He's a Keeper!

Chameau gets Millikan's hood settled on his shoulders; otherwise, he's already settled in quite well, thank you very much.

After over nine months on the job, Caltech's eighth president, Jean-Lou Chameau, was inaugurated in a brief, simple ceremony at the start of Caltech's 113th annual commencement on June 8.

Chameau, who took office on September 1, 2006, was not in favor of a lavish affair that traditionally rivals a commencement in terms of pomp, circumstance, and cost, and desired instead to emphasize the students' accomplishments.

In the ceremony, overseen by Chairman of the Board of Trustees Kent Kresa, Robert Millikan's academic hood was placed on Chameau's shoulders by David Stevenson, the Van Osdol Professor of Planetary Science and chair of the Faculty Presidential Search Committee. While Millikan never accepted the title of president, he was the first administrative head of modern-day Caltech, and the passing of his hood to the new president has become an inaugural tradition. Chameau was then welcomed by Ricky Jones (BS '08), president of Ruddock House, who began by apologizing for non-Francophonic Techers' various manglings of his name—Shamu, Chamois, and, in cases of extreme confusion, Jean-Paul Revel [professor emeritus], and Jean-Luc Picard [starship captain]. Jones then spoke of Chameau's exhaustive efforts to get acquainted with faculty and students. He concluded with the story of Caltech's recent foray into the olive oil business (See *Caltech News*, 2007, No. 2 for details) and the role Chameau and his wife, Carol Carmichael, have played as part of their efforts to make the Caltech campus operate in a more sustainable manner, ending, "I'm certain that Jean-Lou will continue to encourage the growth of Caltech in ways we never thought imaginable, and to teach us to appreciate Caltech in ways we haven't before."

Chameau then addressed the audience, prefacing his remarks by introducing his wife and noting that "Carol and I are a team, and she is working very hard for Caltech." He went on to say that another university president had congratulated him on winning the lottery—"You have the best board of trustees in the country, the faculty is on a scale ranging from outstanding to genius, and you don't have to worry about a medical school or a football team!"

Chameau then offered some thoughts on Caltech's strategy for the future. He began by quoting Nobel Laureate Ahmed Zewail, the Pauling Professor of Chemical Physics and professor of physics, who said, "Caltech is a place where we dream with focus and freedom," adding "Caltech must be the place where people dream big; it must be the home of faculty and students who will do big things. The nation needs a place like Caltech—more now that ever." To do this, he said, "our commitment to advancing the frontiers of science and technology must include an interest in addressing the toughest challenges we face in society," using Caltech's small size to promote unlikely collaborations across disciplines that might develop, say, a clean energy source based on artificial photosynthesis. "As trustee Bill Davidow said, Caltech is a place where a few great scientists working together can make such 'long shots' happen."

Our small size, he said, should not only give students the ideal research university experience, but should also allow them to enter activities that might otherwise have been closed off to them. "The Caltech student experience should include an unusual menu of high-quality extracurricular programs in music, acting, competitive sports, journalism. . . . And even cooking! Caltech must be the preferred destination for young people who can make a difference, people who can do those big things that will change the world."

Which, of course, brought him to money. He called on Caltech to "develop the same level of excellence in its organization and administrative services as we already have in our academic programs. No university has done that yet. Caltech can do it." He also envisions a campus that is more energy efficient, cost efficient, and sustainable, not just for the savings that can be achieved but because "if we believe it's important to do research in energy and environmental science, we should believe in putting our discoveries into practice." He then noted the challenges of raising money in this day and age, and pledged to do his part to grow the endowment.

To this end he spoke of "friend-raising," noting that Caltech alumni, though wonderfully supportive, number fewer than 25,000—a downside of being small and selective. Thus, "we must cultivate more friends to compensate. My experience to date has been that there is lots of goodwill and admiration for Caltech. We need to leverage this goodwill to make many more friends—locally, nationally, and internationally." □—*DS*

Any Color You Like

If you shine a red laser pointer through a glass windowpane you don't expect it to come out blue on the other side, but with a much brighter beam it just might. At very high intensities light energy tends to combine and redistribute, and red light really can produce blue.

It normally takes brief bursts of megawatts of power to boost light into this high-intensity realm. But now Kerry Vahala (BS '80, MS '81, PhD '85), the Jenkins Professor of Information Science and Technology and professor of applied physics at Caltech, and postdoc Tal Carmon have found a way to do more with less, producing a continuous beam of visible light from an infrared source with less than a milliwatt of power.

At high intensities, light enters the regime of nonlinear optics. We usually notice nonlinearity when there gets to be enough of something to change its environment and rewrite the rules. For example, when a freeway is nearly empty and vehicles effectively have the road to themselves, traffic behaves in a certain way. Put twice as many cars on the road, and the traffic will still behave as if each car owns the road. The only difference is that the flow will double—a proportional, or linear, response. But once traffic nears peak capacity, the vehicles no longer act independently, and the flow becomes miserably nonlinear.

Similarly, light beams pass right through each other at the low intensities we typically encounter, because the photons that make up the beams can usually ignore the cross traffic. At high intensities, however, photons become much more likely to collide and reassemble into other photons—picture three Mini Coopers in dense traffic coalescing into an SUV. The big vehicles of the photon world lie at the higher-energy, or blue, end of the spectrum, with lower-energy photons appearing as red or even infrared light.

Nonlinear optics usually requires brief megawatt intensities, analogous to flooding the freeway with a sudden burst of traffic, but the Caltech researchers attained optical congestion with a much smaller flow by diverting traffic into a tiny no-exit roundabout.

Their traffic circle is a min-

Two adjacent rings can be made to emit different colors, depending on the frequency of the infrared light feeding each one.

From Carmon and Vahala, *Nature Physics*, vol. 3, June 2007, pp. 430–435. © 2007 Nature Publishing Group.

iscule glass donut, a microresonator smaller across than a human hair. It accumulates power so that a mere milliwatt of infrared light flowing outside the device can sustain an internal flow of 300 watts, a 300,000-fold amplification. Although the infrared light is essentially trapped, energy can still escape as visible light when three infrared photons combine into a single photon of tripled frequency.

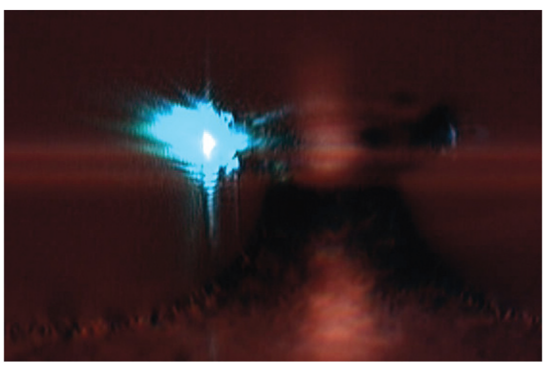
Usually researchers in infrared optics can't directly see their results. This time, Carmon says, "I just turned off the lights and you could see the effect immediately."

Although infrared light is invisible to human eyes, it is essential to modern telecommunications, flowing through millions of miles of optical fiber. Technology to produce, amplify, and otherwise manipulate near-infrared light is well developed and readily available.

"Our device has several important features," Vahala says. "First it triples the light frequency, and second, it works in a wide range of frequencies. This means full access to the entire visible spectrum, and likely ultraviolet. Right now there isn't a way of doing UV generation on a chip. Tunable ultraviolet—that's exciting." Coherent UV sources have applications in sensing and also in data storage, where, for example, the laser's wavelength determines the physical size of the information bit on a compact disk.

The microresonator is part of a promising approach for on-chip optical devices using the silica-on-silicon platform, which is compatible with the electronics of ordinary computer chips. Integrating optics and electronics on the same chip makes the device useful for lab-on-a-chip designs, and the ability to use established fabrication techniques makes large-scale, low-cost production possible.

This work, with Carmon as lead author, appeared in the June 2007 issue of *Nature Physics*. ☐—*JA*



An end-on view of a beam of blue light coming out of the ring.

Mercury's Molten Core

Mercury, the solar system's smallest planet, had long been thought to have cooled and solidified ages ago. So scientists were astounded when, in consecutive flybys by JPL's Mariner 10 in 1974 and 1975, the planet gave inklings of a magnetic field, albeit a weak one—about 1 percent that of Earth. (Then again, Mercury is only 5 percent the mass of Earth.) This suggested the possibility of a molten core, but various measurements and models yielded an array of possible internal configurations with no conclusive evidence for fluid inside the planet—until now, says Cornell astronomy professor Jean-Luc Margot, lead author of a report published in the May 4 issue of the journal *Science*. The report shows that Mercury does indeed have a liquid center, although how big will only be determined by further observations.

The idea to examine the state of Mercury's core began brewing during Margot's O. K. Earl postdoctoral fellowship at Caltech, from 2001 to 2002, which, says Margot, "came with the freedom to investigate the science problems that I found interesting." Among them was a hypothesis—posed by physics professor emeritus Stan Peale of UC Santa Barbara, a coauthor on the paper—that the nature and extent of Mercury's core could be determined via observations from afar. Because Mercury is the closest planet to the sun, its surface temperature is too toasty for the spacecraft of today, so the scientists turned to radar astronomy. Margot began the work at Caltech by designing a way to test Peale's idea and by gathering preliminary data, and continued it at Cornell.

They applied a technique—derived from ideas first set forth in the 1960s and revived recently by coauthor Igor Holin of the Space Research Institute in Moscow—called the "speckle displacement effect," using JPL's 70-meter antenna at Goldstone, California; the Arecibo Observatory in Puerto Rico; and the Robert C. Byrd Green Bank Telescope in West Virginia. From 2002 to 2006, 21 different radar signals were beamed to the planet from Goldstone or Arecibo, and their echoes were received by two of the three antennas each time. Each echo had a unique speckled pattern, reflecting the planet's surface roughness, which swept across each receiver in turn like spots of light from a rotating disco ball, allowing Mercury's spin rate to be determined to within one part in 100,000. To make the measurements, the planet and the receiving antennas had to line up in a configuration that lasts only 20 seconds on any given day. "Everything had to happen within that 20-second time window," Margot says.

The team found tiny variations in Mercury's spin rate that could only be explained by the sun's gravitational influence on a planet that is part liquid. "We have a 95 percent confidence level in this conclusion," Margot says. The variations, called longitudinal librations, arise as the sun's gravity exerts varying torques on the planet's slightly asymmetrical shape. In addition to measuring Mercury's spin rate, the authors also made a vastly improved measurement of the alignment of the planet's axis of rotation, showing that Mercury's spin axis is almost perpendicular to the plane of its rotation around the sun.

Goldstone observations were enabled by coauthors Raymond Jurgens, senior JPL engineer, and Martin Slade, head of the Goldstone Solar System Radar and JPL's Planetary Radar Group Supervisor. □—*EN*

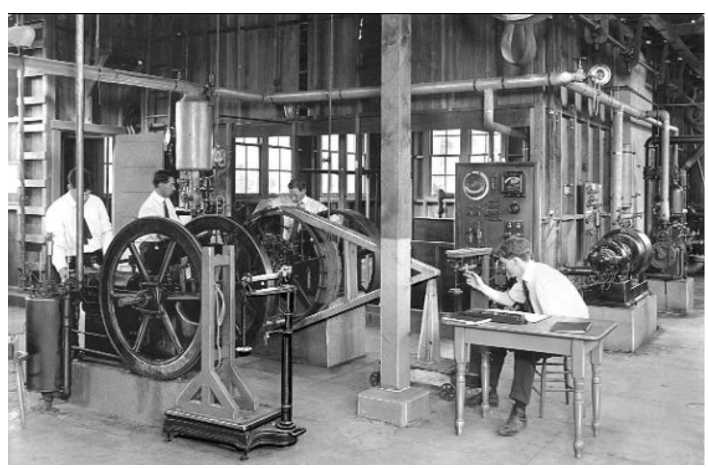
Mechanical Engineering Celebrates its Centennial

Mechanical Engineering at Caltech turns 100 this year, and a party called "It's All About ME" was held on March 30 and 31. "I was in rather a quandary trying to organize it," laughs Chris Brennen, the Hayman Professor of Mechanical Engineering. "The alumni only like to hear about the past, and the faculty only like to hear about the future. I got complaints from both groups, so I must have done a good job." The hundred or so returning alums got a dose of history, but they were also treated to lectures and posters on current research, and talks by alumni on new directions in the field. There was also live entertainment, as it were, in the form of a restaged ME 72 design competition and a demonstration of Alice, Caltech's self-driving entry in the upcoming DARPA Urban Challenge in which robot vehicles will try to navigate themselves through 60 miles of city streets.

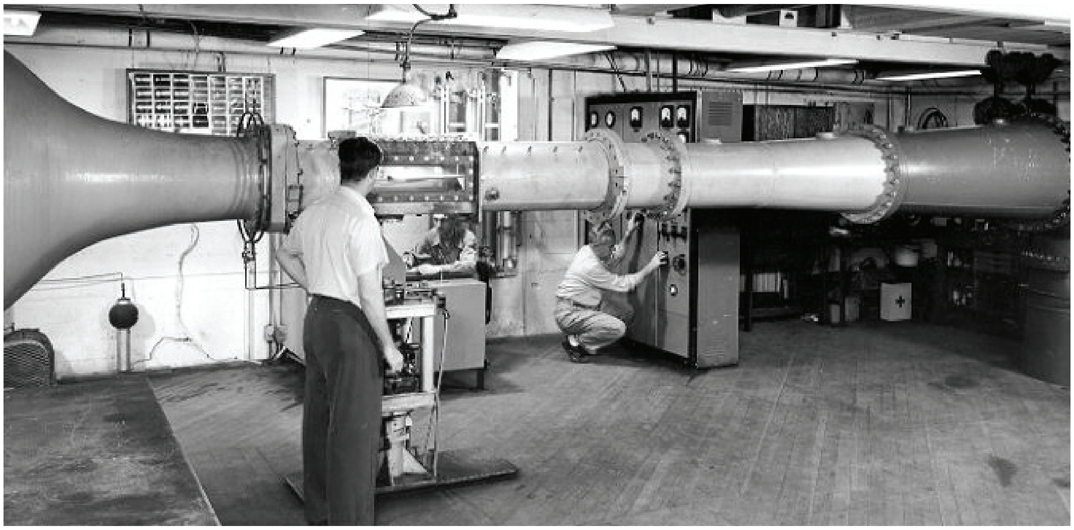
In 1907, the then-Throop Polytechnic Institute was in a cluster of buildings in downtown Pasadena, at the intersection of Fair Oaks Avenue and Chestnut Street. The ME department's start was modest enough—the only degree offered in engineering was electrical, and the sole ME course, Theoretical and Applied Mechanics (lab and lecture), was listed as Math 13. But as the catalog for 1907–1908 stated, "It is also the purpose of the Institute to extend the work along these lines as demand for it arises." Arise it did—the 1910–1911 catalog listed two faculty associates in mechanical engineering and, in the tradition of the low student-to-faculty ratio for which Caltech remains famous, two juniors pursuing mechanical engineering degrees. By the time Throop changed its name to the California Institute of Technology in 1920, the ranks had grown to three professors, an instructor, and 81 students.

But it was Caltech's Pump Lab, founded in the early 1930s by Robert Knapp (PhD '29) and instrumental in developing the equipment needed to bring water from the Colorado River to a thirsty Los Angeles, that "marked the transition from the department being a technical school that trained engineers to inventing the engineering of the future," says Brennen.

This transition was complete by World War II, when Knapp and colleagues turned their attention to broader issues of hydrodynamics. Chief among these was the noisy cavitation caused by the high-speed propellers on submarines that alerted their prey to their presence, and gave their positions away to the destroyers waiting above. And on the other side of the battle, torpedoes dropped from airplanes tended to take off in any old direction upon hitting the water. The problem was solved by stabilizing fins invented at Caltech and tested first in the lab and then at full scale up at Morris Dam, in the San Gabriel River canyon above nearby Azusa. "The remarkable body of literature generated in those years is

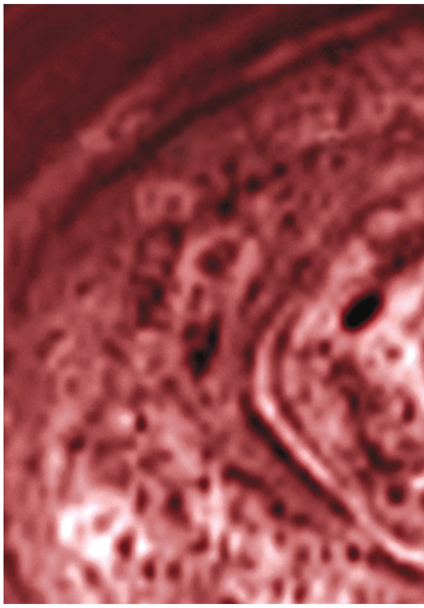


Throop Polytechnic's Hydraulics and Mechanical Engineering Lab in the early 1910s. From left: Raymond Catland, Charles Wilcox, Harold Black, and Robert Bultman, all BS ME '15.



Left: Caltech's Hydrodynamics Laboratory's high-speed water tunnel, designed by Knapp, seen in the mid-1940s.

Above: Two ME alumni speakers, Garrett Reisman (MS '92, PhD '97) and Robert Behnken (MS '93, PhD '97), seen at their day jobs training for their upcoming Space Shuttle flight to the International Space Station in February 2008. Reisman gets to stay there, replacing ESA astronaut Léopold Ehyarts.



still sought out—50-year-old reports that are still read by people working in high-speed flow," says Brennen. "And during the centennial, most of the people that wrote those reports were here."

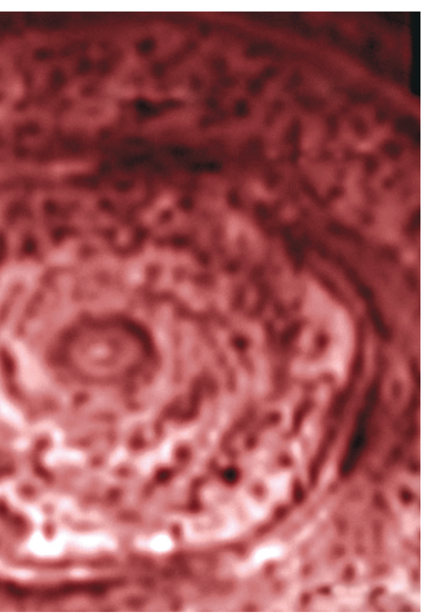
The study of high-speed flows burgeoned in the 1950s and '60s, with the development of the instruments and equipment needed to observe them. "The million-frame-per-second camera designs developed by Albert Ellis (BS '43, MS '47, PhD '53), for example, are still in use today to observe fractures as well as flows," Brennen remarks. [For more on cavitation and high-speed cameras, see *E&S* 2007, No. 1.] These instruments, in turn, allowed various faculty members to do basic analyses of how combustion chambers, gas turbines, and jet engines work, leading to the much more efficient designs of today. Similar strides were made in analyzing flows in which more than one state of matter is present, such as the solid-liquid jumble found in a mudslide, the solid-gas (granular) flow of coal in a power plant, or the three-phase flows of solid, liquid, and gas in a core meltdown in a nuclear reactor.

All of this analysis meant a lot of new mathematical techniques were needed. Various faculty members rose to the challenge, devising methods for grappling with random and nonlinear phenomena. A good example is the development of the mathematics underlying nonlinear elasticity, which refers to a situation where the force required to bend something is not proportional to the amount it bends. This includes the behavior of rubber or anything else that's soft and squishy, as well as such exotica as the shape-memory alloys used, for example, in stents to hold open clogged blood vessels. Roughly half of these are made of a metal that, at body temperature, opens up from a collapsed, easily insertable form into a hollow tube.

An influx of young faculty in the 1980s took the department in a host of new directions, says Brennen. "Mechanical Engineering has broadened tremendously—thin films, robotics, computational mechanics, control and dynamical systems, bioengineering, nano- and microsystems. The centennial was a celebration of that diversification." The professorial faculty now numbers 17, and the department is ranked third in the nation among graduate programs by *U.S. News & World Report* and fourth in worldwide impact by the Institute for Scientific Information's Science Citation Index.

The department's next century will undoubtedly bring more new directions, says Brennen. "Engineers take ideas and turn them into practical solutions. Energy R&D is a big component of ME today—producing devices to make energy or use it more efficiently. But there are other threads. The mechanics of biological systems and biologically compatible systems will be big in the future. So will the engineering of complex systems—how do you engineer, design, and fabricate complex electromechanical systems from cars to spacecraft?" Not surprisingly, the Caltech-JPL connection was a recurring theme throughout the celebration. "JPL has gone a long way in inventing the organizational techniques needed to do this successfully. In my view, despite all the consumer-product effects one hears about, this is by far the biggest spin-off from JPL and from NASA, and the continuing development of these complex management and control methodologies is likely to be a major part of mechanical engineering in the future." □—*DS*

Below: A hexagon around Saturn's north pole, glimpsed by the Voyagers in the early '80s, is still there. The feature, near 78° north latitude, was shot by Cassini in infrared light in October 2006. The structure extends at least down to the 3-bar pressure level, some 75 kilometers below the visible cloud tops, and may be a standing wave.



Medea's Antimalarial Mosquitoes

Malaria infects more than half a billion people every year, and kills more than one million, mostly children. Despite decades of effort, no effective vaccine exists for the disease, caused by single-celled *Plasmodium parasites*. The parasites are transmitted to humans via the bite of infected mosquitoes. One way to stop malaria is to make the mosquitoes themselves fight the disease. This can be tricky, however, because bugs carrying the disease-resistance genes are likely to be less reproductively fit than their wild counterparts, and thus less able to spread their genes. But now Caltech Associate Professor of Biology Bruce Hay, postdoc Chun-Hong Chen, and colleagues have developed a way to make such genes spread themselves quickly throughout an insect population.

"People who live in areas affected by malaria and other mosquito-borne diseases are bitten often," says Hay, "so there will be little benefit unless most of the local mosquito population is disease resistant."

The technique exploits a maternal-effect dominant embryonic arrest—or Medea—genetic element, a particularly spiteful selfish genetic element. (In Greek mythology, Medea killed her own children to revenge herself upon her unfaithful husband.) "Selfish genetic elements, single genes or clusters of genes, are more successful than your average gene at passing themselves from generation to generation," says Chen, even if their presence makes an organism less fit. "Our idea was to create a selfish genetic element that could be linked with a specific cargo, the disease-resistance gene, as a way of rapidly carrying this gene through the population."

Medea elements were first described in 1992 by Richard Beeman and colleagues at Kansas State University, who found one in the common flour beetle *Tribolium castaneum*. The version developed in this project uses two linked genes. One gene, the "poison," is turned on in the mother and produces a piece of small noncoding RNA, or microRNA, that prevents a protein known as myd88, which is crucial for embryonic development, from being made. The second gene, the "antidote," codes for a microRNA-insensitive version of the gene that produces myd88. Since all of the mother's egg cells will contain the poison microRNA, only the fertilized eggs that get the antidote from either parent will survive.

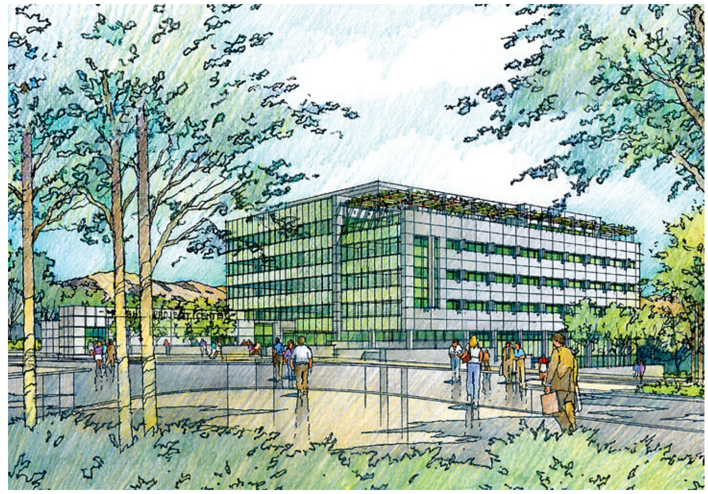
Fruit flies carrying this synthetic Medea element spread quickly throughout a laboratory population of wild-type flies. After just a few generations, all of the flies in the population carried at least one copy of Medea. "To our knowledge, this work represents the first de novo synthesis of a selfish genetic element able to drive itself into a population," says Hay. "It provides proof of principle that, at least in a highly controlled laboratory experiment, we can change the genetic makeup of a population." The team now plans to use the technique to transmit a real payload—a disease-resistance gene—into the mosquito. "There is a real possibility that disease transmission can be suppressed in an environmentally friendly way," Hay continues. "The mosquitoes will still be there, but with one or two tiny genetic changes that make them unable to transmit these dreadful diseases."

Even mosquitoes can only breed so fast, and in order for this approach to work, about 10 percent of the local population needs to contain the Medea element. "So it has to be introduced into the population reasonably frequently, which is very doable," says Hay. "In the '70s when people were doing biological mosquito control, they would breed mosquitoes in factories, and they would sort out the males and sterilize them with radiation. They were releasing millions of sterile mosquitoes every day. You *really* didn't want to be trapped in that factory overnight."

A paper describing the work appeared in the April

27 issue of *Science*, with Chen as the lead author. The other authors include Caltech postdoc Haixia Huang; grad student Catherine Ward; incoming freshman Jessica Su; biology staff member Lorian Schaeffer; Ming Guo, assistant professor in the departments of neurology and pharmacology at UCLA's Brain Research Institute, David Geffen School of Medicine; and Hay. □—*KS*

A rendering of JPL's new "green" Flight Projects Center by its architects, LPA.



So Green, It's Gold

From their campus on the edge of the Arroyo Seco, teams of engineers at the Jet Propulsion Laboratory plan and operate decades-long missions throughout our solar system. Now they've applied this long perspective to their own quarters, beginning with the groundbreaking May 7 of a six-story "green" building whose efficiencies will benefit JPL and its environment for decades to come.

The new Flight Projects Center will reduce its environmental footprint in ways both low- and high-tech: from bike racks and showers for bicycle commuters to "smart ventilation" that regulates airflow according to usage as measured by CO_2 sensors that determine the number of people in a room.

NASA requires that all new buildings be silver-level certified under the Leadership in Energy and Environmental Design (LEED) rating system, established by the nonprofit U.S. Green Building Council. The rating system encourages the design and construction of buildings that are better for both their occupants and the environment. Says Mark Gutheinz, JPL's manager of facilities engineering and construction, "I wanted to see if we could push the designers. This will be the first gold-certified building in the NASA inventory."

The designers managed to go gold while remaining within the building's $65 million budget, and its demand-reducing features will earn JPL a total of about $100,000 in up-front rebates from both Southern California Edison and Pasadena Water & Power. And then there's the long-term reduction in utility bills for the lifetime of the building.

The new building will also save JPL money in other ways. "Projects turn over on a regular basis, so we have to keep creating space," Gutheinz says. "We spend a lot of money here moving people around." The Flight Projects Center is designed to accommodate each project group during the project's early phases, when specialists from all over JPL need a common work space. Different groups will cycle through, but the modular work spaces won't need to be reconfigured.

Less tangible but equally important will be the comfort and morale of the 625 people who will begin to inhabit the building in 2009. The building's gold certification also recognizes the quality of its indoor environment, giving points for attention to details like thermal comfort and construction from low-vapor-emitting materials.

Expanses of windows on the upper floors will offer views of the first-floor auditorium's green roof, landscaped with native, drought-resistant plants. "What's going to be noticed most immediately is the amount of daylight," Gutheinz says. "You're going to feel like you're outside no matter where you are in the building." But all that greenery isn't intended merely to refresh the soul—the plantings help keep the building warm in the winter and cool in the summer, and help filter air pollution all year round. □—*JA*

Speaking of green things and outer space, the grass may not always be more verdant on the other side of the star cluster. So concludes a study at Caltech's Virtual Planetary Laboratory that was recently published as two papers in ***Astrobiology***. Depending on the range of colors emitted by the local sun, leaves in other hues might be the most efficient at soaking up the available energy. This illustration, by ***E&S***'s own Doug Cummings, was published in the July 2007 issue of ***Discover***.

A Rubber-Band Laser

Even if you never find one in your Cracker Jack box, the 10-cent tunable dye laser opens up a world of possibilities. A Caltech collaboration between Demetri Psaltis, the Myers Professor of Electrical Engineering, and Axel Scherer, the Neches Professor of Electrical Engineering, Applied Physics, and Physics, has produced a microfluidic "chip" that contains such a laser, a feat that could make a variety of laboratory-grade diagnostic tests as readily available as disposable plastic thermometers.

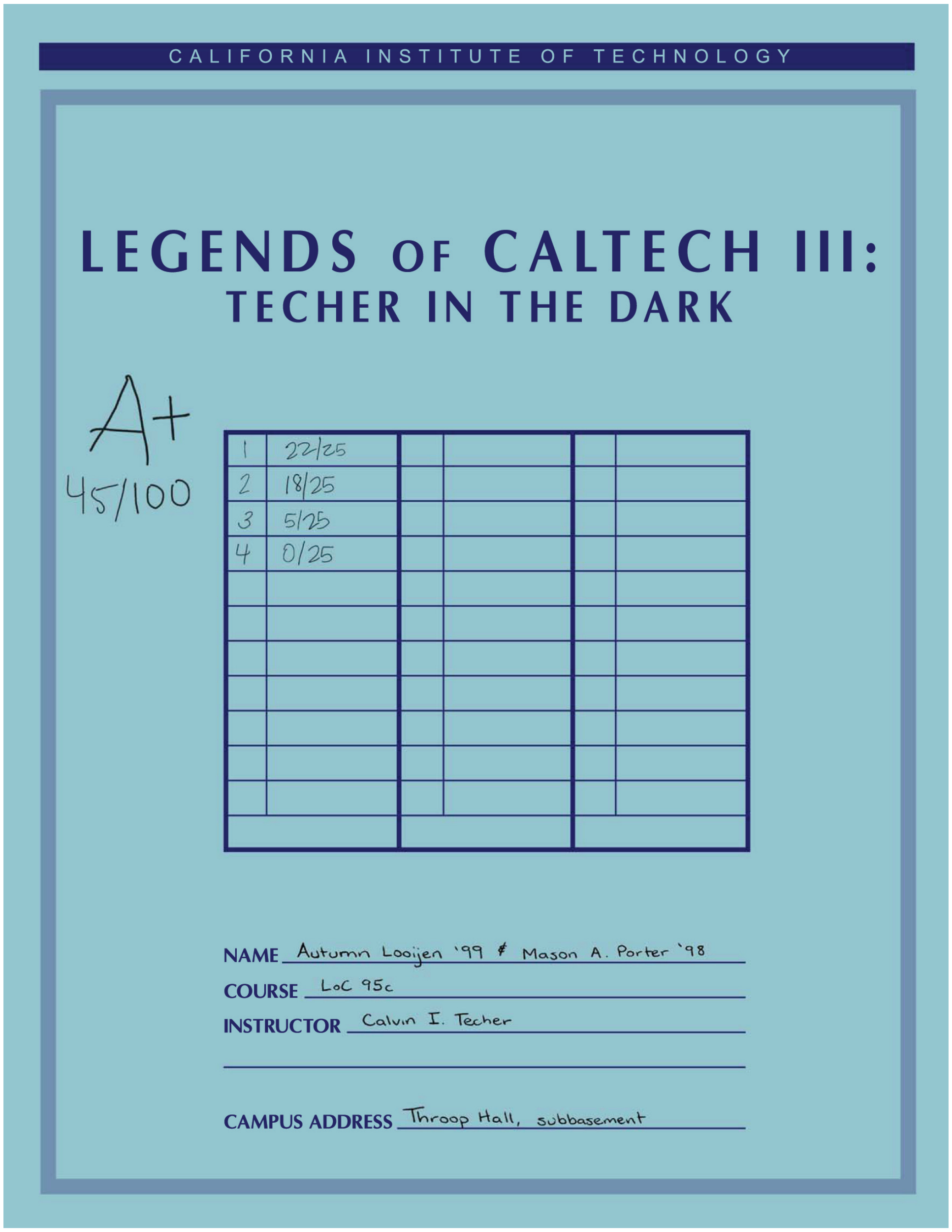
Microfluidic devices can send very small samples through multiple simultaneous analyses, and putting a laser on the chip adds spectroscopy to the toolbox. Inexpensive, single-use devices preloaded with the necessary chemicals would be perfect for biomedical applications. "You take your spectrum and then throw it away," Scherer says. A paper on the work, by grad students Zhenyu Li and Zhaoyu Zhang (MS '06), Scherer, and Psaltis, will appear soon.

The group uses a process called replication molding to stamp out any number of copies from a single, precisely machined master, similar to the way the music industry made vinyl recordings available to millions. "You could do this in your garage," Scherer says. "I *have* done this in my garage."

These records are pressed in silicone rubber—clear, flexible, and very cheap. "This is bathroom caulk," Scherer says. Inject dye into the device with a syringe, and with a boost from an external light source, your laser is ready to go. The group used the equivalent of a green laser pointer to pump the dye, but portable devices could use built-in chemical or semiconductor light sources. Yet don't let the simple means and humble materials fool you. "This does the same job as a $20,000 tunable dye laser."

In some ways it may even do more. All lasers emit a mix of colors, and with dye lasers that mix can be very broad. That's what makes them tunable—if you can pick out just the narrow range of colors you want. This penny-sized device uses a series of evenly spaced pillars, running in a line down the center of the laser cavity's fluid channel, to act as a diffraction grating. The laser is excited by an external source, and the grating allows only the light whose wavelength matches the pillars' spacing to be emitted.

Yet rubber is flexible. Squeeze or stretch the device with your fingers and the spacing changes, as does the laser's wavelength. Try that with your $20,000 instrument! ☐—*JA*



The third volume chronicling Caltech pranks is out. Edited by Autumn Looijen (BS '99) and Mason A. Porter (BS '98) and published by the Caltech Alumni Association, *Legends III* picks up where *Legends of Caltech* and *More Legends of Caltech* left off, and also successfully captures some lesser-known tales of Caltech pranking dating back to the 1950s. Stunts in this instalment include reengineering a building elevator to consistently deliver passengers two floors below where they wanted to go; converting Hell Alley, the hottest hallway in Blacker House, into an ice rink in homage to a resident who was going to get married "when Hell freezes over;" and mating one of the original Compaq PCs to a Lloyd House Coke machine in the days before e-commerce so that purchases could be debited to a student's account. (For a while, those of legal age were even able to buy beer from the machine.) So what's next? *Legends IV*, of course—a website (http://www.legendsofcaltech.com) includes a form on which your own stories may be submitted, as well as additional stories that didn't make it into print.

Legends III , whose cover art depicts the dreaded "Blue Book" used for Caltech finals, is available at the Caltech Bookstore for $12.95. It can also be ordered online at http://www.bookstore.caltech.edu/. A dollar from the sale of each copy goes to the Caltech prank fund. □—*DW-H*

Plastic Food?

In 1967, the career advice given to a certain graduate played by Dustin Hoffman was "plastics." Forty years later, Caltech chemical engineering professor Julia Kornfield (BS '83, MS '84) would add "shish kebabs."

Shish kebabs are beautiful, tiny structures that can form when polymers crystallize during flow. When magnified a million times, they resemble a skewer running through a stack of bell peppers. Inside plastics, they make car body panels stiff and carpet fibers strong, and impart a nice, glossy finish. But they're not without their problems—they might help you to resist a scratch, but they might also cause a layer to peel off. And that's why people want to control them.

Kornfield, Yoshinobu Nozue at Sumitomo Chemical Company, and coworkers have upended the conventional wisdom about how shish kebabs form. Shish kebabs occur in polymers known as polyolefins, which make up half of all plastics used—over 100 million tons per year. In addition to being used for car parts, polyolefins are also used to make pipes, wire, cable, carpets, fabrics, disposable syringes, and many other things. Manufacturers can custom-design a polyolefin's properties by varying its degree of crystallinity and the way the crystals come together. The result can be as hard as steel or as soft as a rubber band.

PICTURE CREDITS: 2 — Bob Paz; 5, 6 — Caltech Archives; 6-7 — NASA, NASA/JPL/U. of Arizona; 9 — Doug Cummings

"The plastics industry can tailor-make molecular distributions, but we don't know how to manipulate them," Kornfield explains. "This discovery opens up a whole new neck of the woods that people didn't know they could explore, and they'll be able to create combinations of properties you couldn't get before."

Much as an inspiring leader can influence the action of thousands, the researchers discovered that some molecules—especially the long ones—can marshal many others to create the shish, which then direct the formation of kebabs. This knowledge will allow for greater control of the creation process itself.

"In other words," says Kornfield, "you could make things by injection molding that you couldn't make before, and injection molding is a very cheap, fast process—you can pop a plastic bumper for an automobile out of its mold in a couple of minutes. So you bring down the cost of manufacturing and at the same increase the throughput."

A paper describing the work appeared in the May 18 issue of *Science*. The lead author is Shuichi Kimata, a former postdoc in Kornfield's lab, who played a central role in linking Kornfield's group at Caltech with Yoshinobu Nozue's group at Sumitomo and collaborators at the University of Tokyo. □—*RT*

The 200-inch Hale Telescope at Caltech's Palomar Observatory, fitted with an adaptive-optics system that removes atmospheric blurring, has found a star unlike any ever seen before. Those lines that form a near-perfect square aren't some sort of camera artifact—they're real clouds of gas in two hollow cones whose mutual vertex is a hot star called MWC 922 in the constellation Serpens, the serpent.

Christened the "Red Square" by Peter Tuthill of the University of Sydney, leader of the imaging team, the finding was published in the April 13 issue of *Science* in an article coauthored by James Lloyd of Cornell, which provided the infrared camera. The lines pointing out from the center that look like teeth of a comb may be "shadows cast by periodic ripples on the surface of an inner disk close to the star," said Lloyd.

This image, which is not in the paper, was taken in near-infrared light at 1.6 microns. It incorporates data from the Keck II telescope as well as the Hale, and has been sharpened to enhance faint details.