



DARPA

Up to the Challenge

Harnessing bio data

Saturn's secrets

Birth of the iPod





Message from the Dean

Cornell University's College of Engineering, the preeminent engineering school in the Ivy League, has a long history of excellence in undergraduate and graduate education within the context of a uniquely broad and renowned research-intensive university. Our strengths have developed from cutting-edge discovery, a genuine commitment to students, and a sincere desire to contribute to society. We are global leaders in the discovery of new knowledge and creation of transforming inventions, the development of innovative interdisciplinary research and programs, and the education of students who will better the future. Never before has there been such a great opportunity for creativity, innovation, and rapid breakthrough discovery.

Reflecting the dynamic pace of innovation in the college, we are refocusing our efforts to keep you informed:

- We have launched a redesigned website, www.engineering.cornell.edu, with improved navigation, expanded content, and up-to-date news and events.
- Starting with this issue, we've redesigned *Cornell Engineering Magazine* to better communicate the excitement of our research and the commitment of our academic community to educating the next generation of leaders, innovators, scholars.
- We have published a strategic plan that will guide the college's priorities and initiatives for the next ten years. This is a dynamic document that will continue to grow and change, adapting to new knowledge and discoveries as the future unfolds.
- We have in press a publication to describe our research directions and to showcase our faculty's interests and accomplishments in projects that will have a real impact on the quality of human life.
- We are capturing this tradition of innovation in a history of Cornell Engineering to be published next fall, as both a tribute to those whose early work established our commitment to excellence and a touchstone for those who will carry it forward.
- We are producing a new fact brochure that will provide a quick check of the vital statistics of the college—thumbnail metrics that will help us chart our progress.
- We are developing a video presentation in which faculty, students, alumni, and corporate partners share with viewers the unique aspects of Cornell Engineering that brought them to the college and the wealth of opportunities available here for collaboration in research and education.

Together, these initiatives will provide a clear picture of where we are, how we got here, and where we are going. The brochure included with the initial distribution of this issue of *Cornell Engineering Magazine* is a synopsis of the strategic plan. The complete plan and the brochure are available online: www.engineering.cornell.edu/strategicplan. We invite you to visit the web site to review the plan and to follow our progress as we work together to place Cornell Engineering in a position of unique transnational leadership. Your comments and feedback are welcome.

W. Kent Fuchs
Joseph Silbert Dean of Engineering
Cornell University

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Up to the Challenge

Cornell students hope their autonomous vehicle is headed for pay dirt in the rugged terrain of the desert Southwest.

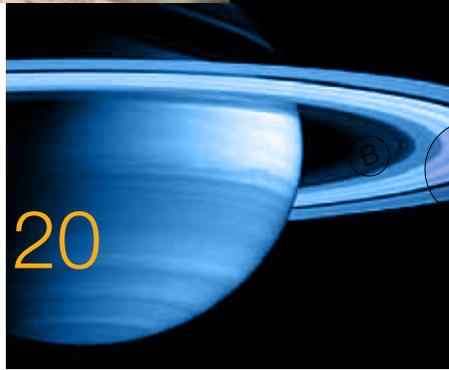
By *Melanie Bush*

The Rings Revealed

"I love to travel, and this is just the greatest way to go," says Joe Burns; he's talking about his virtual trip to Saturn aboard Cassini.

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Data Connections

It's too soon to say that Biozon will unravel the mystery of life, but this new tool is already allowing biologists to gain better understanding of genes and proteins.

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Behind the Music

Jon Rubinstein '78 EE is the person Steve Jobs entrusted with the responsibility of bringing a digital music player —Apple's iPod—from concept to market. Does that make him The Podfather?

By *Ken Aaron*

DEPARTMENTS

News

At home and abroad: Cornell heads new AI institute, forms new partnership with India, renews a contract to manage Arecibo, and

begins the search for a new president. Student teams in racing and robot soccer deliver a one-two punch to the competition.



People

Running the gamut: Faculty join life sciences and provide leadership in biotechnology and underground infrastructure; win awards

for advising, photonics, protein processing, computer graphics. Students showcase their research and study the sky. An alumnus leaves his mark.



Hometown Hero

Cooking Lessons: Working on a solar oven project in Senegal over the summer, Cyprienne

Crowley proved what she already knew: it's not just about the engineering.





INTELLIGENT INFORMATION

New institute launched this year marks Cornell's preeminence in the AI research community.

Suppose the computer from the starship Enterprise or the HAL 9000 from "2001, A Space Odyssey" had been scanning intelligence data four years ago. Perhaps it would have made the connection humans missed between terrorists and flight schools. Or suppose such a computer were designing airline flight schedules: You might get home for the holidays a little faster.

These are just some of the possibilities of "artificial intelligence," or AI, which is not really about making computers that talk back but rather about using computers for the things they are good at: dealing with massive amounts of data or problems with a vast number of choices. These are the sorts of problems that are being examined by Cornell University's new Intelligent Information Systems Institute, launched this year with a \$5 million, five-year grant from the U.S. Air Force Office of Scientific Research (AFOSR). In keeping with university policy, none of the research will be classified.

Other problems on the table include game theory, information retrieval, and automatic verification of software and hardware, according to Carla Gomes, Cornell associate professor of computing and information science and applied economics and management, and director of the new institute. Some 20 other Cornell faculty members are affiliated with the institute, Gomes said, including not only computer scientists but also faculty in operations research, applied economics, mathematics, and engineering. Visiting scientists will be more the rule than the exception, she added, with at least 10 scheduled to arrive this year.

The institute dedicated its new facility in Upson Hall last spring with a ribbon-cutting attended by AFOSR officials and researchers from the Air Force Research Laboratory in Rome, N.Y., with which Cornell has close research ties. The laboratory also collaborates with Cornell in the Information Security Institute headed by Fred Schneider, Cornell professor of computer science.

The newly remodeled space includes computer terminals that provide access to the institute's dedicated computer cluster, a high-performance computer made up of a cluster of 12 Intel processors operating in parallel. But the main purpose of the spacious facility, Gomes said, is to inspire collaboration among scientists. "There are whiteboards everywhere," she pointed out, "and open workspaces, stimulating the exchange of ideas."

The creation of the institute has created a buzz in the academic community, according to Robert Constable, Cornell's dean of computing and information science. "At one time Cornell wasn't even present in AI, but now we're being recognized as one of the top places, and we're seeing it in the applications to graduate school." This year, he said, there have been more applications from students wanting to work in AI than any other field, and more of those accepted have decided to come to Cornell than ever before.

—Bill Steele, Cornell News Service



Cornell News Service

Carla Gomes thanks Northrup Fowler, chief scientist of the Information Directorate of the Air Force Research Laboratory (AFRL) in Rome, N.Y., for his support in launching the new institute. Looking on are, from left, Robert Constable, dean of computing and information science; John Graniero, director of the Information Institute of the Information Directorate of AFRL; and Maj. Amy Magnus, program manager at the Air Force Office of Scientific Research.

"At one time Cornell wasn't even present in AI, but now we're being recognized as one of the top places."

CHALK UP ANOTHER WIN

Cornell University's Formula SAE race car team won its ninth world championship in May at the Pontiac Silverdome in Pontiac, Mich. Cornell has won the competition three years out of the last four. It was the 19th year that a Cornell team has entered.

The Cornell engineering students scored 906 points out of a possible 1,000 in a series of events that ranged from design evaluation to competitive driving, and they won the SAE Foundation Cup honoring Cornell alumnus Neil Schlike. The team was first in the climactic endurance race, won the Bosch Engine Management System Award for its engine control computer, and took second place in the autocross event.

The team brought home \$3,750 in cash awards to be applied to next year's car, plus 18 tires awarded by Goodyear and Hoosier Tire.

The second-place team was the University of Western Australia with 868 points, third was the University of Wisconsin-Madison with 853 points, and fourth was the University of Waterloo,



Ben Kennedy

Canada, with 812 points. In all, 140 teams from around the world participated.

The joy of winning was tempered by a report that three students from the University of Minnesota-Mankato died in a highway accident on the way to the competition. Mankato would have driven car No. 28, so each team added a small 28 to its car, and many teams added a Mankato State sticker.

The Formula SAE competition, sponsored by the Society of Automotive Engineers, Daimler-Chrysler, Ford Motor Co., and General Motors, challenges students to design and build a race car and drive it in a series of events. The final score is determined by adding points for driving, design, and presentation.

The climax is a 22-kilometer (about 14 miles) race over a 1-kilometer (1,094 yards) road course, at speeds up to 60 mph. Each team fields two drivers, each of whom drives 11 kilometers (about 7 miles). Although this is primarily a

Nick Fishbein drives Cornell's car through the skid-pad course, a maneuverability test, during the 2005 Formula SAE race car competition at the Pontiac Silverdome. The competition concluded May 22 with Cornell winning for the ninth time in 19 years.

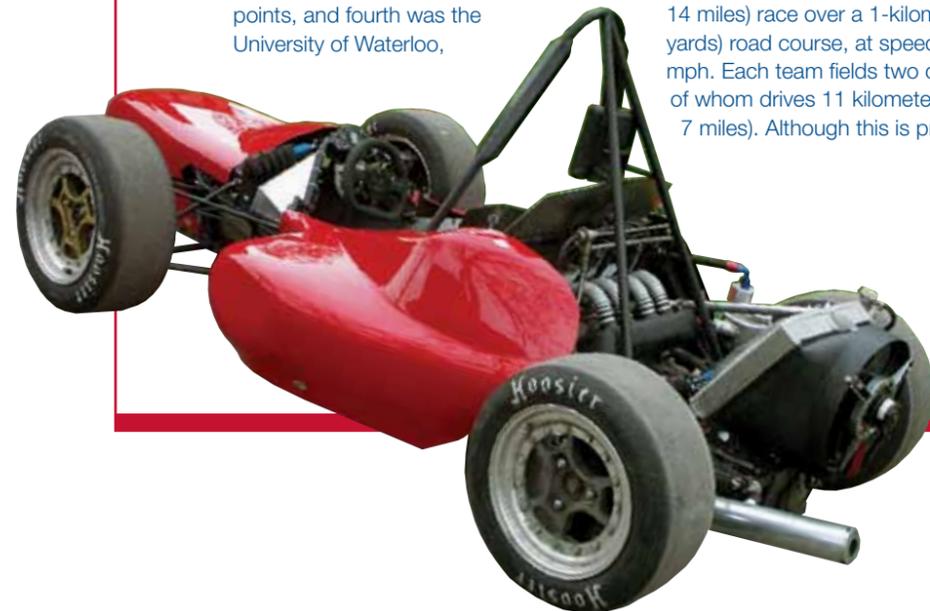
race against time, usually five cars drive the course at once, so overtaking and passing skills contribute to a driver's success. But engineering is crucial here as well: Due to breakdowns, only about 40 percent of entrants finish the race.

Other driving events included an acceleration test, driving around tight circles, and autocross, in which drivers race a short but unfamiliar course. Teams also were judged on their designs, on a "business presentation" pitching designs as if to potential investors, and on what the car would cost if put into production.

Al George, the J. F. Carr Professor of Mechanical Engineering, was principal adviser to the team. Brad Anton, Cornell associate professor of chemical and biomolecular engineering, was co-adviser. Team leaders, all seniors, were Ben Kennedy, chassis; Chris Davin, engine; Chris Hopkins, electrical and computer; and Erin Green, business.

Principal sponsors of the Cornell team include General Motors, Hunter Industries, Heller Industries, Lockheed Martin, General Electric, and Shell Oil. Some 50 other firms and alumni contributed parts and other support.

—Bill Steele, Cornell News Service



Charles Harrington

PRESIDENTIAL SEARCH BEGINS

The formation of the Presidential Search Committee to nominate a successor to former Cornell University President Jeffrey S. Lehman was announced in July by Peter C. Meinig, chair of the Cornell Board of Trustees, and Diana M. Daniels, vice chair of the board. Lehman stepped aside from the presidency June 30. Hunter R. Rawlings III, president emeritus of Cornell and a current member of the faculty, is serving as interim president.

Daniels chairs the search committee. "I feel honored to have been chosen to take on this important task. We are all Cornellians, and the continued excellence of our great institution is uppermost in our minds. The committee will work diligently to nominate the person best suited to lead Cornell in fulfilling its goals for the future," she said. "The committee will seek advice from the entire Cornell community and from academic leaders throughout the nation and around the world on the characteristics that should be sought in a new Cornell president."

The committee membership includes representatives from several Cornell constituencies, including trustees, faculty members, undergraduate students, graduate students, employees, the Weill Cornell Medical College and Graduate School of Medical Sciences, senior Cornell administration and alumni.

For more information, see <http://www.cornell.edu/presidentsearch/>

—Cornell News Service

VOTE OF CONFIDENCE

The National Science Foundation (NSF) has renewed Cornell University's management contract for the operation of Arecibo Observatory, the world's largest and most-sensitive single-dish radio/radar telescope. A Puerto Rican landmark, the huge telescope is famous as the locale for several movies, including the James Bond film "GoldenEye" and the movie version of Carl Sagan's *Contact*.

The contract with the National Astronomy and Ionosphere Center (NAIC) at Cornell—which runs until March 31, 2010—is for approximately \$70 million, making the NAIC the second-largest federally funded research center on campus. NAIC has managed the observatory for the past 34 years.

The award was approved March 30 by the National Science Board, which establishes NSF policies, following a 15-month-long competition for management of the observatory with the Universities Space Research Association, created by the National Academy of Science in 1969 and largely funded by NASA.

"We are very pleased with the confidence that the NSF has shown in supporting Cornell's proposal to continue its management of NAIC, and we welcome the challenge to develop further the scientific research capabilities at the observatory," said Bob Brown, director of NAIC, who spends 25 percent of his time at Arecibo.

NAIC was created by Cornell in 1971 as a national center for radio science to operate and manage the Arecibo Observatory for the NSF. The 1,000-foot-diameter (305 meters) Arecibo telescope was completed in 1963 at the initiative of Cornell electrical engineering professor William E. Gordon.

The center provides access to state-of-the-art observing facilities at Arecibo for scientists in radio astronomy, solar system radar astronomy, and atmospheric studies.

Operating with 11 people at Cornell in Ithaca and a staff of 136 at the observatory in Puerto Rico, NAIC administers observing time to more than 200 telescope users annually in the astronomy and aeronomy academic communities.

—David Brand, Cornell News Service



Courtesy of the NAIC-Arecibo Observatory, a facility of the NSF.

A WORTHY OPPONENT

Cornell University's soccer-playing robots placed second in the Small Size league in the RoboCup 2005 competition held July 13–17 in Osaka, Japan, losing 4-0 in the final match against the FU-Fighters of the Free University of Berlin, Germany.

"It was definitely a bittersweet moment. Our system worked wonderfully all around, and I think the entire team did a spectacular job. We were just beaten by a better team. Many congratulations to the FU-Fighters, who absolutely deserved this win," said Steve Lowe, a member of the electrical design team.

RoboCup is an international competition in which teams of autonomous robots play soccer entirely under computer control. Cornell competes in the Small Size or F-180 league, in which the robots are rolling machines about 8 inches square, playing on a field about 12 feet by 16 feet.

Cornell has won the championship four times, beginning with the 1999 competition in Stockholm, the first time the Big Red team entered. They went on to win in 2000 in Melbourne, Australia; 2002 in Fukuoka, Japan; and 2003 in Padua, Italy.

Team members are Karu Watugala, Oliver Purwin, Eugene Byrne, Sergei Lupashin, Michael Cen, Anshuman Bhairavbhat, Homan Lee, Ivan Han, Hor Siu, Mike McCabe, JinWoo Lee, Steven Keiper, Jeff Johnson, Steve Lowe, Chris Lehmann, Mike Sherback, Len Evansic, Patrick Conrad, Tom Hanselman, Umang Khanna, and Mi Zhou. Raffaello D'Andrea, Cornell associate professor of mechanical and aerospace engineering, is team adviser.

—Bill Steele, Cornell News Service



Cornell robots scrimmage to prepare for the RoboCup 2005 competition held in Osaka, Japan, in July.

From left, Madhavan Nair, director of the Indian Space Research Organization; Ramesh Rao, director, University of California–San Diego's (UCSD) Division of the California Institute for Telecommunications and Information Technology; Cornell President Hunter Rawlings; Manmohan Singh, prime minister of India; and Frieder Seible, dean, UCSD Jacobs School of Engineering at the signing ceremony.



Provided

Ill signed a three-year agreement with Indian Prime Minister Manmohan Singh on July 20 in Washington, D.C., that will bring visiting faculty and disseminate their lectures via EduSat. "This is a tremendous opportunity for Cornell University faculty to gain wide exposure in India's higher education system, and for Cornell to enhance its ties with India at the highest level," Rawlings said.

Carnegie Mellon University, the State University of New York at Buffalo, and the University of California campuses at Berkeley and San Diego are partners in the consortium along with Cornell. Qualcomm Inc., Microsoft Corp., and Cadence Design Systems are funding this program.

Kent Fuchs, dean of Cornell's College of Engineering, said: "Cornell enjoys long and meaningful relationships with Qualcomm and Microsoft; this program provides an opportunity to extend that relationship to collaborate with our peers at top institutes in India."

Cornell has a very strong Indian student presence on campus, with 333 Indian nationals, the fourth-largest international presence on campus.

The university maintains eight existing agreements with Indian institutions, mostly in agriculture, according to David Wippman, Cornell vice provost for international affairs. This engineering-oriented agreement expands the university's relationship with India. "It exposes our top faculty to India's vast student body and opens the doors for other projects," he said.

—Cornell News Service

INDIA EXCHANGE

India, which has cornered the world economy's virtual backroom, now will bring leading American science, engineering, and computing faculty from Cornell University and other top colleges to teach students at Amrita University and other institutions, thanks to EduSat and emerging distance-learning strategies.

Cornell University President Hunter R. Rawlings

ROCK RECORDS

The Museum of the Earth at the Paleontological Research Institution (PRI), which is affiliated with Cornell University, opened a new exhibit in July on ammonoids, prehistoric sea animals that first appeared in the fossil record 400 million years ago, survived four



Ithaca artist Dan Burgevin paints a 12-by-20-foot mural depicting the ecology of life in the seas of the late Jurassic period, when ammonoids swam in massive predatory schools. Photo courtesy of the Museum of the Earth.

major extinctions, and died out with the dinosaurs 65 million years ago.

The exhibit, which will be removed this fall, is the second in an ongoing rotation of temporary exhibits at the museum. It draws on PRI's collection of ammonoid fossils, one of the largest in the country.

The earliest written records of ammonoid fossils are from Roman times, and both Hindu and Native American cultures view the fossils as sacred. Native Americans believe the fossils carry healing powers. Until the nautilus was discovered in the early 1700s, no one had any idea what the ammonoids were.

"Paleontology works by comparing fossils with things that are alive today, so if we hadn't found the nautilus, we would never know what this was," said Warren Allmon, director of PRI, which runs the Museum of the Earth, and adjunct professor in Cornell's Department of Earth and Atmospheric Sciences.

—Krishna Ramanujan, Cornell News Service



to the **UVR** Challenge

By Melanie Bush



Here's the catch: the traveler is a completely autonomous vehicle developed by Cornell students and the route, to be announced just hours before the race, is off-road through the rugged terrain of the desert Southwest.

If all goes well in the semifinal round, Cornell engineers will advance to the final round of the Defense Advanced Research Projects Agency (DARPA) Grand Challenge in October. Cornell's autonomous vehicle will compete against 19 other robotic cars in an attempt to negotiate 170 miles of punishing desert terrain in the Southwest somewhere between Los Angeles and Las Vegas. The stakes are high: winner takes home \$2 million and bragging rights for accomplishing something that's never been done. In the first DARPA Grand Challenge, held in March 2004, the most successful team, Carnegie Mellon, completed exactly 7.4 miles before being incapacitated by a boulder.

The event is part of a congressionally mandated program that authorizes DARPA to conduct tests and award prizes for advances in vital technologies, in this case, the 2001 Defense Authorization Act's goal that one third of all combat vehicles be unmanned by 2015. DARPA is the central research and development agency of the Department of Defense and has pioneered major technological breakthroughs such as the Internet, Stealth aircraft, and smart bombs.

“We aim to end this thing once and for all.”

Ephraim Garcia, associate professor of mechanical and aerospace engineering, is the main faculty adviser of the Cornell team, although he swiftly explains that this is a completely student-run project. Garcia feels confident that Cornell will reign in the desert. “We aim to finish the Grand Challenge. Go 170 miles, collect two million dollars. We aim to end this thing once and for all.”

And what would Team Cornell do with the \$2 million grand prize? Their goal is to establish an endowment for future student projects that would allow Cornell to make a larger impact at competitions like DARPA. But actually, Garcia says, “The kids don’t talk about the prize money. It’s not the culture of the team, which is to execute well technically.”

Garcia has himself blazed a rigorous path on his journey to Cornell. He grew up in New York City as the child of Cuban immigrants and earned his Ph.D. at the State University of New York in Buffalo in 1990, concentrating on smart controls in microelectromechanical systems. Since then, he’s focused on mechatronics, using entomological models to create a new generation of bio-inspired robots. Though he doesn’t consider himself a roboticist, he’s excited by the challenge of building machines that can travel efficiently and change their shapes to adapt to the environment around them.

Garcia has conducted research for NASA, the Air Force, the Office of Naval Research (ONR), and the Army Research



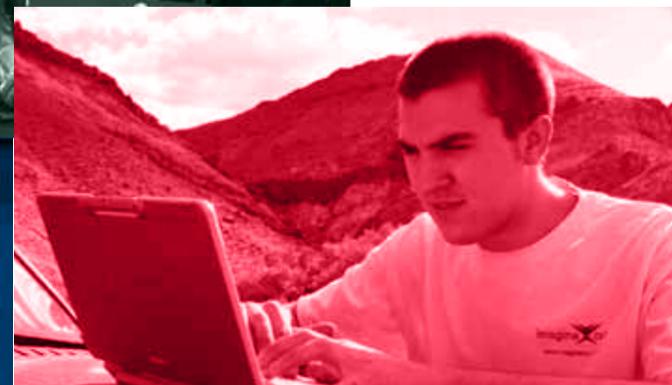
Team and vehicle photos by Peter Moran

Ephraim Garcia, associate professor of mechanical and aerospace engineering and co-adviser of the Grand Challenge team.

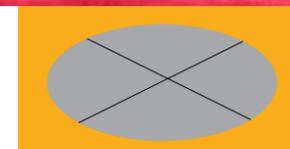
Office; run his own small company; taught at Vanderbilt University; and, most recently, worked in the Defense Sciences Office at DARPA. He was named a Presidential Faculty Fellow by Bill Clinton and an ONR Young Investigator. Now, as part of what he calls his “strange but fun path,” he has come to Cornell.

Arriving on campus in 2002, Garcia admitted at the time that a typical career trajectory would lead to a high-profile job in industry after a stint at DARPA. But, he says, “I wanted to get back to the trenches of academia, to go someplace where there were really good students and really good colleagues.”

And if Cornell’s Grand Challenge team has a secret weapon, Garcia is convinced it’s those really good students, who this year put together not one but two potential entries for the event. “The energy of college students is not to be underestimated, and Cornell kids are a zealous group, working incredibly hard and achieving things that no one would ever expect from undergrads. I’ve been very impressed with the students’ ability to equip two teams.”



“DARPA sees the future of the military in machine-augmented human forces.”



Garcia believes Cornell students are especially well suited to large, ambitious projects like the Grand Challenge in part because of classes like MAE 225 Mechanical Design and Synthesis. “Synthesizing so many elements in class motivates them to create real projects, to realize that products are not just something you buy. It makes them want to do everything themselves. I think my mechatronics class—combining electromechanical systems—has also helped. It has further demented their thinking, in a good way.”

Daniel Huttenlocher, co-faculty adviser and the Neafsey Professor of Computing, Information Science and Business, is also impressed with the student team. “The most amazing thing about this whole project is that last summer they had nothing. Now they have two vehicles that run autonomously. And not only do they work hard; they work smart. They’ve done a thorough analysis of what went wrong last year, and they know where to get their hands on things and when to go look for experts.”

Cornell’s involvement with the Grand Challenge dates from the summer of 2004, when then-sophomore Noah Zych ’06 ME used the proceeds of his undergraduate research grant from the College of Engineering to do a feasibility study on how much it would cost to field a vehicle. “It all started with the students coming to me, and me saying, ‘Wait a minute—let’s think about this,’” Garcia says.

“DARPA sees the future of the military in machine-augmented human forces,” he continues, “robotic vehicles that will follow soldiers on foot into battle carrying firepower and ferrying wounded soldiers back to hospitals.” This year DARPA has made the course not only longer and tougher but more akin to a real battlefield, laying down obstacles like tank traps, for example, along the route. “Those will stop a vehicle that can’t sense them,” says Garcia. “DARPA wants to get people really thinking about this; accomplishing their own research objectives is the purpose of the contest.”

For the 2005 event, 190 teams from both academia and private industry applied, but only 20 would ultimately be selected to compete on the basis of numerous safety inspections and qualifying rounds. The Cornell team already aced its site visit from DARPA on March 1. In an e-mailed report to colleagues, Garcia wrote: “The DARPA Grand Challenge team did extremely well yesterday in front of two DARPA Program Managers (PMs).... The first vehicle’s performance was a flawless three runs of 200 meters, following a path set by GPS waypoints. The DARPA PMs put trashcans at blind spots ... but the artificial intelligence algorithms were robust enough to avoid them in all cases.

“When the second vehicle was about to begin its trial, a computer power supply fried, smoking spectacularly.... The team adapted brilliantly, cannibalizing parts from a desktop [computer] that was being used for diagnostics. The second vehicle also performed its requisite runs with about ten minutes to spare. The PMs were very impressed with Team Cornell’s ability to adapt under a very adverse situation.”

The university teams seem to have several significant advantages over industry professionals. “Industry teams made up of paid workers tend to be smaller than school teams,” says Isaac Miller, a Ph.D candidate in mechanical engineering. He’s one of the few grad students involved in the project; about 90 percent of the team members are undergrads. “We not only have more manpower but more time. Kids are working 10-hour days, seven days a week. If you get a group of crazy undergrads together, they can do anything.”

“Technically, the team that completes the race the fastest will win,” says Matthew Grimm ’06 ME, head of the business team. “Realistically, whoever finishes will win.”



“Technically, the team that completes the race the fastest will win.”

Grimm calls himself “the overall problem solver, the logistics man.” His focus has been on helping the team navigate the university bureaucracy and cultivating the kinds of large-scale sponsors a project like this needs. And large-scale sponsors have been found. AMD has provided substantial cash and equipment. Singapore Technologies (ST) donated the entire second vehicle, Titan. When the vehicle had engine trouble, ST sent an engineer to Cornell to assess the problem, shipped the truck to Detroit for repairs, then returned it to the team race-ready.

“It serves both of us,” says Grimm of the ST sponsorship. “DARPA is one of the huge contractors in the military; ST wants to break into the military market. This is a way for them to get their name and products into the forefront.” (Additionally, Cornell has the second-largest Singaporean college population in the U.S., after Stanford.)

The other vehicle, Code Red, was assembled out of different sponsors’ parts. “We never ask for gifts, just for at-cost or discounted donations, which are incredibly valuable. Companies have been exceptionally generous; in turn, we give them something to brag about.” Grimm estimates the team has raised approximately \$90,000 in cash and \$250,000 in in-kind donations, all in less than one year.

The three major components involved in mastering the Grand Challenge are the artificial intelligence system, the data-gathering sensors, and the vehicles themselves. “This whole project is a system of systems, as well as one of getting all the systems to talk to

each other appropriately,” explains Garcia. “There are servomechanisms that control things like the steering and the brakes; I think of this level as a vehicle’s musculoskeletal system. At the next, middle level there’s a GPS (Global Positioning System) for basic path planning. With that come the LIDAR (Light Detection and Ranging) system and the stereoscopic vision that the car will use to process information collected from the world. This is a higher-end thinking in which the vehicle will see the landscape and the obstacles and fuse this information into its view of the world. Then the artificial intelligence (AI) will make decisions about where to go in that world by massive computation—algorithms based on cost: ‘In which direction will I be least likely to get stuck?’ A vehicle with an accurate view of its world will have a huge advantage.

“Realistically, the battle will be won or lost by how good the AI is,” says Garcia. “It needs the ability, for example, to navigate complexities like the difference between a dense shrub and a rock. The LIDAR, along with other sensors, must answer the question does this object flex? Is it a bush or a rock? There’s a decision tree constantly being generated: ‘What if...what if...what if?’”

Brian Schimpf ’06 ORE is the AI team leader. “A lot of teams had trouble last year because their systems couldn’t handle sudden changes; they were designed to avoid what was right in front of them,” says Schimpf. “The path-planning systems we’re implementing are much more intelligent—they’re not just dealing with immediate problems. If the vehicle has a small rock in

front of it and a corridor ahead that swerves to the right, our AI will synthesize this information completely. Also, our AI will learn as it’s going, adapting simulations in real time in response to the terrain. Being able to adapt is a huge advantage.”

Team Cornell installed the same sensing configuration and AI algorithms in both vehicles. As Schimpf explains, “We put all our energy into designing one set of code.”

For data-gathering, the Cornell team is using a versatile combination of sensors. The vehicle will integrate a GPS, LIDAR, stereoscopic vision, and tactile feedback to provide the vehicle with information. These sensor systems act as eyes, providing the input needed to create a model of the world. Unlike the human eye, these sensors operate on a variety of wavelengths, acquiring much more information than even the most experienced driver can gather.

The racecourse itself is defined using GPS waypoints, so an accurate GPS receiver is essential. Most commercial units have 20-foot accuracy, and while that is suitable for most uses—hiking in the woods or giving directions in a car—Cornell’s receiver and antenna have an accuracy of 10 centimeters. The receiver also uses a signal from a subscription service called OmniSTAR that provides corrections to improve accuracy further. When the GPS service goes out or becomes less accurate, for instance in a valley, the vehicles will also use an inertial navigation unit to pinpoint position.

The stereoscopic image processing, which mimics a human driver’s eyes, will be used for intermediate and short-range obstacle detection, with original algorithms providing dramatically improved speed and object resolution. Motion parallax (a form of motion flow) will allow the cars to identify objects separate from the ground plane using sequential video frames from a single camera. These two complementary techniques will compensate for the shortcomings of each. The vehicles will also employ texture recognition to distinguish between penetrable and impenetrable obstacles.

The data from each individual sensor (LIDAR, stereo vision, GPS) are combined into one large map of the world, which the AI will use to track where the road is, where obstacles are, how big the obstacles are, where the vehicle is on the race course, and the current status of the vehicle (for instance, how hard it’s accelerating). A path-planning algorithm uses the data to decide on the best way to navigate to the next waypoint, and a separate function, called the system controller, translates the world model into actual driving commands: how much throttle is needed, for example, or which way the vehicle needs to steer.

The final crucial ingredient for success: a vehicle that can reliably travel the 170 desert miles that Cornell

hopes will incapacitate their competition. Riding on 38-inch tires, Code Red can handle virtually any terrain that could be encountered. Its suspension geometry was originally designed for rock crawling, an extreme variant of off-road racing. Titan is based on a military light strike vehicle, designed to handle demanding combat situations, and is the perfect host for the sensing platform, lightweight and durable, allowing it to support sensors and computers without sacrificing performance.

“I do not think that these cars finishing this course is an impossible goal,” says Garcia. “Once a vehicle goes 10 miles—if its decision logic is that good—the next 10 miles will be easier. This is an incredibly difficult technical problem, if a team like Carnegie Mellon, with 20 years of robotics experience and 15 years of government contracts, can only make it seven miles. It’s true this year they have the edge of experience—they’ve seen things firsthand. But they also didn’t do very well, so maybe there are ruts in their thinking.”

“Carnegie Mellon represents the opposite end of the spectrum,” says Huttenlocher. “They have a huge robotics department, a huge budget, faculty research scientists, and professional engineers working on this. Cornell is taking the approach of general skill and spirit. And Ephraim Garcia is a great role model, an energetic, positive guy who doesn’t think ‘no’ is ever the right answer.”

On June 6, DARPA announced the 40 teams selected to advance to the semifinals of the Grand Challenge competition. Those teams will compete head-to-head in the National Qualifying Event at the California Speedway in September, where half will advance to the finals.

Given only one entry slot for the semifinal round, Team Cornell had to make a choice between their vehicles. “We decided to enter the Titan since the design makes it easier to

mount all the large components, such as computers and generators, that we need to include,” explains Schimpf. Although Code Red won’t go to the competition, it was nevertheless critical to the team’s success. “There was about six-week period in which Titan was out for repair,” Schimpf says. “Without Code Red, we would never have been able to finish the software and sensor systems in time for the site visit.”

The Cornell team has scheduled six full weeks of practice in the desert, testing their algorithms in the field. “I think the main mistake teams made last year is that they didn’t spend enough time practicing,” Garcia says. “But in terms of winning, I actually think we’ve already won. The educational goals these students have achieved cannot be underestimated; they’re enormous, much more than engineers in a corporation would gain in a year.”



“I do not think that these cars finishing this course is an impossible goal.”

The Music Behind

By Ken Aaron

Jon Rubinstein '78 EE, one of the developers of the iPod, describes the team approach and consumer focus that created the popular digital music player.



Flying across the Atlantic Ocean last month, three of the four people sitting closest to me had small white circles stuck inside their ears. The same plastic doodads adorned a couple of people in the row in front of me; same for the row behind. In fact, as I looked around, I could see those dime-sized earphones, and the dangling white plastic cords that tethered them to iPods, in row after row.

That's sweet music to Cornell Engineering alumnus Jon Rubinstein. Rubinstein is senior vice president of Apple's iPod division, a job he's held since last year. He's also one of the fathers of the iPod, the increasingly ubiquitous digital music player: Back in 2001, Rubinstein is the person whom legendary Apple CEO Steve Jobs entrusted with the responsibility of bringing a digital music player from concept to store shelves in an 8-month marathon sprint.

Since it was released that November, more than 20 million iPods have been sold, including more than 10 million this year alone. At its core, the iPod is little more than a screen and a hard drive and some other electronics. But that plastic and metal box, little bigger than a deck of playing cards, has changed Apple's fortunes from the maker of a well-loved but slow-selling line of computers to a relevant-again player in the electronics world.

Rubinstein, who graduated with a bachelor's degree in electrical engineering in 1978 and followed that with a master of engineering degree in electrical engineering from Cornell a year later (he also has a master's in computer science from Colorado State University), has led Apple's hardware engineering efforts since 1997. But the nature of his contribution to the iPod project has been largely unheralded. That's because at Apple, personalities are secondary and products are king, produced by group effort and hatched with much hoopla to a rabid fan base before heading to store shelves.

And the hard-charging Rubinstein keeps with that tradition, crediting the success to his team and speaking of his goals with an eye toward the consumer. His first goal, he says, is to make the best products on the market; his second is to build the best engineering team in the world. "To achieve number one, you really need to achieve number two," he says.

The development of the iPod started with the realization that, in the future, consumers would have a constellation of electronic devices that would tie into their home computers. "Our strategy here at Apple has been the digital hub. It started with that six years ago," Rubinstein said in a recent telephone interview from Apple's headquarters in Cupertino, the heart of Silicon Valley. "We saw the trends starting to form with digital video cameras, digital still cameras, with Palms, with cell phones and all of that. We started developing applications for all of those devices."

So the drive to make the Macintosh, Apple's personal computer line, a digital hub started with software that helped users edit videos (iMovie), organize photos (iPhoto), and keep track of their music (iTunes.)

The trouble with the Mac platform, though, was that even though its hardware and software were widely considered superior to personal computers running Windows, there were still far more Windows PCs than Mac users. The Mac's market share was below 10 percent and falling.



Images and photos courtesy of Apple

Good applications might drive some people to buy Macs, and there's some evidence that the iPod has convinced people to abandon their Windows PCs for the platform. But there was also sentiment that Apple could make a lot of money by making one of the devices that tap into the hub. "While iTunes was under development, we looked at the devices that were available on the market," Rubinstein says. Video cameras and still cameras, Rubinstein and his crew found, were pretty well designed. Lots of people thought Apple would release a Palm-like organizer, but Jobs decided that their day might have passed.

"When we got to digital music players, what was out there was awful. They were big and they were heavy, the user interfaces were terrible," Rubinstein says.

The players that relied on hard drives to store music were too bulky. The ones that used flash-memory chips could only store a handful of tracks. In both varieties, it took too long to transfer songs from computers to the devices, and navigating through those songs was painful enough to make users long for cassette tapes.

"So Steve asked me to go do a music player," Rubinstein says.

As much as iPod users rave about the iPod, it's hard to tell by looking at it why it's such a big deal, technologically. At its core, an iPod is a conglomeration of about a half-dozen different technologies

that make a tiny package when bundled together. It has a display; it has a long-lasting rechargeable battery; it has a core microchip that drives the thing. Technologically speaking, iPod is more a direct descendant of other computer hardware than a new branch on the family tree. "From a system architecture point of view, it's just a slightly scaled down version of the products we were already doing," Rubinstein says.

But in 2000, when Apple first started thinking about making a music player, "the technology really wasn't there yet to make a great player," Rubinstein recalls.

But much of what he knew was necessary really wasn't that far away. So in early 2001, Rubinstein assembled a team to figure out which technologies could be brought together quickly to make a best-in-show music player.

An example of how those pieces came together can be found in the hard drive that led to the device's first marketing campaign — to "put 1,000 songs in your pocket" — and was key to making it a reality.

Greg Joswiak, vice president of iPod product marketing, has worked alongside Rubinstein since 1997. "Jon's very good at seeing a technology and very quickly assessing how good it is," Joswiak says. "The iPod's a great example of Jon seeing a piece of technology's potential — that very, very small form-factor hard drive."



That tiny hard drive, which was 5 gigabytes in the first model but now comes in sizes up to 60 gigabytes, was unearthed during one of Rubinstein's frequent visits to Apple's suppliers.

"The way we found the hard drive, for example, we were doing our usual tech review with the vendor in Japan. We were reviewing the standard drive road map that we were using in our standard product."

While doing that run-through with Toshiba, somebody there mentioned that company's work on a 1.8-inch hard drive, a cool engineering project that didn't yet have a home. "If you could find a use for that, we'd really like that," Toshiba told Apple.

Rubinstein's familiarity with the supply chain is one reason why he was able to bring the iPod to market so quickly, said Mike McGuire, a research director for GartnerG2, a technology consulting firm. "A lot of it came down to the manufacturability of it," McGuire says. "It's one thing to come up with a great concept. It's another thing to make it manufacturable."

He points to the metal back on the iPod as an example of where Rubinstein's expertise came in. Tooling up a production line to produce that shiny back, every single one of which can be personally engraved, wasn't trivial, McGuire says, and "speaks a lot to his contacts in the manufacturing world."

Those are just two bits of the finished product. There were plenty of other hurdles to overcome, Rubinstein says, such as figuring out how to squeeze a dozen hours of music out of the tiny battery (it involves storing the current song on a memory chip so the hard drive doesn't spin incessantly, sucking juice.) There's a perpetual quest to shrink the internal electronics. And there's software, of course; half of the iPod's design team is devoted to the program that runs it. It was no mean feat to produce an interface that never stalls or hiccups when listeners breeze through their songs.

Four years later, Apple still holds a commanding lead in the portable music player market, holding 75 percent of the market. Even Sony, which once invented a portable cassette player called the Walkman that made the notion of carrying around personalized music a reality, has had trouble coming up with a solution; its MP3 players haven't attracted much of a following in Europe and North America, where Apple is dominant by far.

The reason why Apple stays ahead of the pack, consensus goes, is because its product designers and its engineers collaborate from the beginning. "Everybody may have these outrageously cool ideas, but you have to turn it over to the manufacturing guys at some point," McGuire says.

Rubinstein acknowledges that Apple's strength comes from its tendency to consider the average person who would use the device.

"We look at the whole problem, from silicon all the way up to the Internet," he says. "The iPod is successful because we work on the whole user experience. It's not impossible, but it's really hard for other companies to duplicate what we've done," he says.

That experience begins at the point when you unpack your iPod from the box, which is a black sheath that has actual-size photos of the iPod printed on it. Inside the sheath is a box that opens like a book; on one side is the iPod, and on the other, accessories. "Designed by Apple in California" are the only words on the sheath, another reminder that the iPod you are about to turn on was crafted from the loving minds at the company and didn't just fall off some production line somewhere.

The product that results from that kind of arm's-length arrangement is often a confusing mish-mash that only somebody with a computer science degree could understand. Not that that stops these devices from reaching the market — because in tech circles, elegance is favored less than impressing other techies.

Fred Schneider, a Cornell professor of computer science whose operating systems class helped inspire Rubinstein to pursue a career in computers, says Apple's insistence on making its technology transparent to the user keeps it successful.

"All these geeks go off and worry about building computing systems that are neat in some way or another technically and think of a computing system as a special sort of thing. And what Rubinstein taught me, it's no different than a vacuum cleaner. It has to be that easy to use. It has to be that easy, from the time you open the box, so he and the folks at Apple have a very different model of doing business than any other computing company."

As intensely consumer oriented as the iPod is, much of Rubinstein's career has involved working on far less visible, but more powerful, projects. At Hewlett-Packard, where he worked after graduating from Cornell, Rubinstein developed workstations. At his next stop, the bygone Stardent, he was responsible for processor development of a graphics supercomputer.

That technology sounds a lot heavier than what he's dealing with today. But it's not too far different.

"When you've got a heritage of dealing with incredibly complex things, when you get paired with a bunch of people who can design really cool things, it's a challenge, and probably a good one," McGuire says.

Rubinstein downplays the significance of any difference in his current and past work. Both the cheapest iPod, at \$99, and the \$10,000 servers he used to work on share similar lineage, Rubinstein says. "Both are storage devices,"



"The iPod's a great example of Jon seeing a piece of technology's potential — that very, very small form-factor hard drive."

he says. "Apple's a consumer company in its heart. From my perspective, the iPod's just an evolution of that."

One of Rubinstein's next challenges will be to figure out what else will fit under that brand logically. He's not talking — Apple never does about such things — but the rumor mill is ablaze. A video iPod? An iPod phone? Something with wireless Internet? Something else entirely?

"There's just so many dimensions of what we're doing that I see a lot more opportunity going forward," he says. So far, the company has shrunk not only the iPod — its smallest model, the Shuffle, is the same size as a pack of gum — but also its price; iPods sell from \$99 now up to \$399.

Rubinstein's not in the lab doing schematics and ground-level design work any more. His job encompasses everything from exhorting his team to make the device cheaper, to working closely with the legions of companies making iPod add-ons, such as cases, FM transmitters, and other accessories, to plotting a roadmap for future iPod development. "It's a real pleasure to be able to work through a large team of people and create lots of products because at the end of the day, I'm really a product guy. And by leveraging my skills with the capabilities of the team, we can make lots and lots of great products."

In typical Apple fashion, he won't talk about anything in the pipeline, other than to assure that it's "really, really cool stuff."

"I think we're kind of just getting started," Rubinstein says. "I think there's a constant trend to how you improve the product. How do you raise the bar, make it better and better?"

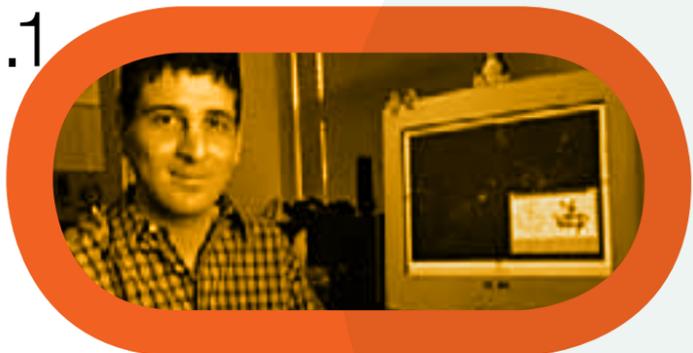
I'm listening to an iPod while I write this. I've owned the album that's playing, by a band called The Shins, for a lot longer than I've owned the iPod. In fact, I've owned almost all of the 1,606 songs currently on the slender white box, about the same size as a deck of cards, for years. But despite that, it's exciting to hit "shuffle" on the tiny jukebox and have a track come up that you haven't thought about, let alone heard, in years — it's a bit like unwrapping the compact

discs all over again. It's that kind of re-discovery that makes the gadget more than a gadget. iPod users — and they include high schoolers, and lawyers, and retirees who'd rather not go anywhere near a computer otherwise — will tell you that the box practically changed their lives and is one of those things that they can't imagine living without. But in a good way — most people can't imagine living without a cell phone, either, but many people would also hurl them into the ocean if they could get away with it.

Rubinstein, who keeps plenty of reggae, jazz, and 1970s rock on his iPods, understands why people get so attached to them. "It makes the music so accessible," Rubinstein says. "It brings all your music together, and it's just right there. That's one of the cool things about the whole iPod project. We didn't have to go to do case studies or focus groups. Everybody loves music. It was so obvious." ■ ■ ■

EC Family 1.1.1.1

A



B

Data

connections

The quest for knowledge takes lots of twists and turns, with both promising leads and dead ends confronting scientists seeking insight into the secrets of life. Sifting through the massive amount of data continuously churned out by labs can be a daunting task for researchers looking to identify and establish links between basic biological phenomena.

Now such researchers have a powerful tool to help bring order to the chaos of computer databases in an array of formats storing information on thousands of proteins and genes. Called Biozon, the project is the brainchild of Cornell computational biologist Golan Yona, who has adapted the latest search technologies used by such Internet giants as Google and Amazon to create a hybrid data processing engine that promises to speed the pace of discovery.

“Biological data is being generated in so many different types and in such large-scale efforts, presenting a challenge to analyze it all effectively and to integrate the available information for the greatest benefit,” Yona says. Research facilities evaluating biological entities in vivo are now producing digital records on the physical sequences of chromosomes, the existence of molecular interactions, the expression patterns of genes, and so on, he notes. “The rules of the game have changed, so that scientists have much more information to consider,” he says.

His solution was to re-examine the way biological data is warehoused, retrieved, and analyzed, employing an extensive and tightly connected logical graph schema and advanced data-crunching methods.

A particular challenge is that the functions of many genes remain to be discovered, and just looking at the gene sequence itself doesn't reveal the characterization. “And, if you really want to analyze a gene, you need to look at not just related genes, but consider also the interactions it forms and the cellular pathways it is involved in,” says Yona.

The same holds true for biological pathways comprising multiple genes. So understanding the pathway requires knowledge of the constituent proteins.

“There is a strong mutual dependency among biological entities,” Yona says.

That mutual dependency is the key to Biozon's effectiveness and is something that

A computational biologist at Cornell has developed a resource to store and explore biological data that may be the key to unlocking the secrets of the protein universe.

By Jay Wrolstad

Proteins

Structures

Interactions

existing biological databases cannot provide. “Biological data is searchable, but we are creating a resource that will integrate all of the data and will relate the entities to each other,” says Yona. That includes connections between DNA sequences and the proteins they encode, relations between protein sequences and the structures that they fold into, and links between expression data and DNA sequences, to name a few.

Biozon currently stores information on no less than 40 million protein and DNA sequences, 30,000 protein structures, and 200,000 interactions, totaling 90 million documents from storehouses such as GenBank, Uniprot, PDB, and BIND, as well as from in-house computations. It also lists some 2.5 billion relations between documents.

“We have created a unified resource that allows a view of every entity in its broader biological context,” Yona says. Down the line, Biozon should be able not only to link to the available databases, but also to augment existing information in such a way that scientists can accurately predict interactions between proteins, their domain structure and their function, and the pathways they are involved in.

The process of downloading information from a database, analyzing it, and then moving on to the next depository is a tedious, time-consuming chore for researchers who often lack the skills to do the job efficiently, Yona contends. “We want to help them by compiling the data from multiple databases into a single unified knowledge resource, processing the data to determine relationships between biological entities (such as similarity relations), and then providing those results as part of the database.”

Four years in the making, Biozon remains a work in progress, with mountains of information still to be integrated. The goal is to develop a system that enables open contributions and the sharing of information data using the infrastructure and tools created by Yona and his team.

The big bang in cyberspace resulted in a demand from computer users for help in navigating the Internet, especially for ways to find what they are looking for among billions of web sites. Google leaped to the forefront in search with an uncanny ability to deliver the most pertinent results at the top of what can be very long lists of query results on virtually any topic.

Their success, along with that of engines run by Lycos, Ask Jeeves, AltaVista, Yahoo, AOL, and Microsoft, among others, has ushered in some amazing search capabilities. Computer users can now quickly search through all of the information on their machines, obtain directions to a restaurant, or get a real-time, bird’s-eye view of locations near and far.

The graph theory technology behind such popular search engines serves as the model for Biozon. “The challenge was that there is not much precedent for this type

of database, and few models to use. We had to create the concept ourselves—enabling complex searches not found elsewhere,” says Cornell programmer Aaron Birkland, who collaborated with Yona in creating the foundation for Biozon.

Biozon also borrows from concepts developed by online retailer Amazon.com, a popular web location with the ability to host sites for other vendors and to create purchasing patterns among consumers that often leads to targeted marketing efforts. In a similar manner, accessing a wide variety of biological databases and identifying patterns across biological data has enormous potential for understanding relationships, predicting function, and discovering emergent data structures and biological phenomena.

The more information a researcher has at his or her disposal, the greater the accuracy of assertions being made, says Yona. “We looked at several different web searching methods and developed effective searching techniques, after determining that the Google method is the most effective way to rank and organize query results.”

Biozon’s effectiveness is the direct result of a data graphing structure that is expressive enough to conduct searches that span highly connected entities and can pinpoint those connections, Birkland says. “In biology, meaning is stated as shapes and pathways, and that lends itself to expressive types of searches.”

The underlying data graph holds a mind-boggling one terabyte (roughly a thousand gigabytes) of information in a relational database. A cluster of 50 machines is used to crunch the data. “It’s a very powerful tool,” Birkland notes.

Also working on the search engine were undergraduates Paul Shafer and Tim Isganitis, both of whom graduated with computer science degrees in May. They were charged with finding the optimum way to rank query results.

“Typically results are not sorted by relevance. Instead they may be ranked arbitrarily based on alphabetical ordering or by the date the record was created,” Isganitis explains. “Our method looks at the web as interconnected pages, like Google, with rankings based on the connectivity of those pages; usually the pages with the most links are the most significant.”

This approach can be applied to a database, so that by looking at entities versus words, protein or DNA sequences can be neatly organized. “We experimented with existing algorithms to see which ones provide the most useful ranking of results,” Isganitis says. Biologists can collect information from many sources—some of which may be useful and some of which may not be, because they are outdated or not relevant—and order them to present the most useful information first.

“It was great research experience, and it was very rewarding to see that the technology we helped to develop

was performing as advertised,” Shafer says. “It will be a very valuable tool for biologists.”

Isganitis concurs, saying, “As my first project, Biozon was a valuable experience in that I learned how to conduct proper research methods.” He notes that being an author of a published academic paper detailing the work is a feather in his professional cap and was influential in his acceptance by Carnegie Mellon University to do graduate study at the Language Technologies Institute, focusing on computational biology and artificial intelligence.

To conduct a search on Biozon, the scientist first formulates a question, such as “What are all of the structures of proteins that interact with a particular breast cancer gene?” The answer requires data on protein-to-protein interactions, sequences, and structures and the ability to link it all together. The search engine will query all the relations between structures and proteins, and all relations between proteins and interactions. In Biozon, these relations are not established just based on cross-links between databases. The actual entities are examined carefully to determine possible relations that are often overlooked.

“This increases tremendously the expressiveness of our system,” says Yona, “We can link biological entities based on physical properties, not just on identifiers.” Biozon takes such capabilities a step further by enabling “fuzzy” searches that list tenuous connections among data sets. The notion of similarity is critical, says Yona, because extrapolating on the properties of a particular protein or gene can result in a previously undetected relationship.

Similarities are used often in computational biology to infer relationships, and some databases allow this, but not based on expression data. Measuring the expression levels of different genes can indicate their activity in a cell under certain conditions. Thus, researchers can find correlations between genes, or similar patterns of expression, that are the basis for a functional link (such as an interaction) and in turn suggest new relationships.

Yona is now offering Biozon to the scientific community and getting some rave reviews. “People are excited about how this can be used, how powerful it is,” he says. “A faculty member at one university told me she had a full-time assistant doing these types of searches. There is still a lot of work to do with the prototype, but we have something that is a big advance in database research.”

Also singing Biozon’s praises is David Linn, an assistant professor of biomedical sciences at Cornell who

contributed to the project. “Biologists now have access to all the information they need in one place. This makes it much easier to find data on a given gene and related proteins than searching through several databases,” he says.

Linn cites the search engine’s ability to conduct comprehensive data analysis, noting similarities, as particularly useful to him and his peers. “The big question is, what does a gene do? More than half of the identified genes have no known function, and this will allow us to determine that function more quickly, potentially saving years of time spent on research.”

In delving into the roles of genes in the human olfactory system, says Linn, he has taken advantage of Biozon’s capabilities. “We know that these genes have an effect on neurons in the nose and transmit information to the brain, but we have discovered a number of them that have unknown functions. With Biozon we may be able to determine those functions.” And that’s just one of myriad applications for the search engine, Linn notes. “This has potential for any biological question and any type of biological analysis.”

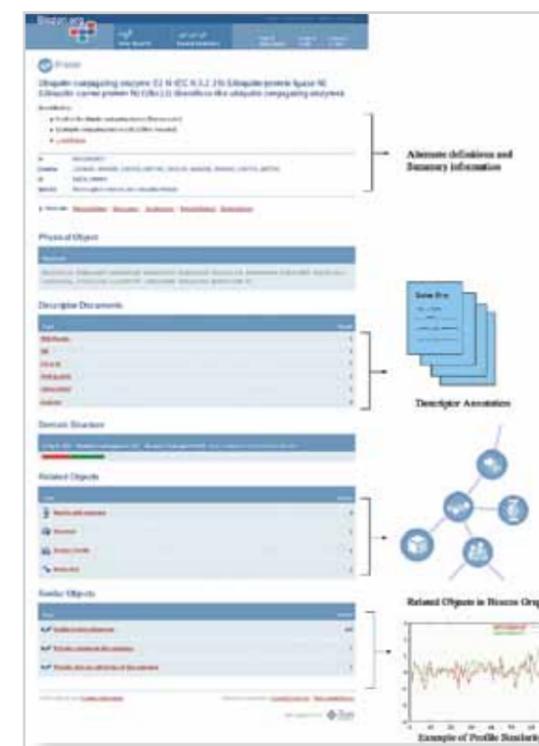
That utility increases with users such as Linn being able to register with Biozon so that they can contribute or access comments posted on the site, store query results for future reference, and get access to proprietary information.

A biologist may want more than just a list of search results. He or she might want the actual entities or biological structures themselves, to

download or review, says Yona. “In Biozon, users can save their queries, materialize the entities, or reproduce prior results,” he says. “Scientists can focus on research rather than on database construction, web tools, and other indirectly related research tasks. This also helps eliminate a duplication of efforts in biology labs.”

To speed the knowledge transfer process, Biozon allows experts to add notes to specific biological entities before the formal publication of a paper. “The time between a scientific discovery and the release of that discovery could be several years. We can provide links to a research Web site and release new information, pending authorization.”

Yona calls Biozon a “complete roadmap of the protein universe” — an apt description of a tool that will help scientists figure out where they are headed and get there faster. ■ ■ ■



THE Rings REVEALED

Sixth from the sun, the planet Saturn is only now giving up secrets that Joe Burns and his colleagues have waited years to learn.

By Kenny Berkowitz '81

Sixteen years after Joe Burns started to help plan the Cassini mission to Saturn, NASA's orbiter has reached its destination, with new data streaming back to Earth every day. It will take years, or even decades, before it's all analyzed, and as the first papers are being published, Burns sits quietly in his office, juggling his three jobs — engineering professor, researcher, and vice provost — and enjoying the vicarious pleasures of being a billion miles away.

"I love to travel, and this is just the greatest way to go," says Burns, a professor of astronomy, the Irving Porter Church Professor of Engineering, and university vice provost for physical sciences and engineering.

"There's the elegant beauty of space, the excitement of exploration, the chance to see new things. It's like traveling to another country, where you're stimulated by seeing something unexpected and trying to understand how that society operates. From a technical standpoint, Cassini provides an opportunity to tackle scientific puzzles that may have very, very simple solutions. Because we're surveying this system in detail for the first time, we don't need to have the answers to the nth decimal place — we just need an order of magnitude. We merely want to understand what we're seeing."

With papers piled on the floor, posters of Saturn taped to the walls, and a bicycle leaning against a bookcase, Burns seems perfectly at home in his office, dressed in a T-shirt and sandals, and speaking with a simple directness that makes a lifetime in space exploration almost sound like an accident. One of five brothers, Burns grew up in the then-rural Hudson Valley, and though he was offered a scholarship to Cornell as an undergraduate, his father sent him instead to Webb Institute of Naval Architecture, located on Long Island Sound. ("When my dad learned that I'd gotten into a school that was totally free," says Burns, "he said, 'Son, you're a naval architect.' So I became a naval architect.")

Webb was so small, with only 17 students in his graduating class, that Burns joined the intercollegiate tennis team, even though he'd never played before, and became student body president. Through Webb's required co-op program, Burns worked as a shipyard welder, an engine room cadet on a merchant ship, and a tester of models for America's Cup yachts. Nonetheless, by the time he graduated, he had already rethought career plans as a ship designer. By then, five years after the Soviet Union launched the first satellite into space and only months after John Glenn became the first American to orbit Earth, the best minds of a generation were turning toward space, and Burns decided to pursue a doctorate.

Coming to Cornell, Burns shifted his focus from fluid mechanics to space dynamics, completing his Ph.D. in 1966 and taking a post-doc at NASA's Goddard Space Flight Center. Two years later, Burns came back to join the engineering faculty at Cornell, where he found himself drawn into Carl Sagan's orbit. Over the next decade, Burns became an expert on planetary dynamics, and apart from research appointments in Berkeley, Moscow, NASA-Ames, Paris, Prague, and Tucson, he's been in Ithaca ever since.

Working with colleagues and students, Burns has discovered numerous irregular satellites in orbit around Saturn, Uranus, and Neptune, sparking research that, since 1997, has tripled the number of known satellites in the solar system; in tribute, he's had an asteroid, 2708 Burns, named after him. Along with teaching graduate and undergraduate classes in mechanics, applied mathematics, astronomy, and physics, he's edited two books, *Planetary Satellites* and *Satellites*; chaired the American Astronomical Society's divisions of planetary science and dynamical astronomy; and spent twenty years as the editor of *Icarus: The International Journal of Solar System Studies*.

As Burns tells it, all this came about through his friendship with various Cornell astronomers, including Sagan — "I was just a space groupie," he says — which led to *Icarus*, press conferences, organizing national meetings, space policy panels, chairships, congressional hearings, and ultimately to membership on the CRAF, Galileo, and Cassini missions. But when colleagues describe him, the stories are very different: "Joe has a tremendously broad, encyclopedic knowledge of the research that's been done in a lot of areas in planetary science," says Phil Nicholson, professor of astronomy, who's known Burns for more than twenty years and works as a member of Cassini's visual and infrared mapping spectrometer (VIMS) team. "His modus operandi is identify a problem and find a graduate student who can make it the nucleus of their thesis. But almost always, it was Joe's idea in the first place. Many

of those students have gone on to become very well known and respected in the field themselves — and they all still talk to him."

"Joe can handle a wide range of scientific questions on all sorts of matters," says Peter Thomas, senior research associate, who was originally trained as a geologist (Cornell Ph.D. '78) and works on the Cassini imaging team with Burns. "He's a great example of someone who has moved beyond his formal training to become very prominent in the field. Because whatever your background, after working for a while in space, you train yourself to do other things. It's all about exploration, and when you're exploring unknown worlds, you learn to adapt."

Burns's first mission, the ill-fated Comet Rendezvous Asteroid Fly-By (CRAF), lasted about five years before it was cancelled by Congress, with some of its hardware later transferred to Cassini. On Galileo, his second mission, he analyzed spacecraft images of Jupiter and discovered two new rings, one embedded in the other and both composed of microscopic debris kicked off the planet's smaller moons. The structures were totally unexpected, and the significance was huge: For the first time, Burns and his colleagues had determined how planetary rings can be continually reborn after they originated, billions of years ago, when the solar system was forming from a flattened disc of dust and gas.

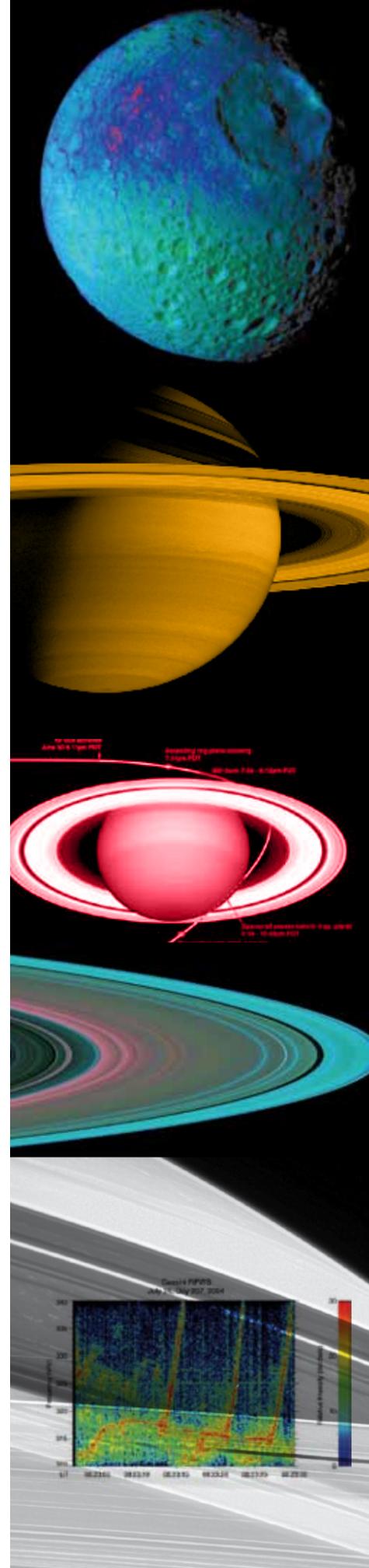
In talking about Cassini, Burns is proud to be associated with the mission's Cornellians: Nicholson; Thomas; Joe Veverka, professor and chair of the astronomy department; Peter Gierasch and Steve Squyres '78, Ph.D. '81, professors of astronomy; and Matt Tiscareno and Matt Hedman, post-doctoral associates

who arrived last year. Also on the Cassini scientific team are Mark Showalter, Ph.D. '85, a doctoral student of Burns's, and two Engineering graduates whom Burns taught: Jeff Cuzzi '67, the mission's leader for studies of planetary rings, and Tony DelGenio '73, an expert on planetary atmospheres. In describing his part in their collaboration, Burns likes to talk about the solar system's smallest bodies — satellites, asteroids, comets, and dust — and the evolutionary effects of even the most minute, barely measurable forces, acting over eons. "If my work has a theme, it may be that the world is understandable," he says. "Even things that at first appear unbelievable can be understood with a little creativity and enough study."

If the example of past missions holds true, some of the most influential studies from Cassini may still be years away, after the data are all archived, analyzed, and analyzed again. Already, Burns and the imaging team have published their first papers in *Nature* and *Science*, with discoveries that have startled the scientific community. New rings have been found around Saturn; new moons



"Joe can handle a wide range of scientific questions on all sorts of matters."



"I was just a space groupie."

“We’ve
spent 16 years
planning this
mission in great detail.
It’s hard to come to grips
with the fact that we’re
actually getting brand new
data arriving every day now.”

have been identified in the gaps between rings; and clouds of oxygen suggest the presence of tenuous atmospheres over the rings.

“Research is a very human endeavor, with a lot of competition that demands a lot of drive,” says Burns. “For the most part, it’s friendly competition, but to some degree, we all want to be the first person to point something out. Nowadays I don’t care so much about publication, but I love to tell people, ‘Look at what we just found!’ It’s not like a steep mountain that I’ve got to climb — I’m old enough now that I don’t need to climb mountains anymore, but I still am excited to learn what’s over that next ridge.”

In its first year, Cassini has captured many tens of thousands more images than the Voyager flyby missions and is expected to send a hundred thousand more before the nominal mission ends three years from now. “In the past, we used to get a snapshot of these rings, just a few pictures that we could stare and stare at,” says Burns. “But now, we get to watch the whole movie, so that we can learn how things change. And because dynamics is what I’m about, if we can see these systems evolve, we can write the differential equations that describe those changes. And that’s fun.”

“Cassini is producing orders of magnitude more data about the rings than anyone has had before,” says Matt Hedman, whose previous training in experimental cosmology prepared him to extract weak signals even when they are contaminated with substantial noise; he is currently working with both Burns and Nicholson. “We’ve been given the opportunity to see things that have never been seen before, things that have only existed in simulations. As a relative neophyte, I’m able to ask Joe or Phil, ‘What does this mean?’ And sometimes they can explain it, and sometimes they can’t — which is especially exciting. I’m learning as I go, and I continue to be amazed at just how complex these systems are.”

“The thing that’s surprised me is just the incredible clarity of these images, and how much detail we can see of some structures that had only been theorized about,” says his officemate Matt Tiscareno, who works with Burns on identifying and unraveling the dynamical phenomenology of the rings. “It’s like being on the front line of exploration and being among the first people wading in and trying to explain all these things.”

For Tiscareno, the wavy edges of gaps in the main rings have a puzzling complexity, raising questions as to how they are generated; for Burns, the latest mystery lies in what generates the kinks of Saturn’s rings, and how to model the dynamical interactions that keep those kinks moving past his camera. Thomas’s greatest surprises have come from the first images of Iapetus, one of the larger satellites of Saturn, which is far less spherical than expected, and has a ridge that’s 20 kilometers high running precisely along its equator, “looking like a walnut, and absolutely no one would have predicted that.” Nicholson, whose VIMS instrument had no equivalent on the earlier Voyager missions, is receiving the first results

of the rings’ composition and is puzzled to see that they’re “remarkably homogeneous, unvarying, looking very much like the ideal laboratory spectrum of low temperature water frost.”

There are traces of iron silicates and organics in the mix as well, and any number of possible explanations, with no clear solution in sight. But the biggest surprise for Nicholson comes from recognizing just how far this mission has come from its inception. “We’ve spent 16 years planning this mission in great detail, deciding what observations we could make,” he says. “It’s hard to come to grips with the fact that we’re actually getting brand new data arriving every day now, which is a huge change in mindset.”

For old hands like Burns and Nicholson, finally arriving at Saturn leads to more planning, not less, with increasing amounts of time spent watching others do the hands-on analytical and numerical analyses that first excited them about space exploration. “Sometimes I think it would be nice to have a week to do nothing except bury myself in the data,” says Nicholson. “Because it’s such a long mission, you’d think there would be plenty of time to do things, but there are deadlines coming up every day. And even though we’re getting data now, we’re still in the process of detailed planning for observations that will happen six months or a year from now. So much of the nitty-gritty science is being done by post-docs and graduate students, and people like Joe and I have to get our kicks from vicariously looking over their shoulders.”

The time is especially crowded for Burns, who spends about half of his day as vice provost trying to facilitate the research of other faculty members in the university and claims that his greatest accomplishment as an administrator is “staying alive. My problem is that I try to be involved in way too many things. I’m attempting to learn about, and help, the dozen research centers that report to me, but not willing to pass up this chance to explore Saturn.” He hasn’t given up teaching, or windsurfing, or dinner parties, or an occasional game of basketball. But more often than not, he’s here in his office, traveling by satellite and plotting his next move to gather as much data as he can before September, when the orbiter will shift into the equatorial plane and won’t reach the proper vantage point to study the rings again until May 2006.

After that, who knows? Cassini is planned to operate in Saturn orbit for two more years, and the project might continue for as long as four years after that, but that future isn’t known yet, and doesn’t need to be. “Planetary exploration is great, because it’s not so far out as astrophysics and extragalactic astronomy, where you can say just about anything, because nobody can ever test you,” says Burns. “Here, if you’re wrong, you know there’s going to be a spacecraft someday that will kick your butt. And that makes it especially stimulating—knowing that you have this challenge to predict some things that are only going to be truly understood by those who come after you.” ■ ■ ■

CONTINUING EXCELLENCE

Lee steps up as director of the Institute for Biotechnology and Life Sciences Technologies.

Kelvin Lee, the Samuel C. and Nancy M. Fleming Associate Professor in the School of Chemical and Biomolecular Engineering, is the new director of Cornell's Institute for Biotechnology and Life Sciences Technologies.

The institute promotes research, education, and technology transfer to benefit the Life Sciences industries, including agriculture and medicine.

"My primary role as director is to work with institute staff to facilitate and foster the infrastructure for doing life science research at Cornell," said Lee, who began his appointment as director in July.

In addition, Lee is responsible for maintaining a healthy relationship between Cornell and the New York State Office of Science, Technology and Academic Research (NYSTAR), the state's funding program to spur technology-based research and economic development. Lee also will administer the institute's Center for Life Science Enterprise, one of 15 Centers for Advanced Technology in New York State, which is funded by NYSTAR.

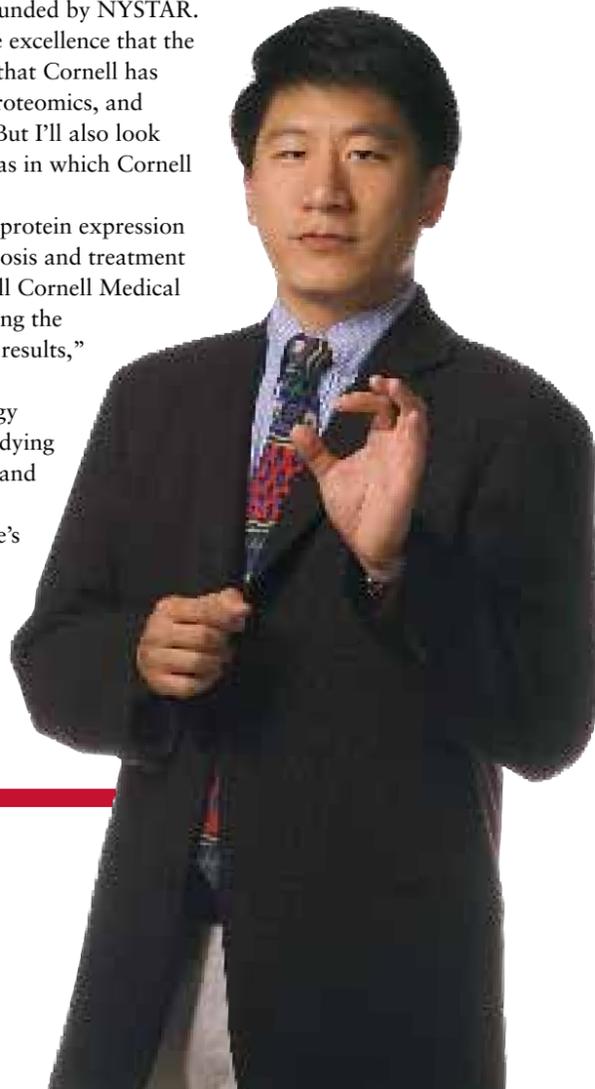
"As I look forward, I'll continue to promote the excellence that the institute is already recognized for," said Lee, noting that Cornell has strong programs in genomics, nanobiotechnology, proteomics, and agricultural-related research, among many others. "But I'll also look for opportunities to nurture and foster emerging areas in which Cornell expertise may contribute."

Lee's own work focuses on studying changes in protein expression in the central nervous system that relate to the diagnosis and treatment of Alzheimer's disease. He collaborates with the Weill Cornell Medical College, where his biomolecular information regarding the disease is clinically applied. "So far, we've had good results," he said.

He also works with Cornell's Nanobiotechnology Center to create next generation technologies for studying proteins, such as microfluidic devices for separating and analyzing proteins more efficiently. In addition, Lee collaborates with the U.S. Department of Agriculture's Agricultural Research Service on campus to research a bacterial pathogen (*Pseudomonas syringae*) that damages tomato crops and serves as a model system that may help shed light on pathogens that impact humans and animals.

—*Krishna Ramanujan, Cornell News Service*

"As I look forward, I'll continue to promote the excellence that the institute is already recognized for."



LESSONS LEARNED

London has responded effectively to the disruption of services following terrorist bombings July 7, but the event underscores the need for a careful examination of the vulnerabilities of the underground infrastructure of our cities, says a Cornell University engineer.

"I was impressed. The London Stock Exchange never stopped. The way they've cordoned off areas, the business continuity was very good. For such a potentially disruptive event, they have done very well in recovering and restoring services," said Thomas O'Rourke, the Thomas R. Briggs Professor of Engineering.

O'Rourke, whose research is aimed at making underground utilities more resistant to damage—whether from man-made or natural disasters—had just returned from London, where he was the featured speaker at a June meeting convened by the Bank of England to discuss financial sector resilience in the face of disasters. Until recently, O'Rourke said, financial institutions had worried mainly about cybersecurity, but after the World Trade Center attack, they became interested in the external infrastructure networks that support their cyber infrastructure.

In his London talk, O'Rourke described the lessons of 9/11, based on his own research at the site. Communications in New York City were widely disrupted, largely because of damage to the underground infrastructure near the collapsed towers. Broken water mains poured 35,000 gallons of water per minute into a seven-story underground space, filling it "like a big bathtub" and flooding transportation tunnels all the way to New Jersey. Falling debris smashed into a vault beside the Verizon building just north of the Twin Towers, cutting cables. "What wasn't severed was flooded by millions of gallons of water from the broken water mains," O'Rourke told his London audience.

He predicted that in a major disaster, cell phones would not be helpful for emergency communications because of the overload on the system. The prediction was borne out after the London bombings, he found. What does work besides two-way radio communication, he said, is wireless e-mail through portable devices like the BlackBerry. Because e-mail is not a continuous flow of data like voice communication, mail routing is more flexible and able to accommodate heavy traffic more easily.

Fortunately, the London bombings did not



Cornell News Service

Thomas O'Rourke (left) uses an earthquake simulator to test gas pipeline performance. His research is aimed at making underground utilities more resistant to damage from both natural and man-made disasters.

attack underground infrastructure directly. They were aimed at destroying transit vehicles and tying up the transportation system. But the underground utility systems of large cities remain highly vulnerable to damage.

"We have been building for ourselves a more and more complex world and packed our systems below street level with more and more different components, often with little planning or integration," O'Rourke pointed out. "These systems have accidents without terrorists. We'd like to make them work better under normal circumstances. Irrespective of terrorism, there's a lot to be gained."

—*Bill Steele, Cornell News Service*

UNDERGRADS IN RESEARCH

Yuk Kee Cheung '05 EE (below, right) discusses her poster on a technique that can create synthetic cell membranes with, from left, Cornell graduate student Jose M. Moran-Mirabal and visiting Purdue Professor Joseph Irudayaraj at the 2005 Cornell Undergraduate Research Board (CURB) Spring Research Forum. About 100 undergraduates presented their original research in posters and oral presentations in the Duffield Hall atria at CURB's 20th Annual Undergraduate Research Forum in April. "CURB is a student-run organization dedicated to promoting, publicizing, coordinating, and celebrating undergraduate research," said CURB president Gali Porat, ILR '05, of Philadelphia. —*Thomas Oberst, Cornell News Service*



2005

RECOGNIZING GOOD ADVICE

Mary Sansalone, professor in the School of Civil and Environmental Engineering, was recently named one of the four 2005 winners of the Kendall S. Carpenter Memorial Advising Award. The awards were established by Stephen Ashley, a member of Cornell's board of trustees, to honor his former adviser, Kendall S. Carpenter, a professor of business management in what is now the Department of Applied Economics and Management from 1954 until his death at the age of 50 in 1967.

The \$5,000 awards recognize "sustained and distinguished contributions of professorial faculty and senior lecturers to undergraduate advising," and nominations were accepted from individual students, university staff, college deans, and associate deans, and department chairs.

"Professor Mary Sansalone has been the most knowledgeable and helpful adviser I have ever had at Cornell University," enthuses one of her students in the School of Civil and Environmental Engineering. Many others commented on the exceptional amount of selfless dedication she has for her

students. "In a group of exceptional advisers, Mary stands out," says William Philpot, associate director of the school.

Sansalone credits her Ph.D. adviser at Cornell, Professor Emeritus Richard White, with teaching her by example to be a good adviser. "He truly cared about his students and always looked out for their best interests. I've always tried to follow his example."

Other advising award winners were Janice Brown, Department of Food Science; Gary Evans, Department of Design and Environmental Analysis; and Mary Katzenstein, Department of Government. Recipients will be honored next spring at a trustee-faculty dinner recognizing the winners of university-wide teaching and advising awards.

Also this year, the awards committee made a program award to Rich Robbins, director of engineering advising, for funds to implement an electronic tracking and web-based evaluation system in the Engineering Advising office.

—Cornell News Service

EXPERIENCING ARECIBO

Talia Kohen always pictured herself in law school after college. But she figured that plan left her free to pursue a bachelor's degree in pretty much anything, so she decided to indulge her analytical side and spend her undergraduate years studying electrical engineering.

Somewhere on the way to law school, though, the Cornell University senior from New York City got sidetracked. And she landed in a crowded little office on a steep hill in northwestern Puerto Rico, just a few steps from the world's biggest and most sensitive single dish radio telescope.

Kohen is one of about a dozen undergraduate students spending this summer at the Arecibo Observatory, which is run by the National Astronomy and Ionosphere Center at Cornell University for the National Science Foundation (NSF). The students are at Arecibo through the Research Experiences for Undergraduates (REU) program, an NSF program that gives undergraduates from around the world hands-on experience in radio astronomy, planetary radar astronomy, and atmospheric science (aeronomy). The students, in various majors and years, are assigned a 10-week project with a staff scientist, and at the end of the summer they present their results to the observatory community.

REU students come from schools around the United States and live onsite, sharing small cabins or dormitory rooms. Kohen's research project is in aeronomy—specifically, studying variations in neutral wind patterns in the thermosphere. The results could have important implications for satellite-based communications systems, which can be disrupted by phenomena in the upper atmosphere.

It's more complex than anything Kohen has done in classes so far, so she has been reading old papers on the subject, breaking them down sentence by sentence when she has to. "It's really hard for this topic," she said. "There doesn't seem to be anything basic or elementary. But what I've noticed about here is, you can be honest if you don't know something. It's okay to say 'I don't know everything.'"

Kohen hopes at the end of the summer she will have good results to offer. "But what's more important is walking away feeling like I understand the science behind it."

Law school, in the meantime, is still a possibility. But probably not right away. "I'll go with this," she said, "and see where it takes me."

—Lauren Gold, Cornell News Service

GRANT FOR GRAPHICS

Kavita Bala, an assistant professor in the Department of Computer Science, was among three faculty members to receive a 2005 research grant from the President's Council of Cornell Women (PCCW), an alumnae group that serves as an advisory council to Cornell University's president. Her research project is "Constrained Texture Synthesis for Computer Graphics."

Other winners include Michelle Campos, assistant professor, Near Eastern Studies, for "Palestine Between Empire and Nation: 'Civic Ottomanism' in a Shared Homeland, 1908–14" and Nancy Wells, assistant professor, design and environmental analysis and the Bronfenbrenner Life Course Center, for "The Effect of the Environment on Obesity in Low-Income Families: Influences on Physical Activity and Diet."

Established in 1992 to help advance the careers of women in academia through support of research leading to tenure, PCCW's Affinito-Stewart Grant Program has presented more than \$462,000 to 151 women at Cornell. The program is named to honor the group's founders, Lilyan

Affinito, a 1953 Cornell graduate, and Patricia Carry Stewart, a 1950 graduate. Both are presidential councillors, trustees emeritae, and members of the Cornell University Council.

This year the three grant recipients will receive a total of \$33,000 in funding from PCCW. Grant applications were reviewed by a committee of 26 faculty members who rated them according to scholarly merit, research design, feasibility, and relevance to promotion and tenure. Nine PCCW members, most of whom are academics from other universities, reviewed the faculty-rated proposals and awarded the grants. Nonacademic reviewers focused on how critical a role the project would play in receiving tenure and whether other sources of funding might be available.

The 305-member PCCW was established in 1990 with the mission of advancing the involvement and leadership of women students, faculty, staff, and alumnae within Cornell and throughout its many constituent communities.

—Mary Faber

SMALLER AND BETTER

A two-year, \$200,000 grant from the New York State Office of Science, Technology and Academic Research (NYSTAR) will help a Cornell University mechanical engineer design smaller, faster, and cheaper devices for processing and producing proteins. The research has implications for a vast array of applications in research of biological systems.

Brian Kirby, assistant professor of mechanical engineering, won NYSTAR's 2004 James D. Watson Investigator Award, which is part of the \$225 million Generating Employment Through New York State Science (Gen*NY*sis) program. Gen*NY*sis supports life sciences research being conducted at New York's academic research institutions. The Watson award recognizes and supports outstanding scientists and engineers who, early in their careers, show potential for leadership and scientific discovery in the field of biotechnology.

The biotechnology and pharmaceutical industries are interested in cheaper and faster ways to produce and process protein pharmaceuticals, such as insulin, Kirby says. He seeks to use mechanical engineering to solve problems associated with a widely used technique, called

high-performance liquid chromatography (HPLC), for separating and identifying proteins.

"Any time anyone does an experiment to understand how proteins are expressed in an organism, they use HPLC to quantify them," Kirby explains.

The machines that currently perform HPLC are about twice the size of a desktop computer. Kirby plans to make hand-held devices packaged in a 4-inch cube that can separate and identify proteins. The miniaturized device should be faster, cheaper, and better suited to work with smaller volumes of proteins.

The grant also will help Kirby develop new procedures for protein production, which is of great interest to pharmaceutical companies that produce proteins on a large scale.

Kirby continues Cornell's connection with the James D. Watson Investigator Award, which began three years ago. Each year, a Cornell faculty member has received the grant: D. Tyler McQuade, assistant professor of chemistry and chemical biology, in 2002, and Matthew Delisa, assistant professor of chemical engineering, in 2003.

—Krishna Ramanujan, Cornell News Service



Conor Mancone, right, an undergraduate in the REU program at the Robert C. Byrd Green Bank Telescope in West Virginia, explores the underside of the Arecibo telescope with Green Bank scientist Ron Maddalena.



2005

“My work wouldn’t be possible without the organisms and without collaboration with biologists who study sea organisms.”

BRIDGE TO BIOLOGY

Lara Estroff, a materials scientist who studies how seashells and bones are formed and then tries to synthesize new materials in the laboratory that emulate the versatility of these natural composites, became one of the first College of Engineering faculty members hired as part of Cornell University’s New Life Sciences Initiative when she accepted an assistant professorship in Cornell’s Department of Materials Science and Engineering.

Estroff’s interdisciplinary work bridges the physical and life sciences, which makes her a good fit for the new initiative.

“My work wouldn’t be possible without the organisms and without collaboration with biologists who study sea organisms,” Estroff said in July from a Harvard University laboratory where she was finishing a National Institutes of Health postdoctoral fellowship. She started work in Ithaca in August.

Estroff’s work takes inspiration from biomineralization—how organisms use minerals and combine them with proteins to make such

highly resilient compounds as bones and seashells. Since materials with properties similar to those found in nature are difficult to reproduce in the lab, Estroff looks at natural processes in the hope of making synthetic materials with improved structural properties.

She is also looking at how creatures such as sea urchins, for example, can take minerals and sculpt them to suit their purposes, as researchers also find it difficult to get minerals to conform to desired shapes in their labs.

Estroff received her B.A. degree with honors in 1997 from Swarthmore College, where she majored in chemistry and minored in anthropology. She received her Ph.D. in chemistry from Yale University in 2003.

“I am looking forward to the collaborative environment at Cornell, and the fact the engineers talk to biologists and physicists and chemists,” Estroff said.

—*Krishna Ramanujan, Cornell News Service*

FOCUS ON PHOTONICS

Michal Lipson, assistant professor of electrical and computer engineering, is among this year’s recipients of National Science Foundation (NSF) Career Awards. The NSF Faculty Early Career Development Program offers NSF’s most prestigious award for new faculty members, supporting the early career development activities of those teacher-scholars who are considered most likely to become the academic leaders of the 21st century.

Lipson will receive a five-year grant of \$450,000 to support further research in photonics, in which circuits consist of tiny beams of light interacting on a chip. The result, Lipson says, will be low-power, high-bandwidth, high-speed, and ultra-small optoelectronic components.

Lipson already has demonstrated methods to guide, filter, bend, and split light on silicon chips at much smaller dimensions than attained by previous researchers, offering the promise of photonic circuits as small as current electronic chips. Confining light in very small spaces, where the dimensions of the waveguide are comparable to the wavelength of the light, has, in fact, been the secret for making some of these devices work, Lipson reports.

Research under the new grant will continue the development of all-optical and electro-optical circuits. Lipson plans to combine the various circuit components she has created into working systems and find out how to build the systems most efficiently. The goal will be to minimize the losses, size, and power of the system while maximizing the bandwidth.

She also will study ways to connect photonic circuits to the rest of the world. Two remaining bottlenecks are the interface between photonic chips and larger optical components, such as optical fibers, and using an electrical signal from conventional electronics to switch or modulate a beam of light in a photonic circuit. Lipson already has built devices that accomplish these goals but hopes to refine them and see how variations in the size and geometry affect performance.

Lipson also plans to refine the techniques used to manufacture photonic chips. While this is similar to making electronic chips, there are special requirements, such as a demand that the walls of waveguides be optically “smooth.” “This investigation is crucial to the real implementation of the concepts of this proposal,” Lipson says.

—*Bill Steele, Cornell News Service*

MARKING THE SPOT



Brien Barnett, NSF

Stephen Parshley '98 ME, a research support engineer in Cornell’s astronomy department, has plans to leave his mark on the world. Literally. The plans are Parshley’s winning design for the 2006 South Pole marker.

The marker will be fabricated and placed at the exact geographic location of the Earth’s South Pole on New Year’s Day 2006 and will remain as the pole’s official landmark for one year.

For the past three years, Parshley, 30, had been throwing on a jacket, grabbing an umbrella, and driving his pickup truck from his apartment to work in a climate-controlled laboratory on Cornell’s campus. This year, however, he puts on insulated undergarments, a fur-lined parka, ski goggles, and lip balm and walks in the pitch black through knee-high snowdrifts and wind chills as low as 140 degrees below zero Fahrenheit to get from his sleeping quarters at the U.S. Amundsen-Scott South Pole Station to a telescope facility 1 kilometer away, where he is a co-operator.

The facility, the Antarctic Submillimeter Telescope and Remote Observatory, houses the South Pole Imaging Fabry-Perot Interferometer (SPIFI), a Cornell-owned instrument for observing star-forming regions of nearby galaxies. Parshley helped build the instrument when he was at Cornell.

Now he is a member of the South Pole “winter-over” crew—an elite group of 86 hardy souls representing a wide range of specific trades who occupy the station during the eight-month-long Antarctic winter, from mid-February through late October, when extreme weather prohibits any flights into or out of the area.

To keep from going crazy, winter-overs engage in a number of recreational activities, including an annual South Pole marker design contest. The competition’s only rules are that the marker must be able to be constructed from the somewhat limited materials and tools available at the station and that it must carry a few specific lines of official text. Any winter-over may enter a design, and the entire crew votes to decide the winner.

Parshley’s design incorporates a model of the new elevated building at the U.S. Amundsen-Scott South Pole Station. Photos by Thomas Nikola.



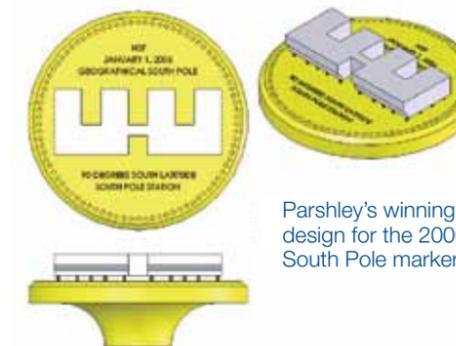
Thomas Nikola

The design, which took Parshley about 15 hours, is both simple in structure and deep in symbolism. Its defining feature is a miniature aluminum model of the station’s new elevated building. The model stands at the center of a 5-inch-diameter brass disk and is encircled by 86 dimples, representing the members of the winter-over crew.

The marker will be fabricated at the South Pole over the next few months by Parshley and Allan Day, the station’s machinist, who estimates that it will take 60 to 70 hours in total.

“Since all the past pole markers have been basically flat with relief-style engraving, I’d been playing around for some time with the idea of pushing the marker into the third dimension,” recalled Parshley. “I also wanted to represent our winter-over crew ... and keep the machining simple. Then it just hit me: the elevated station surrounded by 86 dimples. Straightforward, yet meaningful.”

—*Thomas Oberst, Cornell News Service*



Parshley’s winning design for the 2006 South Pole marker.



Provided

HOMETOWN HERO

COOKING LESSONS

A solar oven project in Senegal gives students a taste of hands-on engineering.

During Cyprienne Crowley's three months in Senegal, tropical downpours, power outages, herds of white bulls roaming the streets, and temperatures reaching 120 degrees Fahrenheit became routine. But she loved the whole experience: living with a Senegalese family, riding in the bumpy *jagen-jaye* (the Senegalese equivalent to a public city bus), going on safari and seeing giraffes, and most of all, just sitting on the floor sharing meals such as chicken yassa with her host family. "Just chicken, rice, and onion sauce—it's really simple but the food is so fresh. I've never tasted chicken like this in America," she said, talking via cell phone from Senegal in July.

Why is an engineer so interested in food? Crowley, who will graduate in May 2006 with a bachelor's degree in mechanical engineering, spent the summer designing and building the prototype of a solar oven. Renewable energy technology, she explained, is much needed for developing countries. In Africa, cooking with wood has led to deforestation, air pollution, and lung and vision problems. Family cooks, traditionally women, need an economical, safe, and quick way to prepare meals each day for large families. The solar oven, which cooks food using only the heat of the sun, is a drawing-board-perfect solution.

Crowley's trip to Senegal was sponsored by Engineers for a Sustainable World (ESW), an organization based at Cornell University, and by CRESF Senegal, an independent non-governmental organization affiliated with Cornell University's Center for Religion, Ethics, and Social Policy. ESW, with more than 3,000 student and professional members nationwide, runs an annual summer internship program that provided support for Crowley's work.

Crowley joined an on-going project to bring solar oven technology to Senegal. She and Janelle Kolisch, a mechanical engineering student from Ohio State, refined the design; Crowley focused on window and reflector orientation to improve the oven's efficiency. The two then built a prototype of an oven at the University of Dakar machine shop. For mass production, the Senegalese company Transtech will manufacture the base; workers employed by CRESF Senegal will assemble and market the appliance.

The oven is insulated with raw cotton, a material easily grown in Senegal, and has two reflectors covered in heavy-duty aluminum foil and a glass top. It can reach 302 degrees Fahrenheit on average and cooks a full meal for a family of ten in about two and a half hours.

The oven's casing is roto-molded recycled plastic, a move meant to help encourage recycling. "There's this huge sanitation problem here," Crowley explained. Bottles and plastic cartons litter the village.

"Another concern in this engineering process is to keep the price low," Crowley said, "so it can be available to as many people as possible." The oven will retail for 25,000 CFA, equivalent to about 46 American dollars.

There was one key factor that the engineering team hadn't anticipated: grease. The Senegalese diet is fish-based and usually fried. The solar oven bakes the food, and it just doesn't taste the same.

"It's a completely different type of engineering than what I've learned at Cornell," Crowley said. "I have to completely adapt

my prior knowledge to the situation that's here. The solar oven is such a different way of cooking than they're used to. Everything here is so based on tradition that it just isn't easy to make this popular."

Even so, she's optimistic that solar cooking will catch on. "I think the main way that it can spread is by peer influence," said Crowley. "If some of the more important, influential women of the village are using this oven, everyone else will want to. It's just a matter of changing their taste buds a little bit." Crowley was particularly pleased to travel to the small village of Mehke, where she observed Canadian nutritionists working with Senegalese women to develop new recipes for the solar oven.

After spending three months working on the solar oven, Crowley hopes to one day return to Senegal to see it in use by the villagers.

"I have always had this altruistic bone in me," she said. "It's a great feeling to devote time to something that's really important to other people."

—Bridget Meeds

"It's a great feeling to devote time to something that's really important to other people."



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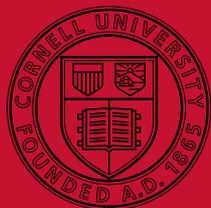
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