Letter From the Deans

Our rankings are very good news.
But is there too much information? Or not enough?

If you tend to look at the world from an engineer's or a scientist's perspective – and we do – the information we get from our rankings is both exciting and, too, a little bit puzzling.

The bottom line is very good: We rank near the very top, not just generally but in many departments, and we're moving up across the board every year. It's all good news. But there are so many different groups rating us, and the methods they use are so broad and varied, it's tough to know just how to sum it all up.

For example, Princeton Review ranks the College of Engineering as #1 in the country, but we can't help but notice that many of the best engineering schools didn't appear within the top ten. That's puzzling.

The Chronicle of Higher Education ranks our materials science department #1, computer engineering #6, and electrical engineering #10 in the country. They also rank marine biology and biological oceanography #3.

Science Watch, published by Thompson Scientific, creates a top 10 list of the best federally-funded U.S. university programs based on the citation impact of their published research. Materials science ranked #2 and engineering ranked #3. That's an important sign that our work is valued by other researchers and relevant to their efforts.

U.S. News and World Report ranks materials science #3, chemical engineering #9, and physics #10 in their list of top U.S. Graduate Schools.

We are proud to be recognized as top programs in Engineering and the Sciences and we work hard to expand the impact of our teaching and research. We continually see federal, corporate and private support for our work increase.

And yet, we know that, ultimately, only one criterion matters: To what extent do our efforts make a positive impact in the world? We hope this issue of Convergence shows the value of our work in a wide range of areas.

Matthew Tirrell
Dean, College of Engineering

Martin Moskovits
Dean of Mathematical, Life and Physical Sciences, College of Letters & Science

Evelyn Hu
Co-Director, California NanoSystems Institute

Dean Martin Moskovits has announced he is stepping down as Dean of Science as of May 1, 2007 to take a two-year leave of absence. He will be pursuing an entrepreneurial opportunity in the private sector.

While the faculty and staff at UCSB are sorry to see him step down, his move is yet another sign of the impact and real-world applicability of the work being done here.
Cover Story:

Is That Tea Real?
The human-computer relationship gets more lifelike at the Four Eyes Lab.

Biobusters
Developing battle-ready sensors – ultra-sensitive and able to “work in dirt.”

Mapping the Body's Zip Codes
The chemistry that guides – and might destroy – cancers.

What Is This?

Shorts...
Have you heard?

Secrets of Sea Bacteria
Marine microbes and the effort to cure drug-resistant diseases.

He’ll Keep You in the Dark
A stargazer’s dream – nonstop night.

QUESTION & ANSWER:

Jennifer Earl and Kevin Almeroth
How computers and the Internet are changing education, politics, business and much more.

For Alumni and Friends
Pages 12 and 13
chicken breast, applewood smoked bacon, cheddar tomatoes, corn relish, crispy tortilla strips and a touch of BBQ sauce. Served with Ranch dressing. Crisp romaine tossed in our
Is That Tea Real?

The human-computer relationship gets closer – and more lifelike – through the work of UC Santa Barbara’s Four Eyes Lab.

Marvels like these are still in the future, but maybe not so far. Computer scientists are advancing on the goal of a truly intuitive interface, where people interact as naturally with computers as they do with other humans. To put it another way, it’s getting harder all the time to tell the virtual from the real.

At the Four Eyes Lab – the name stands for “Imaging, Interaction, and Innovative Interfaces” – the wall between human and computer is being dismantled from both sides. Researchers are developing new ways to make computers more like us in their sensitivity to human gestures and expressions, while coming up with display technologies that mimic 3-D reality.

“We do things that have to do with images,” says computer science Professor Matthew Turk, who started the lab in 2000 after coming to UCSB from Microsoft Corp. He now directs the lab along with computer science Assistant Professor Tobias Höllerer, who came on board in 2003. With the help of PhD students, visiting researchers and alumni, Turk says he and Höllerer are focused on the goal of developing “new technologies that will enable better, more powerful ways for people to interact with computers.”

Eye-Hand Coordination

One example is HandVu, a Four Eyes-developed system that enables the user to guide a computer literally by pointing the way. Turk calls it “a vision-based system for hand-gesture interface.” The user, carrying a computer and wearing goggles with a camera attached, gets the computer’s attention by sticking a hand into the camera’s field of view. The computer, its camera “eye” now locked onto the hand, follows its movements and displays the changing scene inside the goggles.

The system also recognizes different gestures – such as an open hand, a pointing finger or a fist – and takes them as commands. By making a fist followed by a scissors motion with the thumb and forefinger, the user can “grab” a virtual object in the computer’s display, then “let go” of it by opening the fist and pointing the thumb and fingers forward.

This ability to read hand signals suggests any number of possibilities. Link the computer to the global positioning system, for instance, and the scenario of the on-demand map that flashes restaurant menus isn’t all that farfetched.

Höllerer says hand-tracking computers are a step toward a merger of virtual reality with the physical world, so that user interfaces “basically consist of physical objects.” With HandVu technology and GPS working together, he says, one could point to an object, such as a building or even a particular window in the building, and thereby mark it for others who are using the same database (he and his students have done an inventory of trees on part of the UCSB campus in this way). Not only does the object have a label, but the label would automatically appear to anyone looking at it through a linked viewing system – such as the camera and goggles now used with HandVu. “The idea is that, wherever you go, without any additional need for calibration or modeling, you should be able to don your glasses and add annotations to the physical world,” says Höllerer.

Soldiers could use such technology to alert each other to potential snipers. Search-and-rescue teams could use it to mark the ground they have covered and show areas yet to be combed. Virtual objects could be inserted into a real scene through the same method. “A group of architects in front of a construction site can see a fully rendered building before it is even started,” says Höllerer. Landscape architects could do the same scene-painting with virtual trees. Something like x-ray vision is possible as well. Using sensors that detect what lies behind an object and then send their data to the hand-tracking computer, viewers can see “through” the object by pointing at it.

Waiting for Miniaturization

HandVu-type interfaces have some way to go before hitting the consumer mainstream.

At this point, as Turk admits, “we are experimenting with fairly clunky devices.” Users of hand-tracking systems have to carry laptop-size computers in backpacks, and much of their head is covered with a contraption holding a camera (through which the computer sees) and goggles (through which they see what the computer sees). They’re still easy to spot in a crowd. As Turk says of the systems he and Höllerer are developing, “It’s not like we have a company just waiting to stick this in its pocket.” But they also know how technology progresses – toward making things smaller, more powerful and more portable. Höllerer hopes that “within five years or so we will arrive at something that people won’t reject right away.”
One exception to these purely experimental gadgets is the Fogscreen, a display system that is in commercial production and is wowing folks at trade shows and other venues worldwide. Though not developed by the Four Eyes Lab, the Fogscreen has a UCSB link: It was invented by a Four Eyes alumnus, Ismo Rakkolainen, who is now chief technology officer of the company manufacturing it in Finland. As the name suggests, it is a display made of mist, kicked up by zapping ordinary water with ultrasound and then blown downward through a carefully arranged battery of fans into a thin vertical plane 59 inches high and 79 inches wide. This “immaterial display,” as Turk calls it, has unique properties. It can show projected images on both sides, allowing both the front and back of an object to be displayed. And you can walk right through it. You won’t even get wet doing so. The sheet of fog is dry to the touch, give or take a rare drop of condensation.

The Four Eyes Lab has two Fogscreens on loan (they cost $90,000 each), and it has them set up at right angles to create three-dimensional images floating in air. But even a single screen can create a natural-looking interface for virtual objects and human-computer interactions. “The first thing people try to do is reach in and touch things,” says Höllerer. “That is where our lab jumped in and said, “Look, we have to develop interactive technologies for this, because clearly that’s what people want to do.”

The “Holy Grail” – as Seen on Star Trek

Höllerer and his students have devised applications that enable users to manipulate Fogscreen images with handheld devices such as LED-equipped position trackers or wireless joysticks. In one of these, virtual objects such as teapots, balls and cubes can be moved around and made to collide— all seemingly floating in mid-air. In another demonstration, a user can use a joystick to walk through a “virtual forest,” looking in various directions and even changing the

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direction of the sunlight. Somewhere around the corner, in the
3-D space created by dual Fogscreens arrayed at right angles,
Höllerer sees this technology moving toward “the holy grail
of virtual reality in computer graphics, which is basically the
science fiction idea of the holodeck from Star Trek, where you
can bring up any 3-D environment and it looks lifelike.”

The Fogscreens work in much the same way as HandVu
technology. In both cases, the user motions to the computer,
with a hand or a handheld device, and the computer changes
the display in response. Outdoors, it may pin a virtual label
on a tree. Indoors, on the Fogscreen, it might upend a virtual

Teapot. In such ways, two distinct research streams come
together to create new possibilities. Turk’s focus on
computer vision—making computers see and interpret
their surroundings more accurately—dovetails with
Höllerer’s interest in raising the realism quotient of
display technology and 3D interaction. The result is a
new experience of cyber-sociability, with people and
machines communicating as never before.
It’s not always easy to explain how academic research will affect the wider world. But there’s no such problem with the work of the ICB. The institute, funded largely by the U.S. Army and drawing on the talents of the faculties at UC Santa Barbara, MIT and Caltech, tackles today’s headline issues from terrorism to alternative energy. Its research could well make a life-or-death difference for U.S. troops under threat from roadside bombs or civilians who might be prey to bioweapons.

Nowhere is the ICB’s real-world mission clearer than in its work on biomolecular sensors, one of its four major research areas (the others are bio-inspired materials, bio-network science and biotech tools). Its scientists are developing technology that uses biological compounds to detect minute levels of disease-causing organisms, toxins, explosives or other substances in air, water or soil. The goal is to combine unprecedented sensitivity – down almost to single molecules – with reliability, ease of use and ruggedness.

The end-product needs to be literally battle-ready. “There are thousands of different types of biosensors in the literature that work wonderfully in the laboratory,” says ICB researcher Kevin Plaxco, a UCSB associate professor of chemistry and biochemistry. “Our sensors work in dirt.”

They also work in other contaminated environments, such as blood serum. And they can detect staggeringly minute traces – DNA down to parts-per-trillion, for example. They do this by using molecules that are engineered to fold and release an electronic signal when they recognize a particular target. Unlike sensors that rely on adsorption (the binding of molecules to a surface), this technology is “very hard to spoof,” Plaxco says.

Plaxco is working on this sensor project with two other UCSB scientists, Alan Heeger, professor of physics and materials, and Pierre Petroff, professor of materials and electrical and computer engineering. Theirs is one of at least 10 projects currently being carried out by ICB’s biomolecular sensor team, which includes more than a dozen researchers from the UCSB, Caltech and MIT.
Left: Folding based sensors that act as signal transducers are the basic thrust of Professor Kevin Plaxco’s research. Above: Conjugated polyelectrolytes can also be used to simplify the operation of DNA chips and microarray detection of DNA sequences, as explored in Professor Gui Bazan’s laboratory.
Mapping the Body’s Zip Codes

Biologist Erkki Ruoslahti is renowned for his work on the homing behavior of molecules and cells. Now at UC Santa Barbara, he is studying the chemistry that guides – and might destroy – cancers.

The human circulatory system is a vast web of arteries, veins and capillaries through which the substances essential to life – and some harmful to it – flow. It’s also a world of richly varied surfaces. Blood vessel walls are a tapestry of chemical markers, drawing certain molecules to certain tissue types while letting others pass. The Finnish-born Ruoslahti has been studying this complex vascular geography for most of his distinguished career. At 67, he has come to UCSB to run a new research institution and to chart a course for future cancer therapy.

The new institution is the Burnham Institute at UCSB, operated by UCSB and the La Jolla, Calif.-based Burnham Institute for Medical Research. Opened in December 2006, its mission is to chart the markers associated with malignant tumors in hopes of using these “zip codes,” as Ruoslahti calls them, against those same cancers. Ruoslahti is a distinguished professor at Burnham, which he joined in 1979, and holds the position of adjunct distinguished professor in UCSB’s Department of Molecular, Cellular and Developmental Biology.

“We’re looking for specific features in the blood vessels and lymphatic vessels of tumors,” he says, “with the intention of then using these specific markers to enhance the delivery of drugs and diagnostic probes into the tumors.” Essentially, the object is to find the chemical address of blood vessels in cancer – and send a molecule that binds specifically to the distinctive receptor protein. Attached to the molecule, there might be a chemical tracker to detect the tumor or a drug to destroy it. The research challenge is to come up with molecules such as peptides (segments of proteins) that zero in on tumor blood vessel receptors while leaving normal tissue alone.

A Decades-Long Quest

Ruoslahti has been working toward this therapeutic target for more than 35 years. As a post-doctoral fellow at Caltech in the late 1960s, he learned of neurobiologist Roger Sperry’s research suggesting that molecules on cell surfaces precisely guided certain aspects of brain development. Ruoslahti figured that cells elsewhere in the body might also be guided by surface signals and that the spread of cancer cells throughout the body – metastasis – might be a sign of the system going awry. Returning to Finland and setting up his own lab, he worked to isolate zip-code proteins. In the early 1980s, after he had moved back to the U.S., he and his collaborators achieved a major breakthrough with the discovery of RGD, a peptide that plays a crucial role in cell attachment.

Researchers have gone on to develop RGD-based drugs to prevent blood clotting. Ruoslahti stays focused mainly on cancer, studying how tumor-specific “homing” peptides that direct malignant cells during metastasis might be used instead for diagnosis and treatment. The first phase in this research is to draw the vascular map, finding out which areas on the inner surface of blood and lymph vessels, both normal and malignant, are targets for particular cancer cells. Molecules that ape the cell-attachment chemistry of the cancer cell can deliver their payload – a drug or a detection chemical such as fluorescein – to a specific type of tumor. Instead of using actual cancer cells in this process, Ruoslahti’s lab uses phages (viruses that infect bacteria) that home in on particular types of tissue. The phages are injected into mice, extracted after they bind to the target tissue, and then reproduced in greater volume for re-injection.

Once the vascular markers of a target tissue are identified, the corresponding peptides can be isolated from the phages. These then become nanoscale delivery vehicles for drugs or other chemicals. So far, Ruoslahti says, he and his colleagues have found a number of markers that appear with any kind of cancer. More interesting, because of their therapeutic potential, are markers identified with specific types of tumors, such as breast and prostate cancer. “We
don't have anything that we know is absolutely specific for a given type of cancer,” he says, “but we have markers that we know are limited to one of them – mostly breast cancer.” He also says they have isolated markers limited to cancers from “similar types of tissues” – for instance, glandular tissues such as the pancreas.

The Promise of Precision

Ruoslahti says it will take some time before the homing-peptide therapies are ready for Food and Drug Administration approval. “Much preclinical work needs to be done independent of the academic setting,” he says, noting that it took about 15 years after his discovery of RGD for the first RGD-based drug to reach the market. But the therapeutic potential of his zip-code mapping is obvious. With a highly specific marker as its target, a drug can be delivered right to the tumor with fewer side effects. A homing peptide or other molecule that attaches to just one type of tumor would also be a precise diagnostic tool.

For Ruoslahti, bringing a new generation of cancer drugs to market would be a fitting outcome for a career that has already earned him global recognition. He has more than 400 published scientific papers and more than 100 patents to his name. As the Burnham Institute's scientific director from 1989 to 2002, he initiated its growth to an organization with nearly 800 employees, as well as satellite centers in Florida and Santa Barbara.

What brought him to Santa Barbara? He says it was time for a change after 13 years in charge at Burnham. So he stepped down as director at the beginning of 2002. But that wasn’t enough of a change, “so I decided to move somewhere.” He and his life partner, the biologist Eva Engvall (herself notable for discovering ELISA, a famous immunological test), had a place picked out. “Many years ago I fell in love with the Santa Ynez Valley, so we decided to move here,” he said. Another attraction was that “UCSB was very active in nanotechnology and materials science, and my research started gravitating in that direction.” He moved to the area in September 2005 with a temporary appointment. Now he lives on some 1,000 acres overlooking the Santa Ynez Valley and works, at a much smaller scale, surveying the inner landscape of the human body.
QUESTION & ANSWER:
Jennifer, what drew you as a social scientist to this technology-focused program?

Earl: One of my areas of expertise is social movements within sociology. I realized six or seven years ago that social movements were fundamentally changing—or at least with unique, innovative uses of technology, they could fundamentally change. I thought to myself that if sociologists don’t get better at studying technology, then everything I know about social movements is going to be less and less relevant over time.

Give us an example of an activist movement that is changing with technology.

Earl: One is the strategic voting movement, which was essentially people getting together on the Internet to try to game the Electoral College. If they wanted to vote for a third-party candidate but were worried about the effects of that vote on the election between Bush and Gore in 2000, then they could essentially agree to trade votes over the Internet.

The second example is that we’re seeing people serving as something like “lone wolf” organizers. For example, if you have concerns about animal rights, it used to be that you would take action on that by affiliating yourself with an organization, like PETA, that was already well established and then attending their events. Well, the low cost of organizing on the Internet can allow people to become their own organizers. People start petitions on their own online. They start letter-writing and email campaigns online. Scattered individuals started the strategic voting movement that I just mentioned.

Coming from the Computer Science side, Kevin, what’s your interest in this interdisciplinary program?

Almeroth: I actually have two interests. One is more straightforward: to assess the impact of technology on education. There is a whole other dimension that’s a little more radical—trying to understand the impact of nearly ubiquitous access to the Internet through wireless networks. Thinking back to social action, you can think about using cell phones and instant messaging to coordinate a rally. There are other applications, for example, in the environmental area. They’re asking what would have happened with the Exxon Valdez if people had had cell phones on their cameras when they went up there to rescue baby seals. There would have been much more social outrage at that kind of accident.

What would have happened during Hurricane Katrina if you had had today’s pairing of cell-phone video and YouTube— with near-instant transmission of cell-phone video just about anywhere?

Almeroth: The network came down in Katrina, so cell phones couldn’t be used. But to keep this from happening the next time, we’re putting in a proposal to the National Science Foundation for what we call impromptu networks. These would enable FEMA to come in with devices that fit into a trailer, turn up a solar-powered antenna and set up a network that can support both Internet and cell phone communication. The technology also might help people be rescued sooner. We envision cell phones, enabled with GPS, where anyone can help rescuers find stranded people; you snap a picture and send it in. Your cell phone has GPS coordinates, and that’s everything you need to send a rescue team.

Earl: Let me give you an example of something Internet-enabled that was successful in the wake of Katrina. One of the major problems faced by survivors was how to get housing. A group created a Web site that essentially allowed people to announce, “Hey, I have a spare couch that someone can sleep on,” “I have a spare bedroom,” “I have a spare guest house.” Then people who were affected by Katrina could go online and search for housing in the area they evacuated to. The real power of such an application is that it allows...
Upcoming Events
As alumni, you have a special invitation to join us for these exciting events, showcasing innovative programs in engineering and the sciences and offering terrific opportunities for networking and good conversation.

**NEW VENTURE COMPETITION 2007**

**TECHNOLOGY MANAGEMENT PROGRAM**
Check out the entrepreneurial energy at UC Santa Barbara.

**COMPETITION FINALS:**
April 27, 2007
3:00 – 6:30pm
UC Santa Barbara
Corwin Pavilion
www.tmp.ucsb.edu

**GLOBAL WARMING SCIENCE & SOCIETY EVENT SERIES**
**JANUARY 2007 THROUGH MAY 2007**

**Future Events:**

*Elizabeth Kolbert*
Field Notes from a Catastrophe: Man, Nature, and Climate Change
Thursday, April 19 at 8:00 pm
UCSB Campbell Hall
www.globalwarmingsb.org

*Earth Day*
April 22 at 10:00 am - 5:30 pm
Santa Barbara County Courthouse Sunken Gardens
www.sbearthday.org

*Media and the Environment Conference*
Saturday, April 28 at 12-6 pm
UCSB UCen Corwin Pavilion
www.cftnm.ucsb.edu
A New Home for UCSB Alumni: The Mosher Alumni House

The Mosher Alumni House is currently under construction and is scheduled to open this May. It will be a striking facility, designed by award-winning architect Barry Berkus ’55 to serve UCSB’s 140,000 alumni.

Inside you’ll find galleries and terraces, conference rooms, a board room, and a living room. There’s even a parking garage to make a visit more convenient. Its meeting areas, many named for alumni whose gifts have helped make the building possible, will be used for reunions and alumni gatherings, and to help recruit top faculty and staff.

The Mosher Alumni House will include the UCSB Alumni Relations Department and the Alumni Association. It will be a wonderful resource for staff, the UCSB community and the broader regional community of the tri-counties. Come by and see its progress this spring!

Give us your feedback.
What do you think about Convergence?
email: marie@engineering.ucsb.edu
Alan Heeger, a professor of physics, and Nobel Laureate in Chemistry, was awarded the Eni Italgas Prize for Energy and the Environment in Torino, Italy, in March for his innovative research on solar cells made with plastic. The prize, 120,000 euros (about $156,000) is designed to acknowledge scientists with significant achievements in energy and the environment.

Arthur Gossard, a professor of materials, has won the 2007 American Association for the Advancement of Science (AAAS) Newcomb Cleveland Prize for “Coherent Manipulation of Coupled Electron Spins in Semiconductor Dots.” His award is shared by seven other researchers, including Micah Hanson, a graduate student in the Materials Department at UCSB. The AAAS is the world’s largest general scientific society and publisher of the journal Science. The prize was established in 1923 to recognize outstanding Science articles and it is given annually to the author(s) of the best research article or report published in Science. The value of the prize is $25,000; the recipient also receives a bronze medal. Gossard also won this award last year for work he did with David Awschalom, a professor of physics.

The College of Engineering’s Materials Science Department ranks second in total citations among U.S. universities for a 10-year period – 1996 to 2006 – according to Thomson Scientific, based in Philadelphia, PA. In addition, the Physics department ranked first in citations per paper and fourth among U.S. universities in total citations among other institutions in physics for the 10-year period, 1995-2005. The ranking demonstrates how other professors in the field perceive the relevance and significance of the work at UCSB. It is a measurable sign of both the value of the research and its applicability to other research occurring worldwide.

The data, from Thomson Scientific’s Essential Science Indicators (ESI), is a resource that enables researchers to conduct ongoing, quantitative analyses of research performance and track trends in science. Covering a multidisciplinary selection of more than 11,000 journals worldwide, this analytical tool offers data for ranking scientists, institutions, countries, and journals.

Three professors have been named Fellows of the American Association for the Advancement of Science (AAAS).

David D. Awschalom, a professor of physics, was named by the Section on Engineering for outstanding research in the fields of optical and magnetic interactions in semiconductor quantum structures and implementations of quantum information processing in the solid state. Charles E. Samuel, a professor of molecular, cellular and developmental biology, was named by the Section on Medical Sciences for pioneering studies in the interferon field, particularly biochemical analyses that provided understanding of how interferons inhibit virus multiplication and how viruses antagonize interferon action. Alec N. Wodtke, professor and chair of the Department of Chemistry and Biochemistry, was named by the Section on Chemistry for distinguished contributions to the understanding of the chemical properties of highly vibrationally excited molecules in collisions, stratospheric ozone formation, and interactions with metal surfaces. Election as a Fellow of AAAS is an honor bestowed upon select members of the association by their peers. Fellows are elected for their efforts to advance science or for innovations and applications that are deemed scientifically or socially distinguished.

Daniel E. Morse, a professor of molecular genetics and biochemistry and director of the Institute for Collaborative Biotechnologies (ICB) has been named to the 2006 "Scientific American 50," the magazine's annual list of individuals, groups and companies that have demonstrated outstanding technological leadership through their pioneering research. The list, selected by the Board of Editors of Scientific American, appears in the magazine’s December issue.

Also named to the list was Angela Belcher, a former graduate student of Morse and alumna of UCSB. Belcher is now the ICB coordinator at MIT, which is, along with the California Institute of Technology, a partner in the UCSB-based institute. Scientific American recognized Morse for his innovative research developing biologically inspired routes to nanostructured semiconductor thin films. Belcher was recognized for "the use of custom-evolved viruses to advance nanotechnology."
The College of Engineering launched the Solid State Lighting and Energy Center (SSLEC) March 1. The SSLEC, the second generation of UCSB’s original Solid State Lighting Center, is broadening its scope to include new research interests, including clean energy and energy efficiency, critical to reducing global warming. The Center will be directed by Shuji Nakamura, Cree Professor in Solid State Lighting and Displays, and Steven DenBaars, Mitsubishi Chemical Professor in Solid State Lighting and Displays. SSLEC will provide a forum for industry members and UCSB faculty to collaborate across several disciplines – materials science, electrical engineering, chemistry and physics – to address the most challenging problems in solid state lighting. SSLEC’s researchers will develop new materials, devices and advanced fabrication technologies for consumer electronics and energy. The Center will focus on energy efficiency; solid state lighting; power switching; and clean energy.

Mitsubishi Chemical Corporation, of Tokyo, Japan, is the first industrial member to join SSLEC, giving $2.5 million over the next six years to support the Center and its research. SSLEC members will participate in the research program and have access to certain intellectual property developed at the SSLEC. Companies interested in exploring membership in SSLEC should call Yukina Warner, Management Services Officer, at 805.893.5039, or email sslec@engineering.ucsb.edu.

The Burnham Institute for Medical Research has established an affiliation with UCSB led by Erkki Ruoslahti, M.D., Ph.D. Ruoslahti maintains his primary appointment as distinguished professor with Burnham, and joins UCSB’s Department of Molecular, Cellular and Developmental Biology as an adjunct distinguished professor. At the Burnham Institute at UCSB, Ruoslahti has opened the “Vascular Mapping Center,” which will focus on developing applications for vascular “zip codes,” based on technology discovered in his laboratory. [See the related article in this issue of Convergence].

The Burnham Institute at UCSB was created through a collaborative effort of UCSB and the Burnham Institute for Medical Research, based in La Jolla, California. This type of collaboration, involving a highly ranked university and nonprofit, independent research institute, exemplifies the inherent value of interdisciplinary research and collaboration.

A team of researchers led by Shuji Nakamura, a professor in the Department of Materials, has reported a breakthrough in laser diode development. The researchers, from the Solid State Lighting and Display Center in UCSB’s College of Engineering, have achieved lasing operation in nonpolar gallium nitride (GaN) semiconductors and demonstrated the world’s first nonpolar blue-violet laser diodes. The diodes have numerous commercial applications, including high-density optical data storage for high definition displays and video, optical sensing, and medical technology. Because of the shorter wavelength of emission in these devices, they can accommodate higher densities of optical storage than conventional red-laser based systems.

A comprehensive genetic analysis of invasive marine animals and their parasites sheds light on the spread of disease. Published in the Proceedings of the National Academy of Sciences (PNAS) on December 19, 2006, and co-authored by Armand Kuris, a professor of zoology in the Department of Ecology, Evolution and Marine Biology, the study traces the accidental introduction of invasive snails with parasitic flatworms. Understanding the invasion pathways of disease-causing organisms and their hosts is critical to limiting future disease outbreaks in humans, agriculture, and wildlife.

The invaders were probably transported with Japanese seed oysters imported into the waters of the Pacific Northwest.
over a century ago. It is the first comprehensive genetic analysis of an invasive marine host and its parasites. The study, funded by the Japan Society for the Promotion of Science, the Ecology of Infectious Diseases program of the U.S. National Institutes of Health, and the National Science Foundation, points to broad implications for identifying and mitigating spreading disease in a globalized economy.

Luann Becker, research scientist with the Institute for Crustal Studies at UCSB, has received a grant of $750,000 from NASA to further develop the Mars Organic Molecule Analyzer (MOMA), an instrument that will search for the past remnants of life on Mars. The instrument, a mass spectrometer that will search for the chemical traces of life, will probe subsurface soil samples taken as far as two meters below the surface of Mars. The project will be included in a European space mission scheduled to arrive on Mars in 2013.

Becker is the principal investigator of a team that includes French and German scientists as well as two co-investigators from the Johns Hopkins University in Baltimore. Recent evidence of past water on the surface of Mars provided by the two NASA MER rovers – which are still operating after three years on Mars – has spurred interest in developing different, new, and highly sensitive instruments to search for present or past life on Mars. Becker, trained as an oceanographer and organic geochemist, studies the origin, evolution, and distribution of life in the universe, a field known as astrobiology. She was also involved in the analysis of organics in the Martian meteorite Allan Hills 84001; that meteorite revived interest in the search for life beyond Earth.

The College of Engineering has been named by the Defense Advanced Research Projects Agency (DARPA) to a prestigious university/industry consortium to research robust uncertainty management. The project will be led at UCSB by Igor Mezic, a professor of mechanical engineering, and Andrzej Banazuk, technical fellow, at United Technologies Research Center (UTRC) in East Hartford, CT. The $12.5 million contract goes to a consortium of five universities and UTRC to study robust uncertainty management in large networks exhibiting complex dynamics. UCSB, recipient of the largest academic subcontract in the program, will receive $2.3 million from the three-year grant. Participating institutions also include Caltech, Yale, Stanford and Princeton.

The We’re looking for...an Industrial Physicist/Electromagnetics EE.

Industrial Physicist/Electromagnetics E.E.
Experience in computational electromagnetics with the ability to analyze and predict antenna gain patterns for patch antennas and other low profile small antennas. Prefer experience in finite element modeling with commercial packages such as Ansys, Ansoft, or MSC software. Application involves transmission in lossy media in the 2MHz to 2GHz range.

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What is this?

See solution on inside back cover.
You probably don’t think of it when you’re paddling your kayak or splashing in the surf, but sea water is something like iron-poor blood. It is very low in an essential nutrient – iron, in fact – needed by most of the microorganisms that live in it. And Butler, a professor of chemistry and biochemistry at UCSB, is figuring out how these tiny but important players in the marine ecosystem get around that problem.

Butler studies bioinorganic chemistry, the non-carbon side of life. It’s “a huge field,” she says, and the biological roles of iron and other metals play key roles in it. Her main focus is on “ocean water, where there are very unusual transition metal compositions.” (“Transition metals” include such familiar elements as iron, manganese, copper, nickel, silver and gold.)

One thing that makes ocean water unusual is a seeming mismatch of supply and demand. There is almost no available iron but plenty of microorganisms that require it to survive. Butler studies the methods by which sea bacteria extract this scarce metallic nutrient. The knowledge she is gathering has possible applications not just in marine ecology but in medicine as well.

Like all bacteria growing aerobically (in the presence of free oxygen), sea bacteria make compounds called siderophores to convert insoluble iron into a form that they can use. The siderophores produced by ocean microbes are especially efficient, because they have to be with so little iron around. They come in two main varieties, photoreactive or amphiphilic (the latter soluble in either water or fat), and Butler studies both to see how they function – and whether they process only iron. “Maybe they are going to make use of other metals and we haven’t discovered how,” she says.

The current research on siderophores in marine microbes grew out of experiments in the 1990s that tested the so-called “iron hypothesis,” the idea that increasing the iron in sea water would stimulate the growth of micro-organisms (such as phytoplankton) that consume carbon dioxide. The hypothesis did pan out, but Butler doubts if it will be a practical way to sequester CO₂ and fight global warming. So much iron would have to be added, she said, that it “could wreak havoc on the natural environment.”

However, the experiments opened up other routes of inquiry by showing that heterotrophic bacteria (those feeding on carbon sources other than CO₂) were very

Alison Butler studies how marine microbes get the nutrients they need. Her work could lead to new cures for drug-resistant diseases.
good at competing for the iron against other organisms. Could the chemistry that works so well for them at sea be put to other uses? Butler notes that a siderophore her lab discovered in the oil-eating bacterium *Marinobacter hydrocarbonoclasticus* was also just found to be produced by *Bacillus anthracis*, the bacterium that causes anthrax. So understanding how this compound works might help on two fronts, cleaning up oil spills and defending against bioterrorism. Amphiphilic siderophores also “self-assemble into interesting structures,” Butler says, and thus might play a role in nanoscale materials engineering.

The potential application on which Butler focuses most is medical. The bacteria she studies produce siderophores like those of mycobacteria, a genus that includes the microbes responsible for tuberculosis and leprosy, two highly drug-resistant diseases. “In understanding how marine bacteria produce siderophores,” Butler says, “we will get an understanding of how we might disrupt the synthesis of siderophores in mycobacteria.” Learning about the chemical lifeline of benign bugs, in other words, may make it easier to cut the lifeline in harmful ones.

Butler has been at UCSB since 1986, arriving here from a postdoctoral position at Caltech after earning her PhD at UC San Diego. Starting out in inorganic chemistry, she branched out into marine biology at UCSB’s seaside campus. She has worked closely with Margo Haygood, a marine microbiologist on the faculty at Oregon Health & Science University. Among her UCSB collaborators are Matt Tirrell, Dean of the College of Engineering, Professor Joe Zasadzinski in Chemical Engineering, and Professor Cyrus Safinya in Materials and Physics. She says of bioinorganic chemistry, “It’s one of the most exciting fields within inorganic chemistry” and adds, “Carbon is OK, but metals are essential!”
Wayne Rosing was an avid astronomer long before he became a Silicon Valley legend. Now he’s pursuing a stargazer’s dream – nonstop night.

From Apple to Sun to Google, 60-year-old Wayne Rosing has played key engineering roles for some of the biggest corporate names in technology. But none of his past work quite matches the scope of what he’s planning now, through a little-known (at least for now) entity called Las Cumbres Observatory Global Telescope Network Inc., LCOGT for short.

Based in Goleta, LCOGT is more than just another observatory. Its goal is to build the first earth-based 24-hour platform for viewing stars and other nighttime objects. This would be a web of computer-linked telescopes circling the globe in both northern and southern hemispheres, so that observers could watch any spot in the night sky without being interrupted by daytime. Rosing, a senior fellow in astrophysics and engineering at UC Santa Barbara, and a senior fellow in mathematics and physics at UC Davis, is LCOGT’s founder, director, chief engineer and financial supporter. Its scientific director is Tim Brown, an astrophysicist who came to LCOGT last year from the National Center for Atmospheric research in Boulder, Colo. Brown is an adjunct UCSB professor of physics.
“We like to say we’re a global telescope,” Rosing says, emphasizing the singular. When it is up and running, the LCOGT will function as one, big unblinking eye. It will be used to detect changes in celestial objects, such as pulsating stars, as well as to catch sudden, short-lived events such as gamma-ray bursts that may signal the collapse of stars into black holes. “If something goes off, the probability is that we’ll have a telescope that can look at it,” he says.

Well before it is finished, the network will be serving globally as an educational tool. Thanks to remote telescope controls and the Internet, students in Europe are already using two of LCOGT telescopes, in Australia and Hawaii, for real-time observing during their school hours. As the web of telescopes is filled in, Rosing wants to set up a similar link for Santa Barbara schoolchildren to a future telescope in the eastern hemisphere, possibly in South Africa.

At its completion, the LCOGT as Rosing envisions it will have overlapping global webs of reflecting telescopes in three sizes. The smallest will have mirrors with a diameter of 0.4 meters, or just under 16 inches. There will be about 25 of these around the world. They will mainly be used in schools, but Rosing says they can be used for certain types of scientific work as well. At the next level there will be a global network of 1-meter telescopes. These, he says, “will enable us to do pretty serious science” on super-novae and other transient events. The largest scopes will have 2-meter mirrors and will be used for more detailed observing based on data from the 1-meter group.

Searching the World for Sites

A land-based telescope network can do the same round-the-clock observing now possible only through much costlier orbiting telescopes. But this advantage comes with a challenge — where to find enough suitable sites to cover the night sky 24 hours a day, in both northern and southern hemispheres. The range of sites is narrowed by climate, accessibility and the fact that three-quarters of the planet is covered with water. Most of the world’s big telescopes are in a few choice locations that combine high altitude, clear skies and that astronomers call good “seeing” — a low level of turbulence in the atmosphere. The peaks of Hawaii, northern Chile and the Atlantic island of Tenerife in the Canaries fit this bill, and they’re studded with big scopes as a result. Australia and South Africa offer some good sites as well. So far, Rosing has bought two 2-meter telescopes, one atop Haleakala on Maui and another at the Siding Spring Observatory in New South Wales, Australia.

That leaves some gaps. Eventually Rosing would like to have a few 2-meter scopes, along with around twenty 1-meter instruments, spaced evenly north and south of the equator. Sites in Chile, Australia and South Africa could do the trick for the southern half of the globe. The northern half is more challenging. Between the prime sites on islands in the Atlantic and Pacific, there’s a huge swath of the planet taken up by the Eurasian land mass. Much of it is too cloudy during the summer monsoon to be suitable. Other areas are too remote to be practical or safe. Rosing says the region around Urumchi, in the far west of China, might work. But he says it’s risky to put a telescope in the middle of nowhere rather than at an established observatory where it has plenty of neighbors. Vandalism is one threat. “If we put a telescope on some random mountain, some hunter will decide it’s a target,” he says.

Rosing has done quite a bit of astronomy-focused travel, including about 20 trips to Chile. And he’s likely to be on the road again, possibly in some of the world’s hard-to-reach places, as he tries to find the best spots for LCOGT telescopes. Some of the 0.4 meter reflectors being built for LCOGT will probably be used as survey telescopes in this quest, set up to monitor sky conditions at prospective observatory sites. But the first of these will be set up closer to home — right in Rosing’s back yard in Santa Barbara.

Watching and Waiting

None of the individual telescopes in the completed LGOCT will come close in size, or light-gathering power, to the largest telescopes in use today. But the network will have a unique ability to monitor a spot in the night sky for transient events that take place over just a few hours. Even the largest earth-based telescope will miss these if they take place when the telescope is in daylight. LCOGT’s Brown says this “time-domain” astronomy is well-suited to detecting planets or studying subtle changes in the size and shape of stars. Finding planets doesn’t require a particularly large telescope. The first planet detected outside our solar system was found with a 2-meter instrument in France, Brown says, and one planet crossing in front of a star was picked up with a 10-centimeter scope “more akin to telephoto lenses you see on sidelines at a football game.”
From 2000 to 2005, he was vice president of engineering at Apple in the early 1980s and later led teams that developed Internet technology. He was a director of engineering at Sun Microsystems. Rosing has had a celebrated career in computer and Internet: "It occurred to me that a network of telescopes around the world was something I could achieve if I set my mind to it." And set his mind to it he did, so much so that he now calls his Google years a “distraction” from his main mission – though he’s grateful for “having the opportunity to be distracted.” He explains: “The challenge to cap my career with helping build Google Engineering was irresistible. I commuted to the Bay Area from early Monday to late Friday night for nearly five years. My basic commitment was to grow Google engineering from about 60 to a thousand engineers and to keep and try to enhance the creative culture. Every minute of that time was a challenge and fun.”

In 2005, he and Dorothy moved from near Las Gatos to the Santa Barbara area. Why here? Rosing says they were looking for “good weather, ocean, a great university, culture,” and a community small enough to “get our head around.” His ties to UC Santa Barbara go back a bit further. The engineering staff at Google had a large contingent of UCSB alumni or former faculty – at least 20 or 30, he estimates. He also knew Matt Tirrell, Dean of UCSB’s College of Engineering, through Google connections. When it came time to retire from the Silicon Valley scene and get serious about building LCOGT, Rosing found that UCSB, along with the Kavli Institute for Theoretical Physics, had both facilities and talent to offer. The project’s headquarters are in leased UCSB space at a Goleta engineering research center, and it has a large UCSB contingent of scientists and engineers. Two UCSB graduates are on its engineering staff, three UCSB students are interns, and three post-doctoral researchers are working with Brown on the science side. “The connection with the university and Kavli is really fundamental,” Rosing says. "If we were attempting to do this somewhere else, it would be very difficult.”
Kevin, as someone who has been with the CITS since the beginning, how would you sum up its achievement so far?

Almeroth: To use a business analogy, this campus and many others have very successful established business units – the academic disciplines – that resist major, rapid changes. But centers such as CITS incubate new ideas and, at the same time, generate a lot of give and take. They might start with the existing research interests of faculty members, who come together in the center, but then it spawns new educational programs and creates new research directions as well. In the end, you’ve got tightly coupled education and research that, if successful, have an effect on the established disciplines.

And Jennifer, what do you see ahead for the Center?

Earl: We are also looking at ways to help incubate research beyond the kinds of things that we’ve already done. For instance, I’ve been talking with various people about putting together a toolkit lab that would be a repository for the kinds of computer-based research tools developed here at UCSB. Say I have a set of computer programs that have been written for a particular project but also could be used by other researchers. I donate those programs to this repository, so that if someone else is doing research, before they write their own code, they can look at this repository. We want to see ourselves as building almost like a snowball going down a hill – taking what we’ve done before and using it to get more and more productive research rolling.

How close are we to doing what you say – that is, using actual cell phones for this feedback mechanism?

Almeroth: This comes full circle. Now we’ve been tasked with another engineering problem that gets us closer to solving this societal problem. I actually think it’s a little harder technologically, just because a cell phone is a more flexible device. You hand somebody a clicker and say, “Press one through nine,” it’s a little bit easier. But we’ll task it and we’ll go off and write a little applet that you can put on your cell phone and it will work just fine.
All the projects and participants share the common aim of advancing sensor technology for practical applications. But they come at that target from several different approaches. The folding-biomolecule technology of Plaxco, Heeger and Petroff is just one of these.

Another project group is developing biosensors using surface enhanced Raman spectroscopy (SERS), a method of detecting genes and other objects containing just a handful of molecules. This one includes UCSB physical chemistry Professor and Dean of Sciences Martin Moskovits as well as Plaxco and UCSB chemistry and biochemistry Professor Norbert Reich. Moskovits is also investigating the use of “nanowires” – tiny enough to be packed 50 to 100 per square millimeter -- to detect target molecules. Reich is studying the potential of metallic and semiconductor nanoparticles for detecting pathogens. UCSB professors Glenn Fredrickson (materials and chemical engineering) and Joan-Emma Shea (chemistry and biochemistry) are developing computer simulation techniques to study the self-assembly principles of biosensor materials.

UCSB chemistry and biochemistry Professor Guillermo Bazan is working with Alexander Mikhailovsky, manager of the university’s Optical Characterization Lab, to amplify biosensor signals. Many biosensing molecules emit light when they recognize a specific target, Bazan says, but the light is too weak to be used in a detection device. Bazan's project uses light-absorbing polymers to transfer the molecule’s signal and make it about 100 times stronger.

In another UCSB project, Carl Meinhart and Kimberly Turner, both associate professors of mechanical and environmental engineering, are making sensors more efficient by using electric currents to pump fluids and concentrate target molecules. Meinhart says they are able to raise the concentration of DNA molecules 100-fold with just a 50-volt charge. They are also developing sensors to detect airborne chemicals.

Scott R. Manalis, an associate professor in biological and chemical engineering at MIT, has developed a sensor called the suspended microchannel resonator (SMR), which captures molecules or cells flowing through a tiny vibrating channel. Caltech chemistry Professor Nathan Lewis is developing detection technologies that mimic our sense of smell.

All this diversity has a purpose beyond the mere competition of ideas. The ICB operates on the assumption that no single sensor technology will meet all the needs of the Army or the civilian economy. The institute aims to produce multiple options for detecting different types of substances in different environments (such as toxins in liquids or airborne bioweapons). “There will never be a single platform for bio-sensing,” says Bazan. “You need a variety of different platforms that are complementary to each other.” Also, as Moskovits notes, “It’s prudent to assess a variety of different approaches” with nanotechnology still so young. “The fact that each of us uses a rather different embodiment of the sensor technology is the right thing to do for a university at this stage of development of the field,” he says.

Early-stage it may be, but sensor technology is far enough along to get scientists thinking about potential commercial applications, not to mention the military uses that the Army has in mind. Moskovits, who says his nanowire technology is "probably 10 years away from commercialization," nevertheless has an idea or two for putting it to practical use. He suggests that “inexpensive diagnostic chips” could be made from arrays of nanowires coupled to semiconductors, then deployed “every few feet in an airport” to detect explosives.

As for biomolecular folding, Plaxco and Heeger see plenty of possibilities. Plaxco says they might be used with “hand-held electronic devices” that don’t need reagents and are “reusable in minutes.” They could be used to detect a wide range of particles, from small molecules such as cocaine to pathogen-related DNA sequences and platelet-derived growth factor, a protein “believed to be diagnostic for several types of cancer.” Heeger says “the basic work” on this technology has been done, with researchers now “learning how to improve the sensitivity and selectivity.” The next step, he says, “is either to spin off a company or get someone interested in developing it as a commercial venture.” That stage won’t happen at the university, he adds, but “the science-to-technology part is being done here and done well.”
What is this?

A team of UCSB researchers, in collaboration with colleagues from UC Berkeley and StrataGent Life Sciences, of Los Gatos, California, has designed a novel pulsed microjet system engineered to deliver protein drugs into the skin without the pain or bruising that deeper penetration injection systems cause. The research was published in March in the Proceedings of the National Academy of Sciences. “The microjet system delivers precise doses into superficial skin layers, thereby mitigating pain,” says Samir Mitragotri, a professor of chemical engineering at UCSB and a lead author of the paper.

Spotlight on Alumni Giving

We are grateful to our alumni for the impact their philanthropy is having on our faculty, students and programs. Below are two examples of major gifts at work.

Dr. Isaac and Mrs. Margaret Barpal

Dr. Barpal, (M.S., Ph.D. EE, ’68/’70) along with his wife Margaret, generously established The Barpal Family Graduate Fellowships – of which one is for a Cal Poly SLO student wishing to attend UC Santa Barbara’s College of Engineering. Centered above is Roopa Chari (‘05 Fellow).

Drs. Susan and Gary Wilcox

Drs. Susan and Gary Wilcox (both ’92 Ph.D. alumni, Gary in Molecular Biology & Biochemistry, Sue in Economics), established the Wilcox Family Endowed Chair. This Chair supports outstanding UCSB faculty in areas related to biotechnology and human health, and is a permanent tool to retain top scholars and to promote faculty leadership. The 2007 inaugural chair holder is MCDB Professor Dan Morse.

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