Northpoint, which now has the nation’s largest digital subscriber line (DSL) network footprint.

In the afternoon, Kenneth Goldman ’71, senior vice president and CFO of @Home Corporation, spoke of the company’s growth as a provider of both content and Internet access. He emphasized customers’ seemingly boundless demand for bandwidth, as they get used to full-motion video, audio, and high-resolution photographs on their desktops. After a break, Cornell faculty members Toby Berger, Venu Veeravalli, Zygmunt Haas, and Sheila Hemami outlined their work on the theoretical underpinnings of tomorrow’s technologies and systems solutions.

Saturday’s program featured the perspective of a venture capitalist. Michael Zak ’75, general partner, Charles River Ventures, told an enthralling story of being an early investor in CIENA Corporation, a leader in optical networking systems.

Mayo Stuntz ’71, COO of America Online’s Interactive Services Group, and Mario Vecchi ’69, vice president for broadband development at AOL, wrapped up the conference with a presentation on the blurring of the four traditional “boxes” in people’s homes: television, the hi-fi system or “mood box,” the computer, and the telephone.

Attendees were asked to list suggested topics for next year’s conference on an evaluation form. Rumors are that suggestions relating to “Space 2001” abounded. Whatever it turns out to be, if it’s half as informative and fun as this year, it’ll be worth the trip.

—Leila Belkora

SPIRO TAPPED FOR VP

Early in his career, Mark Spiro struggled with a decision—whether he wanted to be a scientist or an academic administrator.

“I guess it’s clear which path I chose,” said Spiro, an associate dean for Cornell’s College of Engineering who is leaving Cornell after a 22-year career to become a vice president at Colgate University.

But Spiro may have gotten the best of both worlds. He began his career at Cornell as a technical assistant in the Division of Nutritional Sciences and then as manager of operations and assistant director for the Department of Chemistry; he later moved to the College of Agriculture and Life Sciences research office as an executive officer, and then to the College of Engineering as an assistant dean, and then as an associate dean.

For the past few years, most of his energy was devoted to leading faculty, administrators, and building professionals through the conceptual and design phases for Duffield Hall, a $62.5 million project.

Spiro, 50, entered Ithaca College as a music major and received his bachelor’s degree in psychology, with a minor in audiology, in 1972, and he received his master’s degree in audiology from Ithaca College the next year. He subsequently received an undergraduate degree in chemistry at Dalhousie University in Halifax, and later completed his doctoral coursework in educational economics at Cornell.

He came to Cornell in 1978 at the age of 28, working as a technical assistant in nutritional biochemistry before being hired by the chemistry department. He gained experience in managing land grant funds and database management in the College of Agriculture and Life Sciences and was hired by former dean Bill Streett as the director of administration for the College of Engineering in 1987.

“I was very fortunate that Bill had hired Mark, because when you become dean, you need a really world-class individual as your right-hand person,” said John Hopcroft, who succeeded Streett as dean in 1994. “Mark has an unparalleled ability to seize a large, complex problem, take it apart, analyze the pieces, and put it back together again to solve the problem.”
City of Ithaca workers place the spans on the new Carl Sagan Bridge over Cascadilla Creek near Adams Street June 12. The bridge is constructed with lightweight bars made from fiber reinforced polymer (FRP) developed by Petru Petrina, a lecturer in Cornell’s School of Civil and Environmental Engineering.

One of Spiro’s goals was to improve the college’s standings in the then-new U.S. News & World Report rankings of colleges and universities. After many, detailed conversations with the magazine’s statistician, he began optimizing the information the college provided.

“It was interesting finding out exactly what information was being used in the various statistical categories, and then optimizing those categories, making sure we had included everything we should have,” Spiro said.

The college’s ranking increased from about 10th to 6th the very next year, and remained at between 6th and 8th for several years. “After a few years, of course, everyone realized it was important to optimize, and we lost our competitive advantage,” Spiro said with a laugh. But the college has remained near the top of the list ever since.

Spiro helped improve salaries for associate professors by analyzing the college’s salary rank relative to its peers and rebudgeting college funds. Those activities changed the college’s salary rank from about 16th to 10th. Streett said Spiro also turned the college’s budget records into a computerized budget system and tackled difficult issues regarding space allocation within the college.

Since 1996, Spiro has been involved with the Duffield project—a tremendous facility that will bring many of the college’s researchers and nanotechnology and nanobiotechnology projects together under one splendid roof. But with the design phase over, Spiro began looking ahead.

“The College of Engineering, with an annual budget of about $160 million and about 13 buildings, is larger than many small colleges and universities in this country,” Spiro said. “I think my responsibilities over the past decade in the College of Engineering have prepared me well to move on to an executive level position in another institution.

“I grew up as an administrator in the College of Engineering,” Spiro said. “I had the opportunity to work with an extraordinary staff, a wonderful faculty, including a group of very committed and talented chairs and associate deans, and I have just thoroughly enjoyed my experience here.”

—Joe Wilensky

The first span of one of the nation’s most unusual bridges was set into place Monday, June 12, when Cornell University engineering students and the city of Ithaca joined forces to begin construction of the Carl Sagan Bridge over Cascadilla Creek. The bridge will cross from Adams Street to a city park also named in Sagan’s honor, near the Sciencenter. The bridge’s two longitudinal beams will have nine, 2-foot-diameter circular holes to be filled with the signs of the nine planets.

The pedestrian bridge deck, 7 feet wide and 42 feet long, will contain no heavy steel bars but instead will be constructed from concrete reinforced with plastic-and-carbon bars so light in weight they can be lifted with a finger and thumb.

The project and the lightweight bars are the inspiration of Petru Petrina, a lecturer in Cornell’s School of Civil and Environmental Engineering, who is leading a group of members of the student chapter of the American Society of Civil Engineers in giving his lightweight bars, made from fiber reinforced polymer FRP, their first trial. The bridge has been designed by Petrina and the students, and the design was reviewed by Richard White, Cornell emeritus professor of civil and environmental engineering. The students made the construction drawings, made the FRP, and managed the assembly at the site.

The city of Ithaca is paying $13,800 of the cost of the $18,400 structure, with Cornell paying the balance.

—Cornell News Service
The Cornell student chapter of the American Society of Civil Engineers triumphed in the upstate New York region concrete canoe competition held at Union College April 8.

The concrete canoe contest entails designing and building a boat out of concrete. The team, dubbed C4 (for Cornell Concrete Canoe Company), first won “best design paper” in the competition, then “best presentation” and finally went on to place first in the men’s sprint and third in the four-person, co-ed race. Nine canoes competed in the upstate region contest. Cornell’s toughest competitor was the U.S. Military Academy, which took a first in the women’s sprint race and seconds and thirds in other competitions. Other teams were entered by Union College, Hudson Valley Community College, Clarkson University, the University of Buffalo, Rochester Institute of Technology, and Nassau Community College, which entered two teams.

Cornell men on the team were Troy Zezula, Dan Mullins, David Krell, Paras Shelawala and David Saunders. Cornell women were Martha DelCampo, Courtney Kimball, Karolyn Sutphin, and Lucie Fougner. Team members not competing were Rob O’Neill, John Tam, Peter Velez, and Ed Brillante.

The winning Cornell team suffered no major mishaps. The only damage that was inflicted on the boat occurred at the shore when a competitor’s boat chipped a piece out of the gunwhale. But the canoe was repaired in time for the finals in Golden, Colo., hosted by the Colorado School of Mines, in June. It was Cornell’s first visit to the nationals in a decade. Though the team was unsuccessful, they had their best showing ever, garnering ninth place in the best paper portion of the competition.

C4 MAKES A SPLASH

generation next

From left, Benjamin Nichols, Cornell professor emeritus of electrical engineering and Ithaca school board member; Alec Wright, mechanical engineering consultant; and Michel Louge, Cornell professor of mechanical and aerospace engineering, judge DeWitt Middle School eighth-grader Ira Edelman’s entry in the Junior Solar Sprint competition in the DeWitt gym May 20. Fifth to eighth graders from five upstate schools vied for a place in the regional championship for miniature solar cars. The event was hosted by DeWitt’s technology education program, with help from CU mechanical engineering undergrads.

—Cornell News Service

CHAMPIONSHIP RACING

Cornell’s student Formula SAE team scored well when the Society of Automotive Engineers’ collegiate race car competition was held in Pontiac, Mich., May 17–21. Competing against 103 other teams from the United States and abroad, Cornell scored three firsts, two seconds, and two thirds, taking home $3,750 in prize money.

The overall winner of the competition was Texas A&M, with the University of Wisconsin being the runner-up. Cornell placed 13th overall, losing points after failing to finish the endurance event.

The 25-member Big Red team placed first in the acceleration race, the Goodyear Best Performance Award, and the Bosch Engine Management Award.
In addition to engineering socials, lectures, and other college and department activities, alumni returning for Reunion 2000 in June got into the swing of things with some sporting events. For more reunion photos and stories, visit <http://www.news.cornell.edu/Chronicles/6.15.00/Chron.html>.

Come out swinging

Top: The 5th annual Cornell Baseball Reunion Game, open to all former Cornell baseball players, was held on Hoy Field June 10. In the dugout are, from left, Ed Williams ’50 Agr, Joe Parr ’50 Agr, John Cordes ’47 BChE ’49, and Al Reed ’65 CE, M.Eng. ’66.; Above, left to right: Charles Deakyne ’50 BCE, Bob Bergren ’50 BME, and Hambleton Palmer ’35 ME met at the Dean’s Breakfast; Left: Benjamin Loren, son of Jeff Loren ’75, tries this year’s FSAE car in Barton Hall.

Above: Mike Strickland ’80 EE was among a group of alumni who took turns hanging out on the giant swing at the Hoffman Challenge Course, Cornell Outdoor Education’s facility on Mt. Pleasant.

Above: Mike Strickland ’80 EE was among a group of alumni who took turns hanging out on the giant swing at the Hoffman Challenge Course, Cornell Outdoor Education’s facility on Mt. Pleasant.
The 25-member Big Red team did place first, however, in the acceleration race, the Goodyear Best Performance Award, and the Bosch Engine Management Award.

In addition, team adviser Albert George, Cornell’s J.F. Carr Professor of Mechanical Engineering, was awarded the Sports Car Club of America Carroll Smith Mentor’s Cup, accompanied by $1,000, as the “outstanding Formula SAE faculty adviser.” Also advising the Cornell team was Brad Anton, associate professor of chemical engineering.

Cornell teams triumphed in the overall event in 1997 and 1998 and last year placed third. The students receive academic credit for their work, as a yearlong special project in Cornell’s Sibley School of Mechanical and Aerospace Engineering.

ONE COOL CUSTOMER

A superb example of grace under pressure is Sara Purdy, a mechanical engineering major. Throughout her Cornell career she has played varsity sports (first tennis and then squash), conducted engineering research, and done tutoring and other volunteer work, all the while maintaining a 4.0 grade-point average and making the dean’s list each semester.

Purdy, who moved to St. Louis two years ago but grew up in Manchester, Mass., initially was surprised by her academic results at Cornell.

“A girl from my high school came here three years before I did and she said, ‘They work you really hard.’ Which is true. But I guess I thrive under pressure, trying to manage tennis and studying and everything else,” Purdy said.

She attended Cornell to continue a long-standing love for tennis, having played in junior leagues since she was 14, but also to maintain academic independence.

“I didn’t want to take a scholarship. I actually turned down Georgia Tech because I wanted to be able to really study, and if the coach owns you, you can’t,” she said. “Ivy League schools are the only ones that play quality Division I tennis but don’t have scholarships.”

Last year she decided to switch to varsity squash. “I needed a new challenge. I wasn’t really enjoying practicing anymore. It was still competitive for me, but in the wrong way,” she said.

Playing sports has been a major time investment for Purdy, who says she spent 20 hours each week for all but one month out of the school year on athletics and was away from campus most weekends for games. “It was great, I loved it. Sports let me see another side of Cornell.”

Purdy chose to study mechanical engineering partly to follow in her grandfather’s footsteps. “My grandfather was a mechanical engineer who ended up in consulting, and I have looked up to him since I was pretty small,” she said. “I also had an interest in math and science since maybe freshman year of high school.”

Since last summer, Purdy has researched wake interference and drag reduction with Charles H.K. Williamson, professor of mechanical and aerospace engineering and a Stephen H. Weiss Presidential Fellow. The application of the research is air resistance in large trucks. “It has been great. Hard work at times, but really rewarding,” Purdy said.

Purdy also volunteered at a home to assist teenage mothers in St. Louis for two years, and before that she volunteered at a battered children’s shelter in Manchester. At Cornell, she tutored an hour a week and participated in such community projects as “Into the Streets.”

This fall, Purdy will start work with Andersen Consulting in Boston. “I looked at a bunch of engineering jobs and then did a little soul-searching over winter break, and I decided I didn’t want to be in the technical world as a mechanical engineer. I thought consulting was a good way to still do some technical stuff but also get out and be around people.”

— Mark Siegal ’00, Cornell News Service

ADMINISTRATION UPDATE

John Hopcroft will complete his second term as the Joseph Silbert Dean of Engineering on June 30, 2001. Cornell President Hunter Rawlings has announced a national search for Hopcroft’s successor.

Prof. Tim Healey, who served for a year as associate dean of undergraduate programs, has stepped down to serve as chair of the Department of Theoretical and Applied Mechanics. A college search is under way for his replacement. ♦
Kelley’s Heroes

They started out as strangers, but four years later, it’s hard to say goodbye.

For a freshman, in a sea of 19,000 students, connecting with others and finding a niche can mean the difference between sinking or swimming. Four years ago, Prof. Mike Kelley had an idea to help students make those crucial connections: why not offer a group of his freshman advisees the chance to stay together as members of his research team?

It worked. This spring, that original group of five, plus a few others who came aboard along the way, got together for one last time, partying at the professor’s home the day before their graduation.

Keeping a group of advisees together for four years is quite rare, if not unprecedented, at the university in recent history. Yet, says Kelley, building close personal and professional relationships is rewarding for everyone involved. “We have become good friends, and the students have enjoyed collaborative learning through group projects.” Those projects chiefly involved Kelley’s research into probing our planet’s upper atmosphere and near-space regions. Several of the undergrads were members of the Airglow Imaging Team, which collaborates with Cornell scientists at the radar-lidar observatory in Arecibo, Puerto Rico, in evaluating wind and wave patterns up to several hundred kilometers above the earth.

“I have kept with Prof. Kelley’s group of advisees for four years because he is a great guy, and because I am interested in his field of research,” says Kerri Kusza, a teaching assistant for the professor. “Prof. Kelley is someone you are comfortable talking to, not only about academics but social events and your general mental state. He’s someone you’re not afraid to give a high-five when you run into him in the hallway. He gives specific-to-you advice, not just general suggestions.”

Kusza, a Connecticut native, leaves for Stanford, where she will pursue an M.S./Ph.D. degree studying planetary atmospheres, space and plasma physics, and spacecraft telemetry. She’ll be joined at Stanford by Amy Droitcour, who has been Kelley’s advisee for three years and who notes that he has a good rapport with students. “He’s interested in his students, and I really liked him as a teacher because he’s so good at explaining things—sometimes in several different ways to make it easier to understand,” says Droitcour.

Her studies will focus on satellite-based mapping of the earth’s surface.

Three of Kelley’s four-year core group of advisees are heading for New York City to pursue other careers. Evelyn Mak has enrolled in law school at Hofstra, Tina Fan landed a job doing technical programming for Andersen Consulting, and Caroline Sia, who earned both bachelor’s and master’s degrees in engineering in four years, will go to work at CityBank.

Of Kelley, Mak says with a laugh, “He’s expressive; he uses a lot of hand movement when he talks.” On a more serious note, she says, “He makes sure you understand what he’s trying to teach, and he’s big on teamwork.” She and Fan have been lab and homework partners since they came to Cornell. Mak also considers others in the group of advisees as good friends. “Going through the same courses in the EE curriculum together has created bonds among us,” she says.

Others in the group are going in separate ways: Dominic Alcocer signed up for a hitch with the Air Force, and Lewis Vaughn will pursue a master’s degree at Cornell. “I wanted this group to look like America, with a mix of men, women, and minorities,” Kelley explains. “I was able to pick from a group of students, whereas traditionally at Cornell students are assigned at random to professors.” He is indeed ‘big’ on collaborative learning. “Instead of lectures and textbooks I like to use the teamwork approach, and it has worked out well—the students learned from each other and evaluated each other’s work, and that went into their grades in my classes.”

This approach, says Kelley, is gaining acceptance. “Industry needs to see people working in teams as part of their education, because often that is how they operate,” he says.

A Cornell faculty member for 25 years, Kelley received the Tau Beta Pi/Cornell Society of Engineers Excellence in Teaching Award in 1981. In 1998 he was named a Cornell University Weiss Presidential Fellow in recognition for outstanding teaching of undergraduate students. Kelley is a fellow of the American Geophysical Union and currently the chair of the National Academy of Sciences Committee on Solar-Terrestrial Research.

“I have never seen Prof. Kelley anything but cheerful,” says Kusza. Even on days when he should be exhausted from travel, conferences, or research deadlines, she says, “You’ll see Kelley gliding down the hallway and stopping to say hi and ask how you’re doing.”

Kelley smiles graciously at the compliments, and returns them in kind. “These students are special. They have come a long way in four years.”

—Jay Wrolstad
There are many ways you can make a difference in the College of Engineering. What follows are a few specific areas for which your support would make a direct impact. The larger commitments may be made over a three-year period.

Gifts of any size

- for the Cornell Fund for Engineering, unrestricted gifts are used to enhance many programs that allow Cornell to offer one of the nation’s premier undergraduate engineering educations.

$1,200
- provides a scholarship for one student in the LeaderShape program, a six-day residential experience that promotes vision and builds teamwork among leaders of student organizations.

$1,400
- provides a summer stipend for a graduate student to be trained to be a teaching assistant training facilitator.

$2,500
- funds one LCD display for the new computing center in Carpenter Hall.

$4,000
- buys a new, modern UltraSparc workstation or an NT class PC workstation for the Robert Bechhofer Ph.D. Computing Laboratory in the School of Operations Research and Industrial Engineering.

$5,000
- qualifies for sponsorship of a student team, such as the FSAE car team, the Hybrid Electric Vehicle project, the Rigid Air Foil Team, the RoboCup team, the BRAIN team, or the Concrete Canoe team.

$5,000
- supports the improvement of Computerized Instrumentation Design, a sophomore-level course taken by 25 percent of engineering students in the School of Applied and Engineering Physics.

$6,500
- provides one high-level computer with monitor for the new design laboratories in the School of Electrical and Computer Engineering.

$7,500
- funds a computer projector for the environmental teaching laboratory in Civil and Environmental Engineering.

$5,000
- provides an SGI Octane R12000 workstation computer, essential for advanced computational work in biochemical engineering in the School of Chemical Engineering.

$10,000
- helps support the upgrading of equipment in the undergraduate teaching laboratories in the Department of Materials Science and Engineering or in the School of Applied and Engineering Physics. Many other departments have similar needs.

$10,000
- helps support the undergraduate engineering educations.

$15,000
- provides an SGI Octane R12000 workstation computer, essential for advanced computational work in biochemical engineering in the School of Chemical Engineering.

$25,000
- establishes a named endowment fund to be used at the discretion of the dean or department director to meet college or department priorities or may be directed to a specific purpose.

$50,000
- will fund one year of the CURIE Academy, a one week summer program for high school females interested in engineering careers.

$25,000
- helps provide start-up funding for a new faculty member to become established in research and teaching, making a big difference in attracting the best faculty members to Cornell.

$1 million
- names a significant space in the new facility for the Advanced Science and Technology Initiative named Duffield Hall, in honor of the principal donor, David Duffield ’62 EE.

$1 million
- funds nanotechnology and biomaterials experiments in the Materials Science and Engineering senior laboratory.

$100,000
- renovates a Phillips Hall classroom to provide for instructional technology and an improved environment.

$500,000
- supports the renovation of a college lecture hall; would be named in recognition of a gift of this size.

$500,000
- names the new computing center in Carpenter Hall, a facility that serves students in the entire college.

$750,000
- provides an endowment for the maintenance and upgrading of teaching laboratories. This is a need in every department.

For more information about these or other giving opportunities, please contact:
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Cornell University