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CaltechNews

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In This Issue

California Institute of Technology

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Caltech News

ON THE COVER
If you're (gasp!) French, chances are you know something about good art, so perhaps it's not surprising that the artist who created the cover's buoyant watercolor is Caltech's dean of students, Jean-Paul Revel (shown above, addressing students at Freshman Camp '04). Revel, the Institute's Ruddock Professor of Biology, has often taken his perceptive eye and sketchbook with him on his travels, and created dozens of landscapes and nature studies over the years. But for this campus scene, painted in 1985, he only had to take a short walk outside his office for inspiration. For more on the current state of Caltech student affairs, see page 6 of this issue.

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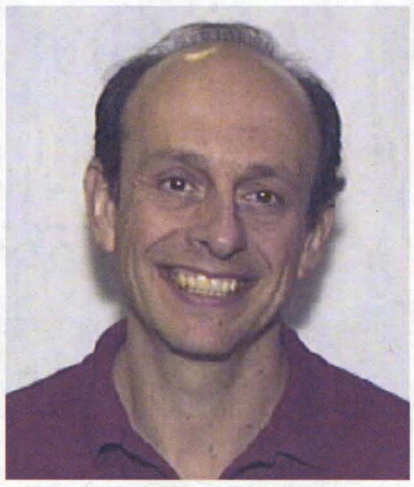
Up Front

Oh Asymptotic Freedom!

Asymptotic freedom is a term commonly associated with—well, not much of anything, really. This is a pity, because if the physicists are right, it is connected to just about everything. The odd language attests to an even odder fact about the edgy nature of reality.

Two of the oldest questions in science are, What is matter made of? What holds it together? About 40 years ago, physicists determined that protons and neutrons are not the fundamental building blocks of nature, but, along with their elementary particle cousins (collectively all called hadrons), are made up of subparticles called quarks. It turns out that quarks hold hadrons together via a force—or interaction, as the physicists are pleased to call it—that against all dictates of logic, actually increases with distance and diminishes with proximity. If one could step inside, say, a proton, and get up close and personal with any of its three quarks (a *Fantastic Voyage* for a new generation), one would discover that in the quark's immediate vicinity, physical freedom (or whatever passes for it on a distance scale of something



Caltech professor of theoretical physics David Politzer is a corecipient of the 2004 Nobel Prize in physics.

less than 10^{-15} meters) is practically infinite. Head for the exits, however, and the quark's pull increases until it too approaches infinity. This weird state is called asymptotic freedom. (An asymptote is a line that draws increasingly close to a curve but never quite meets it.)

Shorn of the physics equations, quark behavior inside hadrons (there are three quarks inside the heavier hadrons, including protons and neutrons; and a quark and antiquark pair inside the lighter ones) is said to resemble a rubber band's. Just as the tension in a slack rubber band increases as the band is pulled harder, so do quarks resist separation the more strenuously they are forced apart—a Romeo and Juliet kind of thing, with mathematical instead of emotional baggage. In the subatomic realm of quantum mechanics, a *Through the Looking Glass* domain where particles act like waves, regularly annihilate their antiparticles, and are here, there, everywhere, and nowhere simultaneously, none of this seems particularly out of place. That this dynamic actually shapes the wider world is harder to fathom. But there it is.

Thirty-one years ago, three physicists fell far enough down the quantum rabbit hole to see asymptotic freedom at work in the microworld, and by extension throughout nature. This was a striking development, so it seems a bit odd that the Nobel Foundation did not put a seal of approval on it a long time ago. Perhaps the judges too were caught up in the contrarian logic of it all—the more significant this work is, the longer we must wait to recognize it. But on October 5, 2004, they did:

Politzer came back from vacation and said, "Sidney, I got the same numbers."

Caltech professor of theoretical physics David Politzer, Frank Wilczek of MIT, and David Gross of UC Santa Barbara were awarded the Nobel Prize in physics for "the key discovery that explained how quarks, the elementary constituents of the atomic nucleus, are bound together to form protons and neutrons."

From that point, on the Caltech campus, events diverged from the usual "we have a laureate!" script. Politzer let it be known that he would not be making any public statements or giving interviews. At the Nobel press conference that Caltech held to explain the somewhat esoteric significance of the absentee laureate's achievement, Politzer's longtime colleague, Mark Wise (Caltech's McCone Professor of High Energy Physics), gracefully translated the science. Wise did not even omit to mention that, just like

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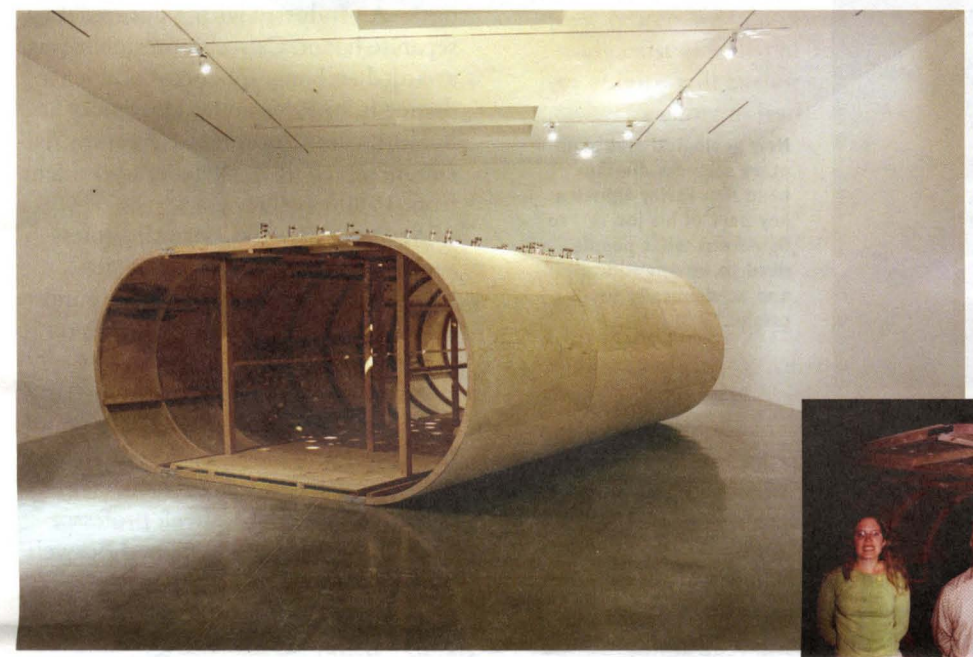
When art and science collude



Caltech graduate student AnnMarie Polsenberg (at left) stands with artist Steve Roden in front of *ear(th)*, the sculpture that they made, which was inspired by data from an earthquake. Below, artist Lita Albuquerque takes a break while installing *Stellar Mapping I*, her sculpture on the Caltech campus.

By Michael Rogers

Transforming data that tracks the movement of the earth during a major earthquake into a walk-through musical sculpture the size of a school bus requires the following: one Caltech geophysicist, a Caltech graduate student who's a robotics expert, an internationally renowned sound artist, and 10 toy glockenspiels. Those were the ingredients in one of three Caltech-related art projects featured in the Pasadena arts festival "The Tender Land," which debuted in October in several venues across the city. The fact that music was an integral part of the sculpture made sense, since the festival borrowed its name from an Aaron Copland opera.

The glockenspiel project, called *ear(th)*, went on view at Art Center College of Design's Williamson Gallery in Pasadena on October 9. The idea materialized when the gallery's director, Stephen Nowlin, asked Pasadena-based artist Steve Roden to make a sculpture that would address the different ways that science and art look at the earth and the environment.

"I had a vague idea about sound generated by science data," says Nowlin. "Steve was interested and took off from there, with the notion of making this strange sculptural piece that houses sound-making devices."

Nowlin, who has collaborated before with Caltech investigators on art exhibitions (see *Caltech News*, no. 1, 2003), found a willing partner in Mark Simons, associate professor of geophysics, who uses satellite imagery to analyze the earth's ground movements. "I gave them some observational data that we made on how the earth deformed during the magnitude 7.1 1999 Hector Mine earthquake," says Simons, adding that he had no problem seeing his scientific results used to launch an artistic enterprise. "There is a lot of room for art as a way to illustrate and get people to appreciate science," he says. (For more on Simons's satellite image of the earthquake, check out this issue's back-page poster.)

Without knowing exactly how his data would be used, Simons turned it over to AnnMarie Polsenberg, a graduate student in mechanical engineering, whose research focuses on underwater robotics. Since coming to Caltech in 2001 from MIT, where she minored in music, Polsenberg has taken design classes at Art Center, and in the fall she started teaching a class there on natural systems and how to apply knowledge of them to man-made structures.

With the earthquake data in hand, Polsenberg and Roden, the artist, devised the mechanical design and other aspects of the sculpture. Polsenberg wrote the computer code that translated Simons's data—a numerical sequence—into musical notes and then configured a microprocessor to operate motors that move wooden arms with fishing swivels attached to large metal washers that strike the glockenspiel bars. "There are 80 different notes that can be played," she says. "We're hoping that walking through the sculpture will be a magical experience."

Roden designed the wood sculptural structure, which resembles an airplane fuselage but which he says was actually patterned after a lamp by the Swiss architect Le Corbusier. Although the glockenspiels play no noticeable musical pattern, and the gentle tinkling of their bars may not immediately conjure images of an earthquake, Roden says that it was never his aim to simulate the sounds that the earth might make during a temblor.

"Mark's data, when plotted on a graph, is visually beautiful," Roden says. "My interest was in using the data to create something like a player piano score. The core is still his research data on movements of the earth. But I'm more interested in creating a listening experience.

"When people walk through the sculpture, it will hopefully sound like rain on a metal awning. When they

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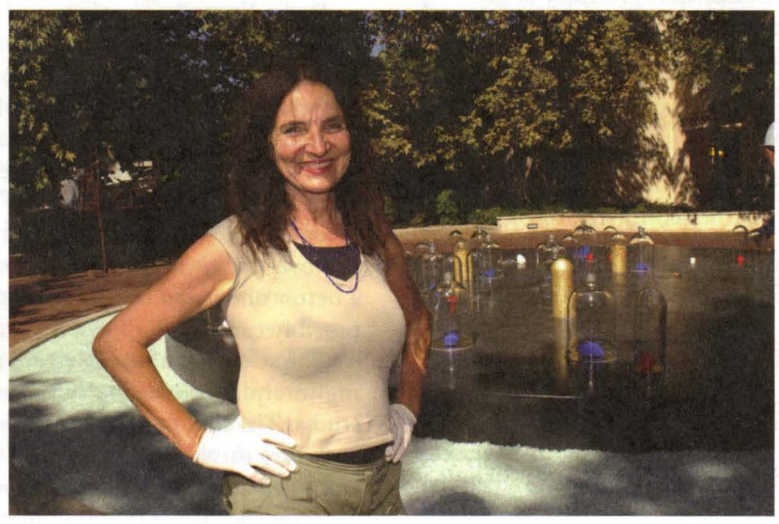

Globe-trotter takes a chair

Geochemist Ken Farley's field research has taken him around the world—probing "helium ages" in California's Sierra Nevada, exploring granite samples on a plateau in Tibet, and investigating volcanic rocks on Robinson Crusoe island off Chile. But Farley will be spending less time on fieldwork and more on deskwork now that he has taken on a new role as chair of the Division of Geological and Planetary Sciences.

Given his background, this avid globe-trotter may not seem like a match for a job brimming with administrative responsibilities and a meeting schedule to match. But Farley, who started the job September 1, takes a different view.

"The chairman has a real opportunity to make the community work," says Farley, who was named the Keck Foundation Professor of Geochemistry in 2003. The GPS division encompasses a broad range of classical and emerging programs, including geology, geobiology, geochemistry, geophysics, planetary science, and environmental science and engineering.

"The most obvious job responsibility," says Farley, "is to figure out what people need to be scientifically and academically successful, and then to figure out how to make that happen in terms of facilities, morale, teaching obligations, everything."

He says that he is looking forward to "sitting around with faculty and working with them to help identify what their problems are and how they can be solved. It's amazing what it takes for people to succeed and how many different things have to be arranged and orchestrated to make that possible. This is something that we do very, very well here at Caltech, so that's a wonderful thing about the place where we work."

Farley, who received his BS from Yale in 1986 and his PhD from UC San Diego in 1991, has spent his entire professional career at Caltech. He arrived as an assistant professor of geochemistry in 1993 and was appointed professor in 1998.

As a scientist, he is interested in the noble gases, so called because they do not form chemical bonds with other elements. As a result, their concentrations in marine sediments, rocks, minerals, and seawater preserve information on the nature of geochemical processes and the timescales over which these processes have occurred.

As division chair, Farley succeeds Ed Stolper, who spent 10 years in the position and also recently served as Caltech's acting provost, before stepping down to return to full-time teaching and research. In announcing Farley's appointment, Provost Paul Jennings said that he and President David Baltimore "feel very fortunate that a colleague of Ken's caliber has agreed to assume this administrative responsibility. He is highly respected by his colleagues for his integrity and conviction, his broad scientific interests, and his understanding of the issues within the division. We look forward to working with him as he takes on the duties of division chair."

New geological and planetary sciences division head Ken Farley thinks a key part of his job is "to figure out what people need to be scientifically and academically successful."

Farley takes the job at a time when the division is tackling an ambitious slate of projects, some of them part of the Institute's current $1.4 billion fund-raising campaign, "There's Only One. Caltech." They include the new Center for Plate Boundary Studies, which will focus on the most important global-scale issues in earth science, allowing scientists to observe and analyze motion at key plate boundaries around the world.

"Plate boundaries are of interest because this is where most of the geologic action happens—earthquakes, volcanoes, a lot of the important processes are best illustrated by plate boundaries, and they also have some societal implications for obvious reasons," Farley says.

Regarding other initiatives, Farley mentions a project to locate and characterize extrasolar planets. "It's a huge effort by NASA and JPL with which some of our planetary scientists are involved. Right now they've already identified some small number of very strange planets in other solar systems, and over the next decade we should see a better understanding of those that are possibly earthlike."

The scientists also anticipate returning interplanetary samples to Earth for study. The first material returned by a cometary mission is expected in 2005, and scientists also hope to obtain samples from an asteroid and from Mars in the years ahead. "The first set of observations will be hugely important for documenting a whole class of objects in the solar system," Farley says.

In other news affecting the division, a major effort to revolutionize scientific computing in geophysics is in the works, supported by a $6.75 million National Science Foundation grant. The initiative, to be called the Computational Infrastructure for Geodynamics, will provide the intensive computing power needed to advance such fields as seismology, plate tectonics, volcanism, and geomagnetism.

The division also is busy planning the eventual consolidation of emerging programs in geobiology and global environmental science. The completion of a new astronomy and astrophysics building, currently slated for 2008, should enable GPS to move its environmental-science programs into a rehabbed Robinson Laboratory after the astronomy faculty relocate. Farley adds, "This is very important to us because right now the people who are in this discipline are spread across many, many buildings."

All things considered, it's not surprising that Farley will scale back his teaching and research. "I'll keep my research program going. I have people in my group who can take care of a lot of the things that I have to draw back from." And the new GPS division chair, who says that he switched his undergraduate major at Yale from chemistry to geochemistry partly because even the nonscientist could understand it, does plan to continue teaching Introduction to Isotope Geochemistry.

"I had roommates who were music majors, and trying to explain to them what I was doing was a bit frustrating. One of the things that appealed to me about geochemistry is that it's very simple to explain."

Recognition

David Baltimore, president of Caltech and Nobel laureate, was chosen by the Israel Academy of Sciences and Humanities to deliver the Albert Einstein Annual Lecture at the academy's headquarters in Jerusalem on March 14. Baltimore spoke on "Biotechnology—An Industry with a Future." In a separate honor, Caltech's president was awarded an honorary doctor of science degree from Rockefeller University at its 40th commencement ceremony. Baltimore served as Rockefeller's president from 1990 to 1991.

Seymour Benzer, Boswell Professor of Neuroscience, Emeritus, has been selected to receive the inaugural 2004 Neuroscience Prize of the Peter Gruber Foundation. Each year the foundation will present a gold medal and a $200,000 cash award "to an outstanding scientist who has contributed to fundamental advances in the field of neuroscience." A Caltech professor since 1967, Benzer was named Boswell Professor in 1975.

Alexei Borodin, professor of mathematics, received the Prize of the Moscow Mathematical Society in 2003. He received his PhD from the University of Pennsylvania in 2001 and joined Caltech's faculty as professor in 2003.

Colin Camerer, Axline Professor of Business Economics; ***Mani Chandy***, Ramo Professor and professor of computer science; ***Alan Hájek***, associate professor of philosophy; ***Kayoko Hirata***, lecturer in Japanese; and ***Feng-Ying Ming***, lecturer in Chinese, were named in June as recipients of 2004 ASCIT (Associated Students of Caltech) Teaching Awards. Awards for teaching assistants went to grad students ***Dave Goulet***, applied and computational mathematics; and ***Mihai Stoiciu***, mathematics; and to then-undergraduate ***Victor Tsai***, planetary science. Tsai graduated in June with his BS in geophysics.

Sunney Chan, Hoag Professor of Biophysical Chemistry, Emeritus, has received the William C. Rose Award, presented during the annual meeting of the American Society for Biochemistry and Molecular Biology/International Union of Biochemistry and Molecular Biology, in Boston, June 12–16. The award recognizes "his outstanding contributions to biochemical and molecular biological research and his demonstrated commitment to the training of younger scientists."

David Charbonneau, Millikan Postdoctoral Scholar in Astronomy, has been selected to receive the Astronomical Society of the Pacific's Robert J. Trumpler Award, which "is given each year to a recent recipient of the PhD degree in North America whose research is considered unusually important to astronomy." The award consists of a plaque and a check for $500. In a

CALTECH LAUNCHES MAJOR NEW INFORMATION INITIATIVE

Information is everywhere. Most of us think about it in terms of mere facts—facts gleaned from a teacher or a colleague, from the media, or words from a textbook or the Internet.

But there are other, near-infinite types of information—the instructions encoded in our genome that tell our cells when to divide and when to die, or the daily flow of data into the stock market that somehow motivates people to buy and sell.

What's needed is a way to harness and understand all of this data so that scientists and engineers can continue to unravel the secrets of nature and the human institutions in which we operate. In an unprecedented effort, Caltech has launched a university-wide initiative called Information Science and Technology (IST)—an initiative designed to draw back the curtain on the nature of information itself and to redefine the way we approach, understand, and use science and engineering. IST will cut across disciplines, eventually involving over 25 percent of all Caltech faculty and nearly 35 percent of students on campus.

Caltech has committed to raising $100 million for IST as part of the Institute's five-year, $1.4 billion capital campaign, "There's Only One. Caltech." Nearly $50 million has been raised in the form of separate grants of $25 million from the Annenberg Foundation and $22.2 million from the Gordon and Betty Moore Foundation. The Annenberg Foundation gift will be used to construct the Walter and Leonore Annenberg Center for Information Science and Technology—a new building that will be the physical center of IST. The building will join the existing Watson and Moore laboratories in forming a core of buildings that link together IST researchers.

Funding from the Moore Foundation will provide seed money to establish four new interdisciplinary research centers within IST. These new centers will join two that already exist at Caltech. Together the six groups will anchor and organize Caltech's effort to lead the way in this new field.

Over the last 50 years, IST has evolved from an activity focused on carrying out more efficient calculations into a major intellectual undertaking that spans disciplines in engineering and the sciences. Although other universities have created schools of computer science (or computer and information science), these are generally related to computer science and software—a limited approach to information science and technology. At Caltech, IST will provide a new intellectual framework for designing and integrating information-based research and instructional programs across the academic spectrum.

"To maintain preeminence in science, the United States needs new and unified ways of looking at, approaching, and exploiting information in and across the physical, biological, and social sciences, and engineering," says Jehoshua (Shuki) Bruck, the Moore Professor of Computation and Neural Systems and Electrical Engineering and the first director of IST. "Caltech is taking a leadership role by creating an Institute-wide initiative in the science and engineering of information. IST will transform the research and educational environment at Caltech and other universities around the world."

"Some say biology is the science of the 21st century, but information science will provide the unity to all of the sciences," says Caltech president and Nobel Prize–winning biologist David Baltimore. "Information science, the understanding of what constitutes information, how it is transmitted, encoded, and retrieved, is in the throes of a revolution whose societal repercussions will be enormous."

The Annenberg gift is the first portion of a $100 million institutional commitment to IST, and is part of Caltech's capital campaign. Now in the design stage, the Annenberg Center is expected to be completed when the campaign ends in 2007.

"I am delighted that the Annenberg Foundation will be a part of this visionary enterprise," said Leonore Annenberg, foundation president and chairman. "As a publisher, broadcaster, diplomat, and philanthropist, Walter Annenberg was known for breaking new ground. Support for this important new initiative surely would have pleased him as much as it honors the work of the foundation."

Founded in 1989 by Walter H. Annenberg, the Annenberg Foundation exists to advance the public well-being through improved communication. As the principal means of achieving its goal, the foundation encourages the development of more effective ways to share ideas and knowledge.

The Moore Foundation gift to fund the IST is part of a $300 million commitment that the foundation made to Caltech in 2001. The four centers funded by the Moore grant are the following: the Center for Biological Circuit Design, which will address how living things store, process, and share information; the Social and Information Sciences Center, which will investigate how social systems, such as markets, political processes, and organizations, efficiently process immense amounts of information and how this understanding can help to improve society; the Center for the Physics of Information, which will examine the physical qualities of information and will design the computers and materials for the next generation of information technology; and the Center for the Mathematics of Information, which will formulate a common understanding and language of information that unifies researchers from different fields.

The Moore Foundation seeks to develop outcome-based projects that will improve the quality of life for future generations. It organizes the majority of its grant-making around large-scale initiatives that concentrate on environmental conservation, science, higher education, and the San Francisco Bay Area.

For more information about IST at Caltech, visit http://www.ist.caltech.edu.

separate honor, Charbonneau has been named to receive the Bar J. Bok Prize for "outstanding research by a recent graduate of the Harvard Department of Astronomy."

Serguei Denissov, Taussky-Todd Instructor in Mathematics, has been awarded the Vasil A. Popov Prize in Approximation Theory. Established in honor of the late Professor Vasil A. Popov of Bulgaria, the prize is awarded every three years to an outstanding young approximation theorist with at most six years of professional experience. The prize was presented in May at the Eleventh International Conference in Approximation Theory, in Gatlinburg, Tennessee.

Charles Elachi, PhD '71, Caltech vice president, director of JPL, and professor of electrical engineering and planetary science, was selected to present a talk under the auspices of the William Gould Dow Distinguished Lectureship, which is "the highest external honor" bestowed by the University of Michigan's department of electrical engineering and computer science, and recognizes the accomplishments of individuals outside the university system "who have made outstanding contributions" in the field of electrical engineering and computer science. Elachi spoke on "Space Exploration in the Next Decade—Challenges and Opportunities."

Mory Gharib, PhD '83, Liepmann Professor of Aeronautics and Bioengineering, has been selected by the Technion—the Israel Institute of Technology, for its 2004–05 Pollak distinguished lecturer award. Two Pollak Lecturers are chosen each year for the Israel Pollak Distinguished Lecture Series, from all areas of science and engineering.

Peter Goldreich, DuBridge Professor of Astrophysics and Planetary Physics, Emeritus, has been elected a Foreign Member by Great Britain's Royal Society, an honor that is bestowed each year on a small number of the world's outstanding scientists. Goldreich, who received the United State's highest scientific honor—the National Medal of Science—in 1995, was cited by the society for "several seminal contributions to an unparalleled range of topics in planetary science and theoretical astrophysics, including spiral arms in galaxies and planetary rings and the explanation of white dwarf oscillations." One of the world's most prestigious learned societies, whose founding helped usher in the age of modern science, the Royal Society was established in 1661 under the patronage of Britain's King Charles II "for the purpose of improving natural knowledge." Isaac Newton served as its first president.

Ali Hajimiri, associate professor of electrical engineering, has been named to the 2004 list of the world's 100 Top Young Innovators by MIT's *Technology Review*. Nominees are recognized for their contributions in transforming the nature of technology and business in industries such as biotechnology, medicine, computing, and nanotechnology.

Hiroo Kanamori, Smits Professor of Geophysics, has been selected as a recipient of the 2004 Japan Academy Prize, which is awarded "for exceptional works and other scientific achievements." The prize includes a medal and a monetary award of 1 million yen, with the emperor and empress of Japan in attendance at the presentation ceremony.

Babak Hassibi, associate professor of electrical engineering, ***Mark Simons***, associate professor of geophysics, and ***Brian Stoltz***, assistant professor of chemistry, have each received the Presidential Early Career Award for Scientists and Engineers. Hassibi was recognized for his "fundamental contributions to the theory and design of data transmission and reception schemes"; Simons for his work in connection with NASA; and Stoltz for his "creative new research in synthetic organic chemistry." The award, which provides five years of grant support, "recognizes outstanding young scientists and engineers who, early in their careers, show exceptional potential for leadership at the frontiers of knowledge."

Lee Hood '60, PhD '68, visiting associate in biology, became the sixth recipient of the annual Biotechnology

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"This unique institution"

—Caltech's vice president for student affairs speaks on the state of student life

The following article is adapted from a talk that Vice President for Student Affairs Margo Post Marshak, shown above welcoming new students at Caltech's second convocation, presented recently to the Caltech Alumni Association's Board of Directors.

This fall marks the start of my third year at Caltech. In my time here, I have come to appreciate why this unique institution means so much to alumni, to share your admiration for Caltech, and to understand more fully the basis for your loyalty and commitment to its value system.

I would like to share some statistics with you about our newest students and your future fellow alumni, the class of 2008. Of our 211 freshmen, close to 30 percent are women, 28 percent are Asian Americans, and 7 percent are underrepresented minorities. With regard to graduate students, the stricter visa regulations that were enacted as a result of 9/11 have had an impact. This year we received only 3,880 applications for graduate study, almost 1,300 fewer than last year. Many foreign students are opting for graduate study in countries with less rigorous visa requirements. As a result, only 35 percent of the incoming class are foreign nationals—whereas, in the years before 9/11, the numbers on average were closer to 50 percent. Of our entering graduate students, 28 percent are women and 6 percent are underrepresented minorities.

In the fall of 2002, when I arrived at Caltech, I was surprised that we did not have an official function, welcoming all incoming students and postdoctoral fellows, at which they could become better acquainted with Caltech's history and culture, and with the scope and breadth of the Institute's celebrated research enterprise. I decided to do something about that, and last fall we held our first convocation. Our second convocation, on September 20 of this year, featured Beckman Professor of Chemistry Harry Gray speaking on his passion for science, Provost Paul Jennings, PhD '63, speaking on the Honor Code and integrity in science and engineering, University Archivist Judith Goodstein reviewing Caltech's history, and President David Baltimore presenting some highlights of our current research.

As for Caltech's newest alumni, our Career Development Center (CDC) annually collects data on graduating students' plans, which turn out to be remarkably similar from year to year. Among the class of 2004 undergraduates who responded to the survey this year, 60 percent are going on to graduate or professional schools, and 25 percent are entering the work force at an average salary of more than $60,000. Those attending graduate schools are mostly pursuing degrees in the sciences, math, and engineering at top universities. All nine who applied to medical school were accepted, three in combined MD/PhD programs. Several are attending law school, including our last ASCIT president, Tom Fletcher, following in the footsteps of his predecessor in the post, Ted Jou.

Many of our 166 PhD recipients are moving on to postdoctoral training, at an average salary of $43,000. Others have accepted tenure-track university positions. Three will attend medical school, and two will go to law school. The remainder who answered the survey have accepted jobs in industry, with average salaries of over $80,000. One is starting a company.

Many Caltech alumni have offered strong and consistent support for our students as they make decisions about the next phase of their lives. Alumni serve as speakers, luncheon guests, panelists, and mentors, as references for employment, and as job recruiters. More than 30 alumni volunteers met with and advised students at each of three recent on-campus career conferences—an undergraduate career conference, a PhD/postdoc career conference, and a leadership conference. Students value alumni support because Caltech graduates best understand how academic experiences at this unique institution inform their next steps.

Turning back to campus life, it is reassuring that, despite their heavy workloads, some students find time for their nonacademic interests. Just to give you a couple of examples, three years ago a group of undergraduate and graduate students formed a team to compete in the national collegiate chess tournament. They won first place, tried again last year, and placed first again. For the last two years our new and amazing women's figure-skating team finished among the top 10 contenders in the national collegiate championship.

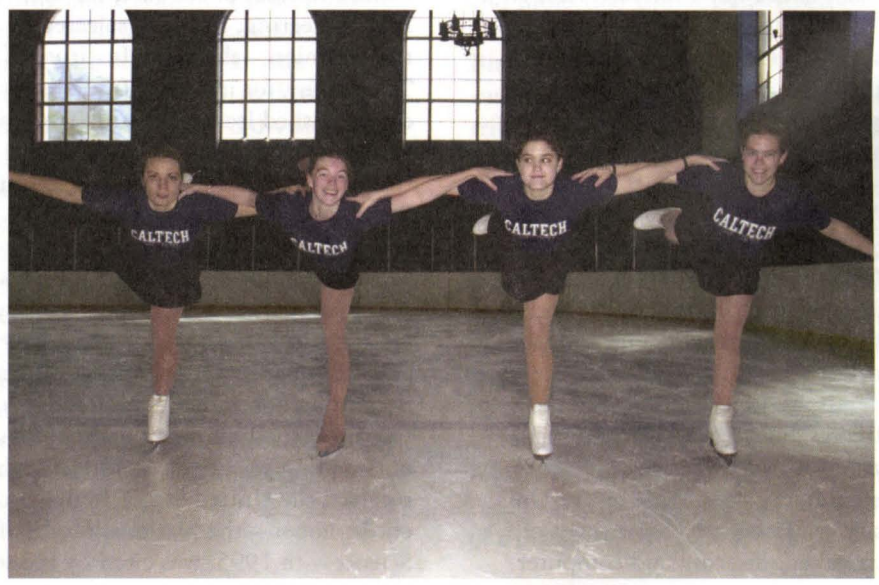
One year ago, we began to spend the interest on a $3 million endowment known as the Gordon and Betty Moore Fund and the Honorable Shirley M. Hufstedler Fund for Enhanced Quality of Student Life, given by Gordon and Betty Moore and the MacArthur Foundation in honor of Trustee Shirley Hufstedler. The fund's sole purpose is to enhance the quality of undergraduate and graduate student life on campus. All members of the Caltech community are eligible to submit a proposal to the Advisory Committee for the Moore-Hufstedler Fund, which I chair, made up of Caltech faculty, students, and staff. Our recommendations go to President Baltimore for his consideration and approval. In the first year, we funded more than 40 proposals, and spent about $300,000 (we had two years of interest available). Examples of programs that received support are a Caltech/WEST (Women in Science, Engineering, and Technology) Graduate Science Symposium, the Caltech Y alternative spring break, Chinese brush-painting and calligraphy classes, an undergraduate career conference, the Social Activism Speaker Series, and an a cappella concert.

Through many contacts with alumni, I know of the deep interest that many Institute graduates continue to have in the quality of student life on campus. So I want briefly to bring you up to date on current projects aimed at preserving and enriching the undergraduate experience, specifically the restoration of the Student Houses, and our plan for a Campus Center.

While pranks and other less flamboyant traditions have turned the Houses into legends, the South Houses—Dabney, Fleming, Blacker, and Ricketts—are genuine architectural treasures in their own right. Unfortunately, as many alumni know, the effects of time and neglect have led to serious infrastructure problems in these residence halls, to the point where restoration has become an urgent imperative. In March of this year, the trustees approved $36.4 million for renovations. The project is on an aggressive timeline, with work scheduled to begin in June 2005, just after commencement. Barring delays, students will reoccupy the Houses in September 2006.

During the renovations, students will live in modular units, or trailers, that they have helped to plan. Each unit will accommodate 12 students. They will be located on the Avery lawn and on the surface parking lot across Holliston in what the students are calling "South Park." We are working with students to ensure that House communities are maintained. House dinners

Caltech's ice skating team has placed among the top ten in national collegiate competition two years running.



The class of 2008 gets put through its paces: Above, Registration 2004; top and left, Freshman Camp, and below, right, moving-in day.

will be staggered at Chandler, and we are adding a covered extension to accommodate two Houses at a time.

At this stage of planning, the South Houses' renovation includes comprehensive systemwide upgrades of utilities and safety features, the installation of air conditioning, and the restoration of the bedrooms, courtyards, terraces and loggias, dining rooms, lounges, and interior Filipino Garden. We also plan to create a new outdoor dining area leading from the South Houses to the Olive Walk and facing the North Houses across the way.

As part of the restoration project, this past August a group of four trustees, three of whom are alumni, and I convened a group for a serious discussion about House cultures. Participants included alumni (among them Association past president Tom Tisch '61 and current president Stephanie Charles '73), faculty, staff, and student representatives from the Houses, as well as the architects overseeing the renovations. The trustees focused on the way students currently live in the Houses, expressing the view that many prospective donors, and prospective students and parents, find it unacceptable.

One of our alumni trustees, Ed Lambert '82, commented that the solution lay not in abolishing student self-governance, but in the recognition that self-governance requires responsibility, accountability, and stewardship. He asked the campus Interhouse Committee (IHC) to prepare a plan that will assure changes in House culture to the extent that the restoration will be respected and preserved, and offered trustee and alumni help in the IHC's planning process.

My staff is also looking for more ways to inform interested alumni groups about the restoration.

Meanwhile, our architects, who are consulting with students, are looking for sensible ways to help preserve revered House traditions such as Ditch Day stacks and constructions for parties. For instance, because students currently anchor some of their constructions to courtyard columns, the architects plan to provide permanent wall anchors as a safer alternative.

We are working to raise the finances for the South Houses' restoration, and we have exciting naming opportunities available at different levels of support. Alumni may contact the Development Office for more information.

Another interesting development concerns Avery House, our most recent residence hall, which was constructed in 1996 with a gift from the late Caltech Trustee Chair Emeritus R. Stanton Avery. Many Avery students, determined to forge a tighter community, wish to accept freshmen. They took this issue to the Faculty Housing Committee, which recommended to the Faculty Board that Avery be permitted to accept freshmen beginning in September 2005. The board went on to vote in favor of this policy, despite a demonstration by residents of the other Houses. This fall the IHC, representatives from Avery House, the MOSH (Master of Student Houses), and staff from the Student Affairs Office began to consider how to implement this plan, taking into account both rotation and Avery's desire to remain an alternative choice for students who do not wish to live in one of the traditional Houses.

Finally, I want to mention two other high-priority capital projects—reconstruction or restoration of the North Houses and the upcoming construction of the Campus Center.

The North Houses are in bad shape. In general students would prefer that we tear them down and build new ones resembling the South Houses. This is an excellent idea, in part because it would allow us to build an additional House on the footprint of Ruddock, Page, and Lloyd. Probably a less costly plan would involve renovating the existing North Houses, but this has not captured anyone's imagination, to say the least. This project also presents an ambitious fund-raising challenge.

In July, President Baltimore announced to our trustees that Trustee Chair Ben Rosen has made a magnificent lead gift to support the construction of the Caltech Campus Center. As now conceived, the center will include a fine music hall; a theater for movies and dramatic productions; an art gallery; student meeting rooms; computer and study rooms; a poster and silk-screening lab; music practice rooms; a recording studio; offices for music faculty; lounge areas; and a café for daytime and nighttime dining.

Many of our peer colleges and universities have these types of facilities, and a consensus has emerged that Caltech also needs a central place where all members of the Caltech community can mingle, and where students can access a broad spectrum of constructive activities. Many of our students believe that the academic and non-academic aspects of life at Caltech are not sufficiently complementary. Once two-thirds of the $35 million budget for the Campus Center has been raised, we will be authorized to move into the design phase and to begin scheduling the construction. We still have extraordinary spaces that can be named by early-leadership contributors to get us to this next fund-raising milestone.

Recognition . . . from page 5

Heritage Award at the BIO 2004 Annual International Convention, held June 6–9 in San Francisco. Hood, a former Caltech faculty member and the biology division chair from 1980 to 1989, is cofounder and president of the Institute for Systems Biology, as well as the cofounder of Amgen, Applied Biosystems, and other biotechnology companies.

Ken Libbrecht, professor of and executive officer for physics at Caltech, has received a 2004 Benjamin Franklin Award for his book *The Snowflake: Winter's Secret Beauty*. The awards recognize excellence in independent publishing, and Libbrecht's book was honored in the Science/Environment category. Booklist says of *The Snowflake*: "Physicist Libbrecht and photographer [Patricia] Rasmussen both grew up in snowy climes, but it took a scientific and aesthetic focus to deepen their appreciation for snow's hidden beauty, revelations they now share in a felicitous union of word and image." Voyageur Press has also now published a new hard-cover, pocket-sized volume by Libbrecht, entitled *The Little Book of Snowflakes.*

Elliot Meyerowitz, Beadle Professor of Biology and chair of the biology division, has been appointed one of 14 Phi Beta Kappa Visiting Scholars for 2004–05. The scholars travel to universities and colleges that have Phi Beta Kappa chapters, and spend two days on campus meeting informally with undergraduates, participating in classroom lectures and seminars, and giving one major address open to the entire academic community. Founded in 1776, Phi Beta Kappa is the nation's oldest academic honor society, with chapters at 270 colleges and universities and over 600,000 members. The purpose of the Visiting Scholars program, which began in 1956, is to enrich the intellectual atmosphere of academic institutions and enable undergraduate students to talk with distinguished scholars from diverse disciplines.

Robert Phillips, professor of mechanical engineering and applied physics, and ***Stephen Quake***, Everhart Professor of Applied Physics and Physics and currently on leave at Stanford, have been named by the National Institutes of Health (NIH) as two of nine recipients of the first annual Director's Pioneer Award. The award will provide Phillips, an authority on the nanoscale mechanics of biological systems, with $2.5 million for the next five years as part of the NIH's new "Roadmap for Medical Research" program. Quake, who works in the areas of biophysics and bioengineering, will receive $2.5 million for the next five years, also as part of the "Roadmap" program.

John Schwarz, Brown Professor of Theoretical Physics, was selected to deliver the keynote speech for the opening ceremony of the Center for Mathematics and Theoretical Physics

Continued on page 12 . . .

there's only **one.caltech**

THE CAMPAIGN

Campaign Highlights

Dabney Hall complete!

Caltech celebrated the completion of the Dabney Hall restoration project with a special rededication ceremony on September 17. The first capital project of the "There's only one. Caltech" campaign, the one-year renovation not only restores Dabney Hall to its original grandeur, but also reestablishes this historic building as home to Caltech's humanities department. The entire humanities faculty is now housed there, and both the humanities library and Treasure Room have been restored as part of the project.

Approximately 300 Caltech friends and faculty attended the special event, which opened with remarks from Caltech's president David Baltimore, and Professor of Anthropology Jean Ensminger, chair of the Division of the Humanities and Social Sciences. These renovations "not only help reclaim the beauty of an extraordinary building but also invigorate the humanities for students through space enlivened by study, research, lectures, and performance" said President Baltimore.

A generous distribution from the Estate of George F. Smith '44, PhD '52, who was a life member and past president of the Associates, funded a matching challenge to all members of the Associates that resulted in naming the building's connecting garden area the Garden of Associates. Under the leadership of Associates president Ted Jenkins '65, MS '66, and the Associates campaign committee, the organization in October reached its $250,000 goal to meet the challenge and fulfill the $1 million naming opportunity

Dabney Hall of the Humanities was named for the late Caltech trustee Joseph B. Dabney, one of the Associates' earliest members, in recognition of his $250,000 gift to the Institute in 1927.

Campaign Support Grows

Support for objectives of the Institute's campaign, "There's only one. Caltech," continues to rise. As of October 31, 2004, $981,133,805 had been raised through the campaign. Likewise, plans for several capital projects are on the move. The Sherman Fairchild Foundation's $10 million pledge toward the Cahill Center for Astronomy and Astrophysics increased the total amount of gifts and pledges to $35 million and has allowed Caltech to begin formal architectural design and engineering plans for the facility. Thom Mayne of Morphosis was retained in September 2004, and construction is tentatively scheduled to begin midyear 2006. Additionally, Pfeiffer Partners, Inc., has been retained to begin plans for the renovation of the South Houses, for which construction is slated to begin in July 2005.

Caltech's Information Science and Technology (IST) initiative is fast moving into the spotlight thanks to a generous lead commitment from the Annenberg Foundation. Building on an interdisciplinary foundation, IST will be the first integrated research and teaching activity in the country that investigates information within a comprehensive intellectual framework. (See IST article on page 5.) The Annenberg Foundation's $25 million grant will support construction of a new building—to be called the Walter and Leonore Annenberg Center for Information Science and Technology—that will house IST research and education activities.

Funding new research activities, the Skirball Foundation has awarded the Institute a $1.5 million challenge grant to help fund Engineering Immunity, a biomedical research project that aims to develop a technology to create immunological methods through an integrated approach combining gene therapy, stem cell biology, and immunotherapy. Initial efforts, which will be led by Delbrück Professor of Biology and Howard Hughes Medical Institute Full Investigator Pamela Bjorkman and Caltech president David Baltimore (who received the 1975 Nobel Prize for his work on cancer and virology), will be focused on developing immunological methods to treat melanoma and HIV. However, it is anticipated that such technology could combat a host of other diseases for which the immune system is currently unable to provide a defense. This is the first grant awarded to Caltech by the Skirball Foundation.

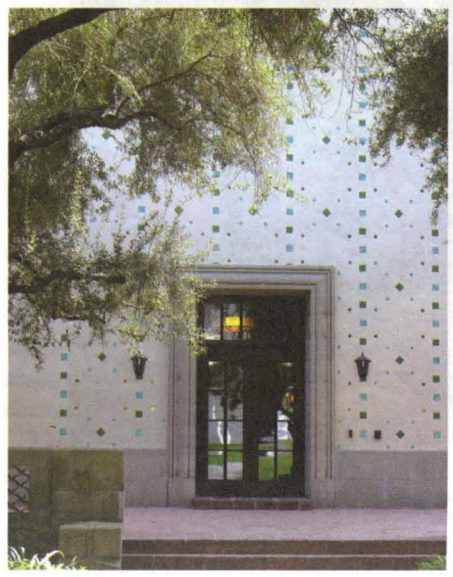
The Gordon and Betty Moore Foundation also recently approved a $25.4 million grant for Caltech's nanoscale systems initiative. These resources will complement the Fred Kavli and Kavli Foundation gifts establishing the Kavli Nanoscience Institute (KNI) at Caltech. The Moore Foundation grant will help fund a variety of programmatic components, as well as laboratory equipment, research facilities, and research and administrative staff associated with KNI. The additional support is helping Caltech to develop new research opportunities and attract more of the world's best researchers to KNI, thus placing Caltech at the leading edge of nanoscale science and engineering.

A $1.7 million bequest distribution from the estate of Alexander and Renee Kolin has established the Kolin Educational Fund to Support Visiting Programs and the Kolin Educational Fund to Support Research Fellows. Additionally, a $1.44 million bequest distribution from the estate of Evelyn L. Bray has fully funded the Ulric B. and Evelyn L. Bray Endowment Fund, supporting the Ulric B. and Evelyn L. Bray Fellowship, the Ulric B. and Evelyn L. Bray Research Venture Fund, and the Ulric B. and Evelyn L. Bray Postdoctoral Prize in Chemistry and Chemical Engineering. Evelyn Bray provided for Caltech in this manner to honor the memory of her husband, Ulric Bannister Bray, who attended the Institute as a National Council Fellow in 1926 and 1927. The Brays' generous bequest cements the family's long history of support for Caltech. Previously, in 1981, Evelyn Bray established the Ulric B. and Evelyn L. Bray Lecture on the American Economic System, which has featured such notable speakers as Armand Hammer, Eli Broad, and Ambassador George Argyros.

Furthermore, collaborative efforts between Caltech's Corporate Relations Office and the Office of Technology Transfer have secured a $250,000 grant from Amgen Inc. to create the Amgen Postdoctoral Research Scholar award. Funding for postdoctoral fellowships greatly adds to the research and academic output of Caltech's small faculty body. Typically working with Institute professors in an existing research program, postdocs often allow the Institute to explore new, interdisciplinary areas of research. The Amgen award will support four postdocs working in the biological and chemical sciences.

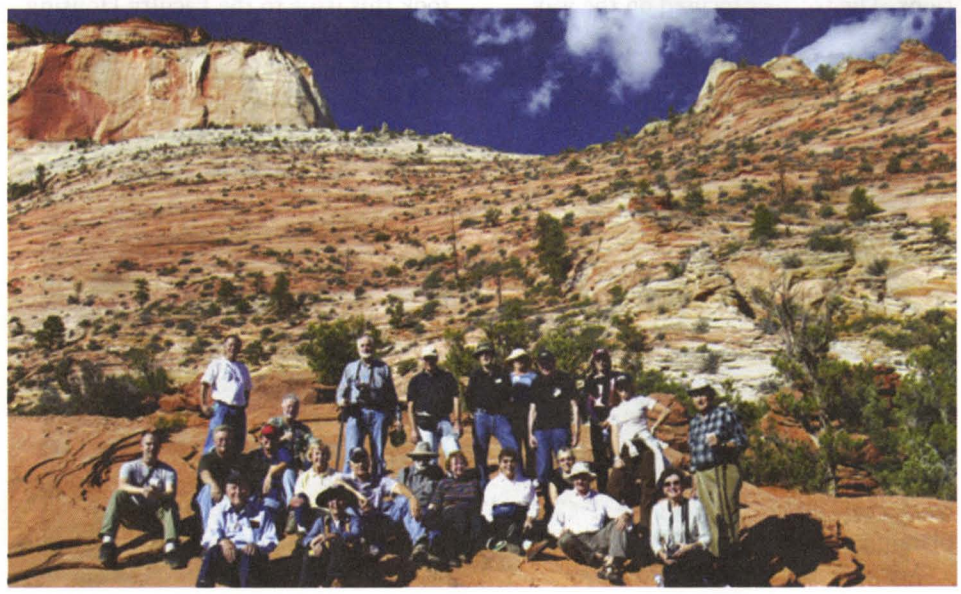
Please call 1-877-CALTECH or visit http://one.caltech.edu for more information on how you can support the Institute's strategic priorities.

Vannessa Dodson



DABNEY DEDICATION. Humanities and Social Sciences Chair Jean Ensminger (top photo) welcomes guests to the restoration ceremony for Caltech's Dabney Hall of the Humanities, whose renovation was completed this past summer. Above, the tile design that now highlights Dabney's north-facing entrance was part of the building's original architectural plan, but only now has it been incorporated into the exterior facade. Below, Dabney's "Treasure Room," which will now serve as an elegant meeting space, was restored by removing artificial walls that for decades had divided the area into offices and hidden much of the original woodwork.

The President's Circle of the Caltech Associates enjoyed exploring the geology and natural history of Utah's Bryce Canyon and Zion National Parks this past October, on a trip led by Van Wingen Professor of Geobiology Joe Kirschvink '75, MS '75. Just above Zion Canyon's Great Arch, the group (below) posed for a commemorative photo.



A Beautiful Mind. An exciting exhibit honoring a certain former Swiss patents clerk drew 126 members of the Caltech Associates to the Skirball Cultural Center in Los Angeles this past October, where they took part in a private tour of the new Einstein Exhibit and heard two lectures from Caltech faculty. Attendees included Associates president Ted Jenkins '65, MS '66 (to the right of the lifesized Albert cutout) and Feynman Professor of Theoretical Physics and general relativity specialist Kip Thorne '62 (on the left), who spoke to the group about Einstein's scientific legacy. Tilman Sauer, scientific editor of the Caltech-based Einstein Papers Project, spoke to the Associates about "The Historical Einstein: The Man Behind the Myth."

Associates Activities

All events will be held at the Athenaeum unless otherwise noted. Individual invitations for each event will be sent monthly. For more information about the Associates, contact Carrie Stubstadt at 626/395-3919, or at associates@caltech.edu. Visit our website at http://giving.caltech.edu/CA/.

***January 31,** Associates Dinner and Program,* with James Heath, Gilloon Professor and Professor of Chemistry—"Nanotechnology, Biology and Medicine."

***February 24,** Associates New Member/ Provost's Circle Dinner*, with remarks by Caltech president David Baltimore.

***March 10,** East Coast Associates Dinner and Program*, with James Heath, Gilloon Professor and Professor of Chemistry—"New Concepts and Technologies for Solving the Problem of Cancer."

***April 9,** "Saturday at the Jet Propulsion Laboratory"*—JPL Tour, Box Luncheon, and Program for Associates, Their Children, & Grandchildren, with JPL director Charles Elachi, PhD '71.

***May 12,** Associates Board of Directors Meeting.*

***May 12,** Associates Tours, Dinner & Program at Dabney Hall,* with members of the Caltech Humanities faculty and Jean Ensminger, professor of anthropology, and chair, Division of the Humanities and Social Sciences.

***June** 7–11, President's Circle Travel Program to Hawaii,* with Michael Brown, associate professor of planetary astronomy, and Jason Saleeby, professor of geology.

***September 10–25,** President's Circle Travel Program*—"A Journey Through the Habsburg Empire," with Warren Brown, associate professor of history.

More than 185 people attended the Associates President's Circle Garden Party this past fall. Guests included Gail Bardin (above photo), the newest member of the Associates board of directors, and her husband, Robert; and (photo below) Caltech trustee Wally Weisman (left) and his wife, Sheila (right), who joined their hosts, Caltech president David Baltimore and his wife, Alice Huang, in the garden of the President's Residence, where the event was held. Weisman chairs the Institute's "There's Only One. Caltech." campaign.

Politzer . . . from page 2

always, the new Nobelist was a regular guy—"only a lot smarter than the rest of us." He added that while the calculation Politzer had carried out was very difficult in its day, it was now routinely done by graduate students. Wise planned to assign it to several of his in the near future.

Politzer himself was a graduate student when he made his landmark discovery, and back in the day, or at least in the decade afterward, he talked to several journalists and historians of science about his role in the asymptotic freedom story. By his account, the Eureka moment was rather serendipitous—it certainly bears out Pasteur's dictum that fortune favors the prepared mind. In 1973 Politzer was in his fourth year at Harvard and, having finished his coursework, was casting about for a thesis topic. One of the hottest areas in particle physics at the time was electroweak theory, which was an attempt to unify quantum electrodynamics (QED)—the quantum field theory of electromagnetism—with the weak force—which, roughly speaking, governs some forms of radioactive decay—into a framework that could be described by a single set of equations. According to *Constructing Quarks*, a sociological history of particle physics by Andrew Pickering (University of Chicago Press, 1984), Politzer thought he might uncover something new if he applied a "beta function analysis" (more on this later) to an aspect of electroweak field theory. He asked his academic adviser, Sidney Coleman (Caltech PhD '62), if he thought this was a good idea. Coleman told him to go ahead.

The excitement surrounding electroweak unification (which would ultimately unify a number of key players with Nobel Prizes) stemmed partly from the fact that the physics community saw it as a major step toward a goal championed by Albert Einstein: that of tying nature's four forces—gravity, electromagnetism, the weak force, and the strong force—together into a single theoretical framework, whose laws held sway in the first moments of cosmic creation (the Big Bang and all that) and whose vestiges can still be detected in nature today. There still isn't a verified quantum field theory for gravity, and at the time physicists didn't have a satisfactory quantum theory for the strong force either. But they were certainly working on it.

The strong force got its name because physicists realized that it had to be stronger than electromagnetism (it's about 100 times stronger at the scale of a proton) to weld protons, whose positive charges would otherwise repel each other, into a band of brothers inside the atomic nucelus. In 1948, Richard Feyman (shortly to move from Cornell to Caltech), Julian Schwinger of Harvard, and Sin-Itiro Tomonaga of Tokyo University had independently created the enormously successful quantum field theory for electromagnetism, QED. (The trio shared the Nobel Prize in physics in 1965.) Now theorists hoped to develop a similar model for the strong interaction.

The strong force did not yield its secrets easily, but by the early 1970s, the picture, greatly simplified, looked like this: Protons and neutrons and all the other hadrons—most of which hang around for the merest instant before they decay into other hadrons— are all made out of fractionally charged particles called quarks. The concept of quarks originated in 1964 with Caltech's Murray Gell-Mann (who named them after a nonsense word in *Finnegans Wake*) and, independently, George Zweig, then at the European Center for Nuclear Research, CERN.

Gell-Mann further proposed that

With its whimsical vocabulary and intimations of the ice-cream truck, construction paste, and primary colors, quark/gluon theory sounded like an outtake from Sesame Street.

quarks come in three different types or "flavors," which he dubbed "up," "down," and "strange." (Three more quarks would eventually join this roster—the existence of "charm," "truth," and "beauty" was experimentally confirmed in the '70s and '80s). Fractionally charged particles sounded looney, but in the right combinations they accounted for the overall makeup of every hadron. A proton, with +1 charge, is thus made up of 2 "up" quarks (each with an electric charge of +2/3) and one "down" quark (-1/3 charge); and the neutron, which has no charge, contains two "downs" and one "up." "Strange" particles, which Gell-Mann had characterized in the 1950s, contain at least one strange quark. The entire taxonomy of hadrons, a classification system of remarkable explanatory and predictive power that Gell-Mann and, independently, Yuval Ne'eman had proposed in 1961, and that Gell-Mann of course had named—he called it "The Eightfold Way"— could be built out of these quarks. (Gell-Mann won the 1969 Nobel Prize in physics for "his contributions and discoveries concerning the classification of elementary particles and their interactions.")

By analogy with QED, in which photons are the carriers of the electromagnetic field, particles called "gluons" carry the strong force, holding hadrons together as they shuttle from quark to quark. But quarks and gluons also possess a "color charge"—a quantum property that has nothing to do with Crayola products—and when quarks exchange gluons, they usually trade "color" (another Gell-Mann coinage) as well. This "color me beautiful" scheme stipulates color charges of blue, green, and red for quarks and gluons; and yellow, magenta, and cyan, respectively,

Continued on page 23 . . .

The Numbers Man and the Magic Kingdom

BY RHONDA HILLBERY

In 1955, C. V. Wood (Disneyland's construction manager), Walt Disney, and "Buzz" Price (from left) look over a model of Disney's plans to create a new type of family attraction in Southern California.

More than 50 years after the fact, Harrison "Buzz" Price '42 still remembers vividly his first meeting, in July 1953, with Walt Disney. From the start, the man behind the mouse was very specific about his vision for a new type of family attraction. "It sounded strange, unlike anything you would expect in an amusement park," recalls Price of the early Disneyland meetings. Disney described a Main Street USA entrance that would usher visitors to four themed meccas: Adventureland, Fantasyland, Frontierland, and the World of Tomorrow.

Although the animation icon knew what he wanted in Disneyland, he also wanted advice. Where should he build his theme park? How large should it be?

An architect friend referred him to the Stanford Research Institute, a nonprofit adjunct to the Stanford University Graduate School of Business. It happened that Price, who was working there as a research economist after earning his Stanford MBA, was plucked to conduct the pivotal location and feasibility studies for Disneyland. That trial-by-fire would mark the start of his 50-year career as a top consultant in the attractions business.

By Price's calculation, he ultimately worked on about 5,000 projects on five continents for Disney and other major clients, helping to pioneer research techniques that would shape the look and scale of the phenomenon that came to be known as the theme park. Along the way he developed a reputation as a guru in the field of what a former president of Knott's Berry Farm coined "roller coaster math."

Price describes his unorthodox career as a wild ride with plenty of bumps, long hours, and little continuity. One project was barely completed before it was on to the next one.

But it was also a blast. In all, Price conducted some 110 studies for Walt and Walt's brother, Roy, including some for Walt Disney World in Orlando and Tokyo Disneyland.

As one of Walt's leading consultants from their first meeting until Disney's death in 1966, Price had unusual access to the creative mogul who helped define family entertainment in the 20th century.

He also got to know other members of the Disney family well, including Walt's nephew, Roy Edward Disney, who today fondly remembers him as "an old friend, of both my family and of the Disney Company." Besides his multifaceted work for the Disney empire, Price worked extensively on the California Institute of the Arts, in Valencia, the visual and performing arts school whose development Walt championed, Roy says.

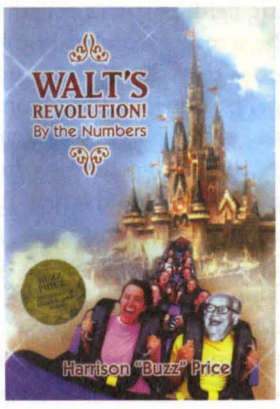
The research economist also worked for Disney's competitors, carrying out planning studies for SeaWorld San Diego, Universal Studios Hollywood, Six Flags Magic Mountain, Knott's Berry Farm, and numerous world's fairs. He even did a study for Caltech on a proposed visitor center at JPL. (It was never built.)

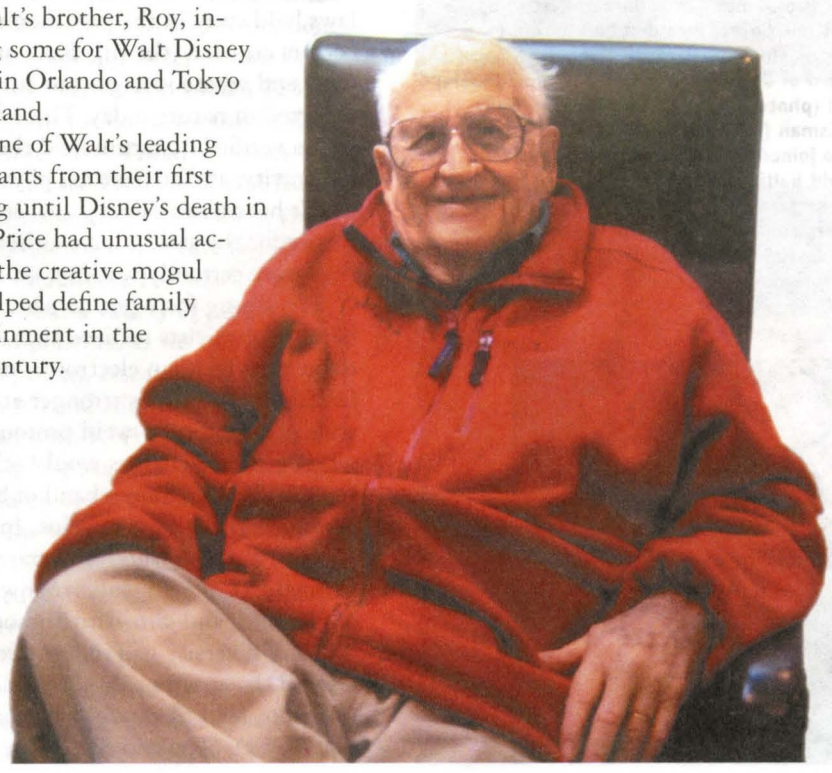
Now semiretired, Price lives in Palm Springs with his wife, Annie, whom he met while he was a Caltech undergraduate. As he reminisces in his home office, surrounded by framed posters, plaques, and awards honoring his lifetime of work, Price's stories spill over with the names of the rich, the powerful, the visionary, and the eccentric. He shares some of these anecdotes in a recently published book, *Walt's Revolution! By the Numbers*, part memoir, part insiders' guide to the economics-of-attractions business, which Roy Disney calls "a terrific tale of the last half-century."

The first recipient of the lifetime achievement award from the Themed Entertainment Association, Price also has earned kudos from the International Association of Amusement Parks and Attractions.

Price comes across as unpretentious and at times irreverent and acerbic, probably not the sort of guy who would fit in seamlessly at a corporation. It's not surprising to hear that he has worked nearly all of his professional life as an independent consultant, and never officially worked as a Disney employee.

He calls the whole theme-park business "inherently predictable. The activity takes place in a cosmos of large numbers surrounded by understood fixed constraints."





Harrison "Buzz" Price recently published *Walt's Revolution! By the Numbers*, part memoir, part insiders' guide to the economics-of-attractions business.

For him, the predictive power of mathematics has always been a big part of the attractions business's charm. Price says he has always loved numbers. As a kid, with compulsive persistence, he jotted down on record covers how many times he played each recording. As an adult, he noted how many ski runs he completed at Mammoth Mountain, and how many track laps he ran as a jogger.

Despite his knack for numbers, Price says he earned only mediocre grades in most courses at Caltech. One of his fondest memories of the place is the time he spent as president of a student club called the Musicale, which staged campus concerts and collected classical recordings. "We had 900 recordings from Carnegie Hall, and I played all of them in Dabney Hall at late hours when I should have been studying. It's a wonder I didn't flunk out."

Dabney's high ceilings provided perfect acoustics for Price's extracurricular activity. "It was a fantastic place and I had the key, and at one end of it there was a great big hi-fi. I've often told my friends I majored in Mozart."

He made up for his academic malaise at Stanford, where as a mature, focused student he finished at the top of his class.

A couple of years later, Price's developing expertise aligned perfectly with Disney's needs.

With his stable of cartoon characters, a bulging film treasury, and a growing fan base glued to that new family magnet, the TV, Walt saw Disneyland as an ideal avenue for expanding the Disney franchise. Always a perfectionist, Walt insisted that it be done right, and on a tight timetable. He wanted to pinpoint the 160 acres that would represent the best location for his dream park, and he wanted it done fast. Disneyland was to open within 24 months.

Price says that his work as a research economist involved plugging in the numbers: customer demographics, holiday and school vacation dates, daily spending estimates. The idea was to yield a park design able to accommodate the crush on peak days while sustaining profitability over the year's slowest days.

Within 12 weeks, Price had analyzed site locations in five Southern California counties: Los Angeles, Orange, Ventura, Riverside, and San Bernardino. Zeroing in on several spots, including Burbank, he examined population projections, future freeway construction, climate, and smog patterns, among other variables.

His population projections showed a rapid demographic shift toward Orange County within the next 10 years. The data converged on an area he called "the amoeba" for its irregular shape, which extended for five miles on either side of the Santa Ana Freeway. Based on Buzz's study, Walt and Roy ended up buying

Visitors flocked to Disneyland on opening day, July 17, 1955.

160 acres of orange groves there, in semirural Anaheim, for about $4,500 an acre.

"Well, we hit it right on the nose," Price is happy to say, backed by decades of tourist validation. "Dead center, that was the perfect place for it." Next came a feasibility study, informed by facts and figures about amusement parks across the United States and Europe.

The next several months passed quickly in a whirl of planning and construction. Rejecting as tacky the usual fare of Midway games, bellowing barkers, and rickety roller coasters, Walt insisted on customized rides and cosmetic perfection. Once Disneyland had been finalized down to the last detail of the Mad Tea Party's spinning teacups, the Jungle Cruise, and Space Station X-1, Walt, Roy, and Price presented the concept to four of the country's leading amusement-park owners at an annual convention and trade show.

This quartet of experts agreed: Disney's grand plans would flop. Without a Ferris wheel, Tunnel of Love, or carnie games, customers would leave with cash in their pockets. Custom rides were too expensive to produce and maintain. Sleeping Beauty's Castle was a dumb idea, with no revenue potential. Finally, they insisted, people won't notice fancy landscaping. They'll trample it.

In typical fashion, Disney brushed off the criticism. Having sunk $18 million into the park, plus the cost of land, he wasn't about to look back.

Disneyland's opening day, July 17, 1955, was a mess. "Not much worked," Price says. "It was hot. Thousands of people were milling about in confusion. I remember being stuck in a throng of immobilized people on the bridge to the Castle. We were mired in sticky asphalt." He stood almost face to face with a familiar-looking man cursing under his breath. "Hello, Mr. Sinatra," Price muttered weakly.

Of course, these inaugural wrinkles were soon ironed out. Within four years Disneyland was attracting 10 million visitors a year. "There was nothing like it in history," Price says. "It had the response of a World's Fair and it was continuous. It was Walt's Revolution."

A few years after Disneyland, Walt guaranteed Price enough steady work to set up his own firm, ERA (Economics Research Associates).

Although he insisted on being called "Walt" by nearly everyone, the company patriarch wasn't warm, Price says. "He was impersonal, but he was loyal and committed to his people. And I learned how to not be afraid of him and how to tell him exactly what I thought. And it worked out fine. "

In his long association with Walt, Price considered himself an outsider with keys to the kingdom. To his client's mind, the conventional company structure had drawbacks, Price says. "It was too controlling, too bureaucratic, too manipulating. He wanted a free independent voice." Disney seemed to think trusted outsiders would tell him the truth, instead of what they thought he wanted to hear.

And although Walt, as Price puts it, "got hooked on what I did for him," their relationship had its ups and downs. Price recalls one memorable occasion when he shared a flight on Disney's private plane listening as Walt and New York City master planner Robert Moses argued about transportation logistics at the upcoming 1964 New York World's Fair. Price says that as the Scotch flowed, the words flew too.

Without warning, Disney abruptly turned to Price, arched an eyebrow, and said, "You're too fat to fly on my airplane." The 215-pound, five-foot-nine Price tried to appear invisible for the rest of the flight. Afterward he immediately went on what might be called a '60s version of today's low-carb diet. "Oh, he stung my pride, and I'd have starved to death if necessary." Embarking on a "hamburger and martini diet," he lost 36 pounds in 12 weeks. (A few months later Walt complimented his consultant's new svelte self.)

After his theme-park mentor died in 1966, Price's relationship with the Magic Kingdom changed for good. "The king was dead, and I had been the right-hand man to the king. There was a new corporate generation. And it was to be expected. I still continued to work for them, but it was not like when Walt was there, when I was in the loop on everything he wanted to do

On Disneyland's opening day, "Not much worked. It was hot. Thousands of people were milling about in confusion." Price stood almost face to face with a familiar looking man cursing under his breath. "Hello, Mr. Sinatra," Price muttered weakly.

in the field of attractions."

As he reflects on the worldwide tourism bonanza that grew out of Disney's initial vision, Price muses that Disneyland might easily have been shelved, especially after the preopening drubbing it received from the industry experts. It went ahead because the Disney patriarch preferred to dwell on potential opportunities rather than on potential drawbacks. "From Walt I learned that 'no, because' is the language of a deal killer. 'Yes, if' is the approach of a deal maker. Creative people thrive on 'yes, if.'" Buzz says that brand of positive thinking guided him for the next 50 years as he took on other big, ambitious projects that had never been done before.

"Before Disneyland, attraction ventures were analyzed with a roll of the dice or designed on the back of an envelope. At the time, there was nobody else doing what we did. We developed an art form."

For information on Harrison Price's book, visit www.ripleys.com.

Buzz and Mickey Mouse share a special moment over a Themed Entertainment Association Lifetime Achievement Award.

Tender Land . . . from page 3

walk out, it should make them think about all the sounds around them that they never pay attention to."

As for Simons, who viewed the work at the opening reception, he says, "It's always interesting to see how people interpret your stuff. My 18-month-old daughter loved running through it and hearing the echoes."

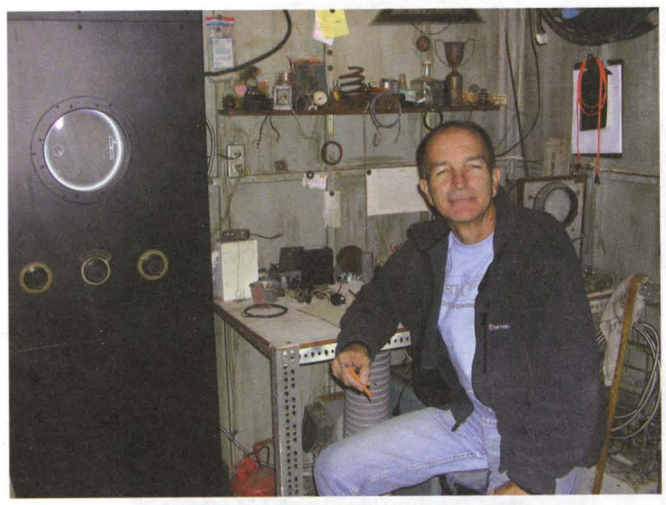
Finding Art in the Stars

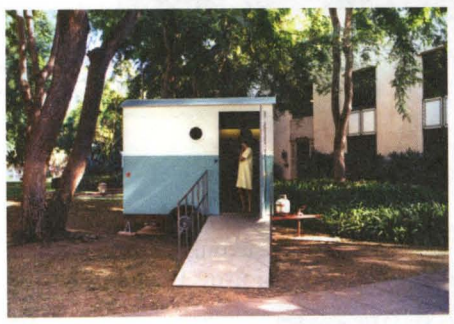
Back on campus, the landscape has been altered by two dramatically different sculptural installations created for the Tender Land festival by Los Angeles artists Lita Albuquerque and Michael McMillen. Both installations, selected by the Institute Art Committee and also curated by Nowlin, will remain in place until April 2005.

For Albuquerque, the festival offered an opportunity for a kind of homecoming. In 1973, her first exhibition as a professional artist was at Caltech's Baxter Art Gallery (which closed in 1985). Her current exhibit, called *Stellar Mapping I*, was partly inspired by astrophysics research carried out at Caltech.

Albuquerque is known internationally for making ephemeral outdoor artworks, including a 1996 project in the Egyptian desert in which she created a celestial map of the northern hemisphere out of blue pigment. Her Institute project draws on the work of the late Caltech physicist William Fowler, PhD '36, whose Nobel Prize–winning research showed that all the chemical elements, other than hydrogen and helium (and a bit of lithium), were generated by thermonuclear fusion inside stars. In her art installation located near Avery House, on the north side of campus, Albuquerque arranged 32 bell jars on a black concrete platform surrounded by a ring of glass chips, and placed red softball-sized spheres, crushed glass, chunks of dry blue pigment, and gold leaf under the jars. The jars are arranged in a pattern that roughly reflects the orientation of stars in the constellation Lupus, where a supernova occurred in the year 1006 to the amazement of observers in both Europe and Asia, who chronicled its appearance in the records of the day. Today, astronomers know that the heavy elements flung from exploding stars are crucial to the formation of new stars and planets.

"*Stellar Mapping I* is both a mapping in the sky of a historical supernova, and the sculptural interpretation of a fantasy lab researching supernovas," notes Albuquerque in a display text adjacent to the exhibit. The items in the bell jars are meant to symbolize "interstellar remnants found from the grand explosion of 1006."





Artist Michael McMillen (top photo) takes a break from his labors in *Dr. Crump's Inductive Geo-Imaging Mobile Laboratory (above)*, the art installation that resembles a strange mini-trailer, which he created on the Caltech campus as part of Pasadena's Tender Land festival.

Albuquerque, who has been on the graduate faculty at Art Center since 1987, says that her work increasingly concerns science, in particular physics. "Over the past 20 years, I've chased solar eclipses in Guatemala and visited observatories around the world, from South America to Hawaii to New Zealand. The Caltech project is about location, mapping, and identity."

The Artful Dr. Crump

The Caltech art installation by Michael McMillen also marks a return to the Institute. When he was a young sculptor in the 1970s, he helped create the artificial boulders in and around what is now Throop Site. (Most of these "pseudoliths" were subsequently replaced with authentic rocks from the San Gabriel mountains.) McMillen's Caltech project, *Dr. Crump's Inductive Geo-Imaging Mobile Laboratory (Field Unit 1)*, is located just a stone's throw from the Throop Site ponds between the Thomas and Guggenheim laboratories.

As one can tell from the title of McMillen's work, the artist makes room for humor in his art. For a 1981 work, *The Central Meridian*, which remains on view at the Los Angeles County Museum of Art, McMillen created what he described as a "walk-in assemblage," which has the cluttered look and musty smell of an old garage, taking visitors on a time journey far from the world of high art.

Dr. Crump's laboratory leads visitors on a different trip, albeit just as offbeat. The lab also doubles as a trailer, containing a lab bench, cabinets stuffed with quasi-scientific paraphernalia, diagrams, and photographs, and a television screen that runs a black and white film of an excavation. In a whimsical note accompanying the installation, McMillen writes, "An ancient rumor from Caltech's fascinating past has come to light with the announcement this past September of a remarkable discovery on the campus. Employing the unique services of an urban archeologist and one-time Caltech student, Dr. C. R. Crump, scientists were able to confirm the existence of a series of buried chambers from the early part of the twentieth century. The object in question is believed to be a subterranean laboratory, sealed and virtually forgotten for over 70 years. Using his proprietary technology and archival data, Dr. Crump was able to locate the position of the rumored facility and conduct preliminary explorations of the sealed interiors with remote sensors."

Dr. Crump's technology, says McMillen, is a kind of underground radar that can image what lies beneath the earth's surface. Over the next several months, visitors to the trailer will encounter an ever-evolving archive of artifacts from the good doctor's research. McMillen, who calls his artwork an homage to the "industrial, Art Deco look" of the Flash Gordon and Buck Rogers flicks he loved as a kid, says that he hopes that Dr. Crump's lab will take viewers out of the present to a different time and place.

Caltech students will have the opportunity to fraternize with Crump's creator over the next several months, since McMillen will serve as the Institute's artist in residence for the academic year. "I will be available to students if they have an art project that they want to pursue or an idea that they want to express visually or if they just want to talk," says McMillen, who adds that he originally planned to major in chemistry in college before deciding that he liked making art more. "I also hope to make work here that will have some significance.

"I'm excited to be here," says McMillen, whose campus digs are in the subbasement of the Moore Laboratory. "Caltech students are exceptional, and I like the challenge of working with students who are not trained in the visual arts but certainly have active minds. I'm sure they'll teach me a lot."

More information on the Tender Land festival can be found on the Web at www.tenderland.org.

Recognition. . . . from page 7

at the Shanghai Institute for Advanced Studies (administered by the University of Science and Technology of China), which took place July 30–31; the honor included the granting of an honorary professorship.

The 2004 Graduate Student Council (GSC) awards for outstanding teaching and mentoring have been awarded to ***Wilhelm Schlag***, professor of mathematics, for teaching; to ***Kip Thorne*** '62, Feynman Professor of Theoretical Physics, for mentoring; and to ***Francesco Ciucci***, a graduate student in mechanical engineering, for his work as a teaching assistant.

Joann Stock, professor of geology and geophysics, was chosen to be a fellow of the John Simon Guggenheim Memorial Foundation, which granted her $30,000 to perform research on "A Comparative Tectonic History of Two Rift Basins" during three months in Mexico. She has also been awarded a Fulbright grant to Japan for 2004–05. Created to promote mutual understanding between the people of Japan and the United States, the Japan Fulbright program will allow Stock to spend six months there, working in her field of marine geophysics.

Ed Stolper, Leonhard Professor of Geology, has been selected to receive the Arthur L. Day Medal, awarded "for outstanding contribution to geologic knowledge through the application of physics and chemistry to the solution of geologic problems." The medal was presented at the Geological Society of America Presidential Address and Awards Ceremony on November 6, during the GSA's 2004 annual meeting in Denver.

Alexander Varshavsky, Smits Professor of Cell Biology, has been named corecipient of the Protein Society's 2005 Stein and Moore Award. Presented annually, the award recognizes the "revolutionary work" of Varshavsky and Avram Hershko, Distinguished Professor at the Technion—Israel Institute of Technology, "in discovering the ubiquitin system of protein degradation, its mechanisms, and its significance to living cells."

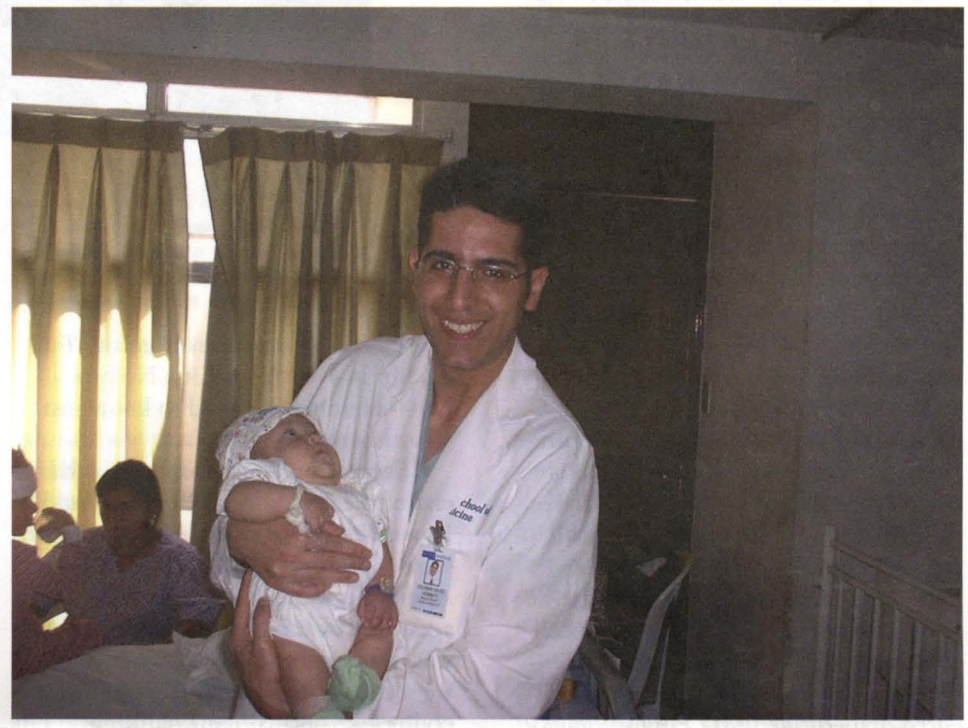
Theodore Yao-Tsu Wu, PhD '52, professor of engineering science, emeritus, was awarded the American Society of Civil Engineers' 2004 Theodore von Kármán Medal on June 15 at the annual Engineering Mechanics Division Conference. He also received the American Society of Mechanical Engineers' 2004 Lifetime Achievement Award on June 22 at the International Conference on Offshore Mechanics and Arctic Engineering.

Ahmed Zewail, Nobel laureate, Pauling Professor of Chemical Physics and professor of physics, and director of Caltech's NSF Laboratory for Molecular Sciences, received a doctor of science, honoris causa, from the University of Oxford on June 23, at the university's Encaenia Ceremony.

Doctors in the House

In partnership with the UCLA and USC medical schools, Caltech is training a select group of current and future MDs in the rigors of science

By Michael Rogers



Caltech MD/PhD student Houman Hemmati cradles one of the young Guatemalan patients he helped treat in 2002.

Visitors to Caltech occasionally ask if the Institute has a medical school. They are often told that not only does Caltech not have a medical school, but chances are it never will. The main reasons given include the enormous costs associated with treating patients and for medical training, political pressures that often accompany research on human beings, and the detour from fundamental research that could result from the creation of a medical school.

But while Caltech has no medical school, it does have med-school students. In 1997, the Institute began accepting MD students from UCLA and USC into its PhD programs. At about the same time, it began participating in a UCLA program called Specialty Training and Advanced Research (STAR), which enables physicians at UCLA who are training to become subspecialists, such as cardiologists or oncologists, to improve their scientific skills by going back to school to get their PhDs. So far, three STAR students have gotten their doctorates from Caltech, and this year two students from USC and three from UCLA became the first MD students in the programs to complete their PhD training here.

Altogether, 18 students are currently enrolled in the MD/PhD and STAR programs. Despite the small numbers involved, Caltech was interested in these ventures so that it could continue attracting some of the best graduate students in the world, says Paul Patterson, professor of biology and coordinator of Caltech's side of the MD/PhD and STAR programs. "The advantage for us," he says, "is that this is a pool of superstudents—many of the best undergraduate students interested in research." And with the onset of the Human Genome Project, stem-cell research, nanotechnology, and other cutting-edge disciplines, the programs have developed alongside students' growing interest in biomedical fields.

Patterson adds that the medical students bring a unique mix of training and experience to the Institute's graduate student population. Students in the MD/PhD programs spend their first two years in medical school before starting the PhD portion of their training, so they arrive at Caltech already primed with a partial medical education. "We think that they bring expertise that our students don't have in the areas of physiology and pharmacology, and a comprehensive knowledge of human diseases," he says.

STAR students—already doctors—have even more to offer. With their extensive medical backgrounds, they instantly become a resource for their Caltech colleagues. "You can be an excellent scientist, but sometimes you don't understand the impact that something can have on diseases," says Joy Frank, a UCLA professor of medicine and physiology and the director of UCLA's STAR program. Not only are STAR students learning advanced-level science at Caltech, but by interacting with faculty and students they are contributing their medical knowledge to Caltech research programs. "It's a two-way street," Frank says, with the physician/students absorbing information at Caltech and giving back to their fellow Institute investigators.

"I believe that a Caltech PhD degree is the perfect complement to an MD, giving the MD/PhD a very strong background to go on in research and teaching," says David Baltimore. "Not only can we provide a strong basic-science training for biomedical research, but with our engineering strength we can help physicians prepare themselves to contribute to advances in medical technology."

The medical students who enroll at Caltech typically join research programs that are either not offered at their home universities or are not strong there. "Caltech has strengths that are different from ours, such as computational neuroscience and organic chemistry," says Stanley Korenman, former director of the UCLA MD/PhD program. "There are imaging facilities at Caltech that we don't have," says Brian Henderson, a professor in the department of preventive medicine at USC, and the director of its MD/PhD program. "Investigations are so specific that there can never be duplications." If you're interested in medicine and "you want to have an academic career, you need to be an MD/PhD," Korenman points out. "It makes sense for clinical departments in research-oriented schools of medicine to seek out these MD/PhDs for their faculties because they are well grounded in both medicine and research."

Patterson says that, compared to the typical Caltech graduate student, most MD/PhD students are more interested in clinically related research, although at Caltech, that still leaves room for diversity. "They're spread all over here: applied math, engineering, biochemistry, and chemical engineering," says Patterson. "A lot are interested in biomedical engineering." They may work on mouse models of diseases, study vision in primates, or use yeast as a tool to investigate cancer.

While MD/PhD students are subject to the same requirements as other Caltech graduate students, Patterson says that they usually get their PhDs a bit faster, partly because they do two or three summer lab rotations before they start full time at Caltech, which helps them home in early on a research program. "MD/PhD students are also very efficient," he says. "They know that they've got years of medical training ahead of them and don't want to waste any time."

For the STAR students, who have often been out of school for a while, it can be quite an adjustment coming to Caltech. "The challenge for the STAR students is that they're already practicing physicians, and now they have to go back to being a student again after going through med school, internships, and residencies," Patterson says.

While many MD/PhD students see patients after they leave school, most pursue research programs. "The vast majority go on to do research," Patterson says. "Very few switch and do only clinical work, which is good because a lot of money is invested in their research training." Of those who do both, he says, "I don't know how they do it. Take the time constraints on the average faculty member at Caltech and add on administrative work and clinical work. The pressure of their schedules is enormous."

UCLA's Korenman says that a recent study reported that 62 percent of MD/PhDs end up as scientists in clinical departments, doing research 80 percent of the time. Most of the others do basic research, without clinical duties, in basic-science departments, in research institutes, or in industry. A relatively small number just become clinicians. All three avenues have value, he says, noting that "doctors with MD/PhD degrees are an important link between basic science and clinical medicine." Agrees USC's Henderson, "A lot of research still needs to be done by people who have an

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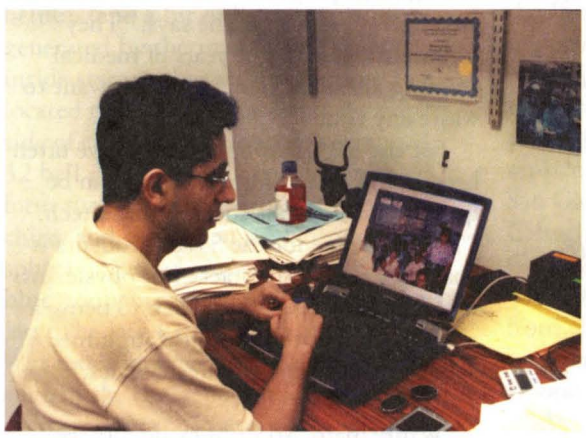
Science, Medicine, and a Gift of Gab

Whether it's in the lab, in the operating room, or on television, this Caltech MD/PhD student is getting favorable ratings

By Michael Rogers

Interviewing Houman Hemmati is not unlike being locked in a room with a stockbroker. Every other minute or so, the wall phone in his Caltech office rings. His cell phone sounds off periodically. And then his computer bleeps to life every 15 minutes as the e-mail messages pour in. With all these urgent communications, you'd assume he holds some type of high-powered position, but, in fact, he's just a student. One of a handful of Caltech's multitalented, hyperdriven MD/PhD students, to be sure, but nevertheless, a student.

At only 28 years old, Hemmati already has the poise of a seasoned neurosurgeon. It's true that to be an MD/PhD student, you have to be pretty self-assured. After all, it's hard enough to earn just one of those degrees. But how many students can walk out of an operating room into a live *Today Show* interview about a breaking news story and handle it like they've been fielding questions from the press for years?



Houman Hemmati (left) in his Caltech office looks at a photo (also shown above right) that he took in 2002, when he assisted an all-volunteer surgical team in Guatemala. The group of mothers gathered to thank the U.S. surgeons, nurses, and assistants for treating their children.

Hemmati found himself on national TV in August 2002, right after UCLA doctors had completed a 22-hour operation to separate one-year-old Guatemalan twin girls joined at the head. Hemmati, a medical student at UCLA, had been in the operating room as an observer, and after the operation he happened to walk outside with the lead surgeon, who was about to do an interview for the *Today Show*. But just before the interview began, the surgeon was called back into the operating room. Hemmati found himself alone, with the camera rolling, as cohost Matt Lauer fired off questions from the *Today* studios in New York City. No problem—Hemmati seemed to know just what to say.

"Everyone had goose bumps at the end of the procedure," Hemmati told Lauer. "People were cheering, people were clapping, people were crying." And then, warming to his subject, he added, "It was more than optimistic. It was overjoyed and we can't wait until we see these kids playing, laughing, crying like normal baby children."

Hemmati went on to do interviews that day with CNN, *Good Morning America*, and other programs. In later press reports about the operation, he was identified as a doctor on the case.

Meeting Hemmati, you can understand why someone, spotting him in hospital scrubs, might peg him as a high-powered MD. At six feet tall, with a ready smile and confident, articulate manner, he easily embodies the qualities that casting agents seem to look for when they need actors to play doctors on film and TV. Although he won't officially become an MD until at least 2006, Hemmati seems to have been preparing for that role since he was a kid.

Hemmati was three years old when his family fled Iran in 1979 during the Islamic revolution and settled in the Los Angeles suburb of Encino. Hemmati's father is a general surgeon, and when Houman was a teenager, he would often accompany his dad on weekend rounds at Northridge Hospital. Always interested in science, he worked part time for two years during high school in a biology lab at Occidental College. In 1993, Hemmati was accepted into Caltech, paid his deposit, and was planning to attend, when he received an acceptance letter from Stanford and changed his mind.

"I wanted to get a broader education as an undergrad," he recalls. "I spoke with Caltech's dean of admissions, and she made me promise that I'd come here for grad school. I figured I never would, since Caltech doesn't have a medical school and I wanted to be a doctor, but I promised anyway."

But while he was at Stanford, he says that he realized that just becoming an MD would never be enough. As an undergraduate, he assisted in the lab of biologist Irving Weissman, known for identifying and isolating blood-forming stem cells. Hemmati says that the experience with Weissman taught him that conducting research in a lab could be just as gratifying as working in an operating room.

After graduating, Hemmati says that he was burned out from his studies. His idea of a break was to get a job at UCLA, working for cancer researcher Owen Witte, who studies the relationship between stem cells and prostate cancer. In 1997, he was ready to resume his education. Still hooked on both medicine and research, he started the MD/PhD program at UCLA.

"There's very little opportunity to innovate as an MD," Hemmati says. "For obvious reasons, you can't experiment on your patients. I love to innovate and experiment and I need an outlet for that. Science lets me innovate in a productive way."

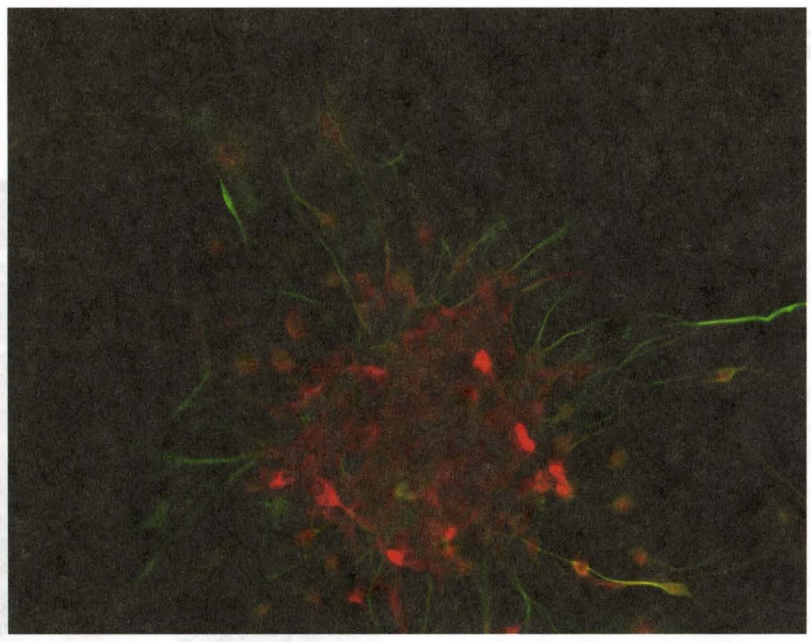
But he says that he quickly realized that he needed a smaller, more rigorous and individualized basic-science training environment. He applied to the nascent Caltech/UCLA program and was accepted in the fall of 1998, fulfilling his earlier half-hearted promise to return to the Institute. He started the PhD portion of his joint degree at Caltech in 1999.

Following his work with Weissman and Witte, Hemmati wanted to continue research into stem cells, which give rise in embryos to multiple specialized cell types that make up the heart, lungs, skin, and other tissues. More recently, as anyone who has followed the controversy over stem-cell research is aware, it has been found that in adults, embryonic stem cells can replace cells that are lost through injury, disease, or aging. Hemmati joined the lab of Marianne Bronner-Fraser, Ruddock Professor of Biology, who studies neural crest cells, a specialized form of stem cell that develops into a diverse range of cell types in vertebrate embryos.

"There's very little opportunity to innovate as an MD. For obvious reasons, you can't experiment on your patients."

But as a future doctor, Hemmati was also interested in studying the developing brains of humans. "I was studying stem cells in chickens and mice, and I really wanted to see human stem cells in neural development in action in real time," he says. "And the best way to do that is to observe the nervous system during neurosurgery on children, whose brains are still developing."

Hemmati says that unlike Caltech, where professors and graduate students



While it may resemble an exotic underwater creature, the object in the image above is a single neurosphere—a floating ball of cells—derived from neural stem cells. Houman Hemmati cultured the neurosphere from a common human pediatric brain turmor that he found contained a population of cancerous stem cells. The neurosphere has been stained with fluorescent antibodies against neurons (red) and glia (green).

freely interact and are often on a first-name basis, student–professor relationships at UCLA tend to be more formal, and he found it hard to connect with a UCLA investigator. But at some point during his first year at Caltech, he met fellow graduate student Kathy Sakamoto, who was already a doctor as well as an associate professor at UCLA (see accompanying article). When she heard that he was interested in studying developing human brains, she suggested that he meet with Jorge Lazareff, director of pediatric neurosurgery at UCLA.

His way eased by Sakamoto's introduction, Hemmati convinced Lazareff to let him observe some of his operations. A world-renowned surgeon, Lazareff conducts a wide range of operations on children, but Hemmati was particularly eager to observe the brain-tumor surgeries. After witnessing several operations, he began to notice that pediatric brain malignancies always seemed to appear in the midline of the brain, which is also the area where stem cells develop. In an adult brain, tumors can show up anywhere.

In June 2001, during an operation, Hemmati brought up the subject with Lazareff. "I said to him, 'Stem cells reside in the middle of the brain. Do you think there's a connection between stem cells and pediatric brain tumors?'

"Lazareff said, 'That's a good question. Someone should look into it.'"

In fact, says Lazareff, other researchers were already looking into it, or at least speculating about a possible connection between stem cells and pediatric brain tumors. Stem-cell research is a fairly new discipline, but links had already been made between some forms of cancer, including breast cancer, and stem cells. With the help of UCLA research technician Michael Masterman-Smith, Hemmati started a research program to investigate the source of the tumors. Lazareff agreed to provide specimens of children's tumors, with approval from patients' families; Hemmati and Masterman-Smith got a $30,000 seed grant from UCLA; and they hired UCLA undergraduates to do some of the basic work. Back at Caltech, Hemmati's PhD advisor, Bronner-Fraser, freed up Hemmati so that he could go off in his own direction.

"Discoveries often come from left field," says Bronner-Fraser. "I believe that if you give people independence, they'll find something unique. Students will devote themselves much more to something that they really want to do."

Hemmati says that he owes much to Bronner-Fraser's liberal outlook. "I'm grateful to Marianne for giving me the freedom and support to follow up on my intellectual initiatives. Her eagerness to let me explore my own interests scientifically is precisely why I chose to come to Caltech. People like Marianne are rare at any other institution."

Pediatric brain tumors are also quite rare, occurring in only three to five children per 100,000. Although other forms of cancer, like leukemia, are more common in children, brain cancer is more deadly. Treatment options include surgery, radiation, and chemotherapy, but these don't always work, and even successful outcomes have a high rate of serious side effects. "While two-thirds of children with brain tumors survive after five years, most of those children end up having psychological, physical, and developmental problems" due to the invasive nature of the treatments, Hemmati says.

It might seem surprising that stem cells could be related to tumors, since most of the recent publicity about them has trumpeted their potential therapeutic benefits. The explanation lies in the cells' innate plasticity. Stem cells have the ability to renew themselves and make undifferentiated cells, but they can also give rise to many highly differentiated cell types. Says Bronner-Fraser, "The hope is that you could use stem cells for curing different diseases where a particular cell type is missing." If Hemmati could show that stem cells are related to brain tumors, it would mean that neurosurgeons might consider getting rid of stem cells as well as tumor cells during surgery—a radical concept.

Other scientists studying this problem had hypothesized that regular neural stem cells can mutate into cancerous stem cells, which can then self-renew, producing more cancer stem cells and also giving rise to the different cells found in a pediatric brain tumor. Hemmati's team and a separate group of scientists from Canada were the first to show experimentally that there are transformed stem cells in brain tumors.

In the course of their investigation, Hemmati and his colleagues analyzed 20 tumors over two years. Using different analytical techniques, they were able to determine that the brain tumors contained a small yet significant fraction of cells that behaved like stem cells. "So now we had something from brain tumors that looked and acted like a stem cell, but what we really wanted was to show that stem cells associated with brain tumors can regenerate in a laboratory dish or in an animal a tumor that is nearly identical to the tumor excised from the child," Hemmati says.

Hemmati's team, including Masterman-Smith, UCLA professor Harley Kornblum, the UCLA undergraduates, and several graduate students and postdocs in the Bronner-Fraser lab, conducted a series of experiments showing that stem cells in the tumor differentiated into neurons and glia—the two main types of cells found in the brain—"in the same percentages," says Hemmati, "as found in the original tumor from which they were derived. In effect, they recapitulated their 'parental' tumor in a lab dish." They transplanted human tumor-derived stem cells into the brains of neonatal rats, and after one month they discovered that the cells had begun to migrate and differentiate, with the healthy stem cells producing healthy neurons and glia and the malignant cells giving rise to malignant neurons and glia. They also found that brain-tumor-derived stem cells had very high levels of a gene shown to mutate blood-forming bone marrow stem cells into leukemia stem cells, and that this gene was absent from the stem cells found in the brains of children who did not have leukemia.

"So we showed that neural stem cells have the potential to mutate into a cancer stem cell, eventually giving rise to a pediatric brain tumor," Hemmati says. "We showed that cancer-derived stem cells can self-renew more often than healthy stem cells. We showed that they can create something that resembles a tumor in vitro, and we have a proposed mechanism as to what might be changing a normal stem cell to a cancer stem cell."

Hemmati's research was published late last year in the peer-reviewed journal *Proceedings of the National Academy of Sciences*. In a Caltech lecture about the project held earlier this year, Bronner-Fraser said, "This study makes an important advance by demonstrating a previously unrecognized connection between stem cells and pediatric brain-tumor-derived cells. By viewing tumors as a type of [undifferentiated] cell gone awry, this opens up new possibilities for diagnosis and treatment."

Hemmati says that more work needs to be done to show that stem cells can recreate a growth as large as a tumor. "After that, we need to find the process that transforms normal stem cells to cancerous stem cells. What is it generally that causes it to be different? If we find the genetic difference we might be able to control it."

Hemmati had to reduce his involvement in the project when he returned this past summer to medical school at UCLA, where he has two more years to go before he gets his MD. "I'll be working 60 to 100 hours a week seeing patients. I'll be studying internal medicine, surgery, gynecology, psychology, and other areas."

While there's some frustration in giving up an active role in research just as it is generating results, Hemmati clearly relishes interacting with patients. At Caltech, he took two weeks off in March 2002 to accompany Lazareff and an all-volunteer surgical team to Guatemala to treat children with neurological diseases.

The group flew to Guatemala City, spent a day repairing surgical equipment in the hospital and cleaning the operating room, and then conducted more than 30 operations on children who had a variety of neurological disorders, including spina bifida and cerebral infections. Hemmati assisted Lazareff, doing tasks like handing over scalpels or putting in shunts.

In some cases, the patient's condition was so bad that the medical team could not operate. Since Hemmati was one of the few team members who spoke Spanish, he often had to break the bad news to the patients' families. "It was very emotional," he says. "The closest I had previously come to life-and-death situations was reading about them. Lazareff told me that without us, none of these children would have survived. You can't save the world but you can make a difference. If we can do that, that's worthwhile."

When their work was completed, the visiting doctors and assistants were called into a hospital ward, where the mothers had gathered with their children to thank them. "They were holding their kids for the first time after the operations," Hemmati says. "They broke into tears and then we broke into tears. And then we all hugged. It was beautiful. Some of them only spoke Indian dialects, but we understood that what they were saying was that while they couldn't pay us, God would thank us. I still get chills thinking of that."

While Hemmati's abundant self-confidence has not escaped his mentors' notice, they tend to approach it with wry humor. They also note that he

Continued on page 17. . .

From Patients to Proteins

A pediatric oncologist makes her already busy life even more hectic by going back to school to get a PhD at Caltech

By Michael Rogers

As she entered her early 40s, Kathy Sakamoto, PhD '04, was in the prime of her career. A pediatric oncologist at UCLA, Sakamoto was a tenured associate professor with her own lab, dedicated to research into leukemia. Between treating her young patients, pursuing her research, teaching, and handling administrative duties, she spent what little free time she had with her husband, a busy cardiologist. That's when she decided to get a PhD at Caltech.

It was 2000, and Caltech had recently joined UCLA's STAR (Specialty Training and Advanced Research) program, which gives MDs who want to focus on research the opportunity to return to school to develop their scientific skills and get their PhDs. Most doctors who sign up have just completed a medical residency program. It is rare for a seasoned physician like Sakamoto to go back to school.

"My peers here thought I was crazy," says Sakamoto during a recent interview in her office at the UCLA Mattel Children's Hospital. "A lot of them thought I couldn't do it. They'd say, 'Why do you have to do it? You already have so much on your plate.' Now that I have my doctorate and I'm writing PhD after my name, they're shocked. I'll show a title slide at a talk and they'll say, 'You actually got your degree?'"

Sakamoto's interest in science developed early, while she was growing up in El Sereno, a working-class suburb of Los Angeles less than 10 miles from Caltech. "I had an interest in science and medicine from watching medical shows on TV," she says. "But I didn't know what those professions were really about until I volunteered in a hospital in high school." Sakamoto excelled in science classes in school and received encouragement from her parents, who only had high-school educations.

Sakamoto went to Williams College in Massachusetts, graduating in 1979, and then spent a year as a technician in a genetics lab at the City of Hope in Duarte, east of Los Angeles. She attended the University of Cincinnati Medical School, where she met her future husband, and then went to Children's Hospital in Los Angeles in 1985 for a one-year internship, followed by a two-year residency in pediatrics, treating kids with a wide variety of illnesses. A rotation in pediatric oncology, in which she treated children with leukemia, sparked her interest in the field. She followed her residency with a three-year fellowship at Children's Hospital, specializing in hematology and oncology.

"When I saw kids with leukemia, I thought, 'That's why I decided to go into medicine,'" she says. "I love the intense relationship with the families—following the children over a long time and seeing how they do. Children have completely different kinds of tumors from adults. There are more molecular and genetic problems underlying the tumors in children. We're dealing with more interesting questions from a scientific point of view. The potential for research was phenomenal, so I thought it would be a good area to study."

In 1990, she became a postdoctoral research fellow in hematology and oncology at UCLA, working with the current director of the UCLA Jonsson Comprehensive Cancer Center, Judy Gasson. She focused on children with acute myeloid leukemia (AML), a frequently lethal form of the disease, with only a 50–60 percent survival rate. She began a project that she's still working on today, analyzing a protein that controls genes that are critical for cell growth and survival. Sakamoto found that the protein is overproduced in the bone-marrow cells of patients with acute leukemia but not in normal individuals. She also found that overproduction of the protein in AML patients is associated with an increased risk of relapse and poor survival.

Sakamoto became an assistant professor in pediatrics at UCLA in 1994, and four years later was named an associate professor. In 1999, she became eligible for a sabbatical and says that she wanted to learn something new. Since she didn't want to be away from her husband, Kenneth Sakamoto, a cardiologist in Torrance, she searched for a project within the Los Angeles area. She had attended a couple of talks by Caltech associate professor of biology Ray Deshaies—who uses biochemical techniques to investigate cell growth and function—and found his work interesting, so she called him up, and asked if she could work in his lab.

"Ray was interested in translating his research into a clinical area, and I'm interested in clinical work," Sakamoto says. "Some of his collaborators were developing a cancer therapy, and he wanted to transfer that to patients. I'd gain expertise, use my own knowledge, and translate that to patient care. To take what we learn in the lab and help patients—that's a dream."

Kathy Sakamoto (above) in her lab at UCLA's Mattel Children's Hospital, where she conducts research on leukemia. At right, she receives her PhD and congratulations from Caltech president David Baltimore at commencement last June.

Deshaies's idea was to use an enzyme called ubiquitin ligase (the first member of this large family of enzymes was cloned and characterized by Caltech colleague Alexander Varshavsky) and get it to attack a protein implicated in cancer. "It works like cutting timber," he says. "When you want to clear-cut the old growth in a forest, you mark the trees that you can cut with a ribbon. Ubiquitin is like the ribbon and the cancer-causing protein is like the old-growth trees in the forest. It would be a completely new way of making drugs." Deshaies had one major problem: despite the potential for a discovery with commercial applications, he couldn't find anyone in his lab interested in pursuing the project.

"Most of the people who come to my lab have a basic-research mindset, and this project was too applied for them," Deshaies says. "This would link basic research with the possibility of developing new drugs. I figured that Kathy, being a medical doctor, would be the ideal person to do it, and I knew if I didn't take her, it probably wouldn't get done."

The project also was a good fit because it was fairly narrowly focused. Deshaies knew that with Sakamoto's obligations at UCLA, she wouldn't have much time to do open-ended research. "Typically, when someone comes to my lab, the idea is less well-formed," he says. "So you do exploratory experiments. In her case, from day one, we had a good idea of the sequence of experiments. So the project did not stray from the original trajectory. Given the limits of her time, it had to be a project like this."

But six months would never be enough to complete the work, and as her sabbatical was ending in 2000, Sakamoto decided to stay on to get her PhD through the STAR program. She had wanted to get a doctorate earlier in her career at UCLA, but was advised at the time not to bother. "The logic back then was that I already had grants and was writing papers." But this time, "I thought that as long as I was going to be at Caltech, it was an opportunity that I couldn't pass up." It was an opportunity that would mean doing two jobs at once, since she'd have to continue her clinical work and research activities at UCLA, and then find time for her graduate studies at Caltech.

"I already had 10 years of lab experience, so I was able to pick things up," Sakamoto says. Although she stopped taking on new graduate students at UCLA, she admits that juggling the life of a student and a physician/professor was a challenge. After her sabbatical ended, she had to resume most of her UCLA obligations, including eight weeks of clinical duties each year. "I'd be at UCLA on Monday and Tuesday, and at Caltech the rest of the week and weekends. Sometimes I'd start an experiment at Caltech in the morning and come back to UCLA that afternoon to finish a different experiment. It took a toll on me physically."

Working in the Deshaies lab as a researcher, Sakamoto also had to learn new investigative techniques, which she mostly picked up from other graduate students, some of whom were roughly half her age. "That was humbling," admits Sakamoto. "I had to go to a lab where I knew nothing. I knew I'd have to start all over again and make mistakes. My peers were great."

Her fellow graduate students quickly discovered that Sakamoto was a fast learner. "I taught her a little yeast genetics, biochemistry, and cell biology," says Wenying Shou, PhD '01, a former Deshaies graduate student. "When she came she wanted to do mammalian biology. I told her that yeast is an excellent model system because it allows one to draw rigorous conclusions. So she decided to learn yeast biology in addition to carrying out her mammalian project. That was impressive. Here was a doctor and she was willing to make an investment to learn basic biology. She was a very good student and picked things up fast. Now, as I get older and mastering a new field becomes more taxing, Kathy has remained an inspiration for me."

For the first year, Sakamoto's research went well. Collaborating with colleagues at Yale, she was able to develop a molecule that would link a ubiquitin ligase to a cancer-causing protein, and thereby bring about the elimination of the cancer-causing protein. But when she attempted to make it work inside cancer cells, there were setbacks. "I spent a lot of time over the next two years troubleshooting," she says. "In science, many experiments fail. I started questioning whether I had made the right decision."

She started to talk about quitting, but her husband urged her to keep going. "She had invested quite a bit of time," says Kenneth Sakamoto. "It had been a little stressful, not seeing as much of each other. But to give up didn't make sense."

"If I commit to something, I like to see it through to the end," says Kathy Sakamoto. By the fall of 2002, she started getting promising results. "That's when I could see the light at the end of the tunnel."

Says Deshaies, "We showed it was feasible that you could effect specific elimination of a disease-causing protein by mobilizing the ubiquitin ligase to attack the protein. Now we have to come up with a drug like that which can penetrate into cells. We tested the idea and it seems like it has legitimacy. It would be a completely new way of making drugs. It would be huge."

Deshaies admits that while he initially had some reservations about having Sakamoto in his lab, since he knew she wouldn't be around as much as the typical graduate student, the arrangement ultimately worked very well. "The fact is, this woman is motivated, she's very organized, and she has good management skills that a 20-year-old doesn't have. She was quite productive for the amount of time she was in the lab. She came up with plenty of technical solutions to problems."

Deshaies says that her medical background was helpful to different degrees. "If you asked me if her medical knowledge assisted in the projects of other students, my answer would be that the impact was probably minimal, since my lab does not do clinical or translational research. On the other hand, if the question is whether people in my lab benefited from having an MD around who was likely to have a different viewpoint, then my answer is, of course, it is always beneficial to have different points of view in a creative environment." Deshaies says that Sakamoto's clinical contacts were also an asset. While she was earning her PhD, Sakamoto found the time to organize a seminar series at Caltech, bringing in some of the top medical researchers from UCLA to give talks.

"I think of all the sacrifice I've made," Sakamoto says. "Since I started at UCLA, it took 15 years to get here, but this is what I want to do. I couldn't think of doing anything else."

As for Sakamoto, she says that the Caltech experience opened up a new research direction, taught her new skills, and has enhanced her credibility as a scientific investigator. "It has really opened doors and given me opportunities that I didn't think would come up. For example, since I got the PhD, I received two NIH grants. Before it was more of a struggle."

Although Sakamoto still has lab space at Caltech and plans to continue her Institute project with a new NIH grant, most of her time is now spent back at UCLA, taking on new graduate students, trying to transfer what she learned at Caltech to her leukemia research, and seeing patients. "I want to do both clinical work and research. Obviously, what we're doing in cancer therapy is not always working. We need to generate better treatments. But if we didn't intervene, our patients would all die. At the least, we give them hope."

And for all the anguish she faces from seeing many of her young patients die, Sakamoto says that what she gets in return keeps her going. "It gives me motivation to see the kids. The kids whom I treat and see are extremely courageous. It's inspiring for me."

Sakamoto admits that treating children with cancer would burn her out if she were doing it all the time, and says that her research provides her with more than a buffer. "Research gives me an opportunity to think more broadly—in terms of helping a lot of people with cancer instead of just the one person I could help as a clinician. At the same time, keeping up the clinical work helps me ask the important questions that I can apply to research. In science, you never leave your work. You're always thinking of experiments or questions. Things come to you while driving to work or when you're in the shower. You're living and breathing your research. It's 24 hours a day.

"My goal is to do the best science possible and to continue seeing patients," she says. "The ultimate goal is to find a cure for cancer, but realistically, it's not that simple. There's no magic pill for cancer. Tumor cells can develop resistance to drugs. Every type of cancer is potentially different. It's very complicated. There's a lot to learn and a lot of questions that need to be answered.

"I think of all the sacrifice I've made," she says. "Since I started at UCLA, it took 15 years to get here, but this is what I want to do. I couldn't think of doing anything else."

Hemmati . . . from page 15

works hard. Says Lazareff, "Houman is an extremely valuable team player. He's also a great guy and a pleasure to be around. He has great enthusiasm and I sometimes have to remind him that he's just a medical student. If we let him loose, he will be in charge of the Guatemala economy."

Adds Bronner-Fraser, "He's very poised and has a special talent. I can definitely see him on the *Today Show* as a science specialist. His coadvisor at UCLA and I often joke that we'll be working for Houman some day."

Before he joins the talk-show circuit, Hemmati must decide about his future in medicine and science. "For a long time I focused on being a neurosurgeon," he says. "But that takes 60 to 80 hours of clinical work a week, leaving little time for research. There are other fields where you can do exciting clinical work and do high-quality science, such as neurology or retinal surgery.

"I like multitasking. I love talking to people and taking care of people. My ideal is to have a career in medicine, seeing patients for a certain amount of time, and to have a laboratory where I can try to answer some of the questions in clinical work that might otherwise go unanswered."

Doctors . . . from page 13

understanding of clinical diseases and are in a position to bring basic science from lab bench to bedside. A clinician is not trained enough in basic science to make that link." Nor, he might have added, is a scientist who is not trained in medicine.

After they get their PhD degrees, STAR students usually spend time as postdoctoral fellows before they go off and establish their own research programs. "Doing the PhD changes the way they approach science," says Frank. "In rigorous labs, like those at Caltech, you must constantly defend the ideas you're putting forth, whereas in medicine, you learn to live with the frustrations that things don't always work. Medicine isn't taught the same way as basic science, so most doctors haven't been exposed to that kind of critical thinking. We want the STAR students to have the best opportunities in the most critical labs."

For now, both Caltech and its medschool partners say they are pleased with the collaborations. "We're very happy with the programs and want to keep them going," says Patterson. "The ultimate test is what these students do in their future lives. If they get positions in leading medical schools and do world-class research, that will show that the programs were a success. We'll have to see what happens. Clearly there is a need. There's a tremendous pool of students who want to do this. But we don't have enough spaces."

Caltech's president David Baltimore, who is currently supervising an MD/PhD student and a STAR oncology fellow, concurs. "We have the capacity to train more students than we now take," he says, "but we would need to develop further financial resources to be able to train them."

Baltimore adds, "I believe that a Caltech PhD degree is the perfect complement to an MD, giving the MD/PhD a very strong background to go on in research and teaching. Not only can we provide a strong basic-science training for biomedical research, but with our engineering strength we can help physicians prepare themselves to contribute to advances in medical technology. MD/PhDs are particularly well-positioned to see the clinical relevance of scientific advances and to make special contributions if the focus of their work provides an opportunity to move science or technology in a clinically relevant direction."

Still a Techer after all these years

Before I became president of the Alumni Association, last year's president and his wife both warned my husband that being president would consume my life this year. I remember joking about that just two short months ago.

It wasn't a joke.

I've recently found myself musing about why I would spend a year so focused on a place where I spent just a short time so many years ago. The answer is that over the years, Caltech and my fellow alumni have become a part of my life, much more so than I could have imagined when I first showed up on campus in 1970.

Just last weekend I threw a small dinner party for two close friends. I got to know one of them when I arrived on campus for rotation and the other a few weeks later. A third of a century later, our shared experiences and interests still bind us together. We laugh at technical jokes and talk about surviving karate with Mr. Ohshima and recount stories of getting caught trespassing in Baxter when it was under construction. Our lives didn't stop after Caltech, of course. We've gone our separate ways and done many different things over the years, but whatever it was we had in common 34 years ago has led to the rich, enduring friendships we share.

I have many non-Tech friends and acquaintances, of course, both professionally and through the volunteer work that I do. When I meet fellow Techers, though, I often find in them a kindred spirit that I don't often find in acquaintances from other parts of my life. This is why I first started attending alumni events, and ultimately why I became involved in running the Alumni Association.

I haven't missed Seminar Day since that first time 15 years ago when someone twisted my arm and insisted I go. Thirty years ago when I was fresh out of school, going back for a day didn't appeal to me. Now Seminar Day makes me feel connected to the frontiers of science, despite the narrow focus of my workaday world. Once a nerd, always a nerd, I guess.

Of course, many Alumni Association events are primarily fun rather than educational. I was dumbfounded a few months ago when I offered to lead a hike at Coe State Park, where I volunteer, and 53 alumni showed up. I like hiking, and apparently a lot of my fellow alumni do too.

Then there are the career opportunities. Just being a Caltech alumna has been good for my career, but the Alumni Association is now focusing on specific initiatives to promote alumni career opportunities. A few months ago, we put up a jobs-posting page on the Association website, featuring jobs targeted specifically at Caltech alumni. In the near future you'll be hearing about other career resources and networking opportunities. Our career focus also encompasses students: We sponsor events for alumni to meet with students and tell them about their career fields. We also encourage alumni who have summer jobs to recruit students from Caltech.

Alumni Association president Stephanie Charles '73 meets the Institute's newest students at Freshman Camp.

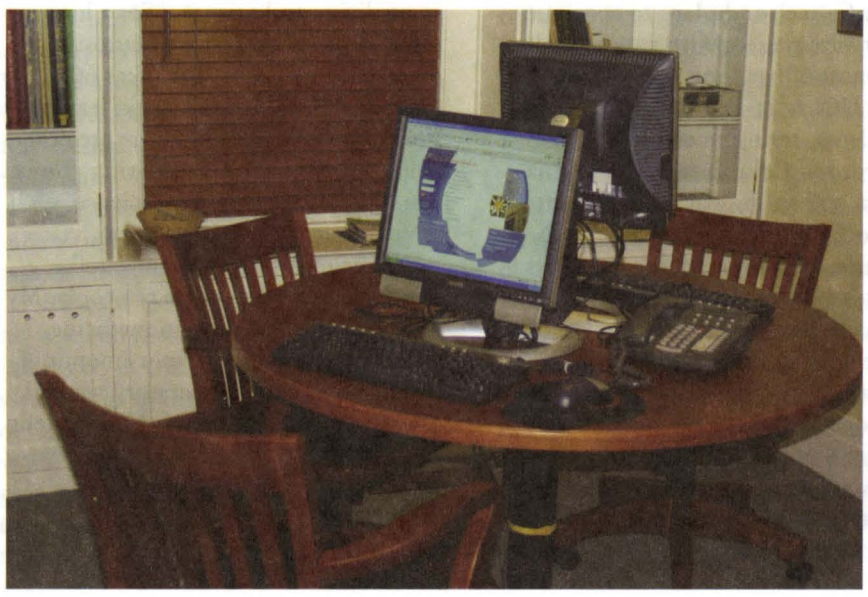
I can't pass up the opportunity to tell you about one career experience I had. As a consultant, I typically find jobs through personal contacts. However, a few years ago I got a contract due to the Caltech Honor Code. As the story reached me, the CEO of this local company never hired consultants because he figured they were scurrilous mercenaries out to rip him off. But he had a problem, and one of his engineers, a backpacking acquaintance of mine, mentioned me as a possible solution. It turned out that this CEO was a Caltech alumnus. He weighed my background (Caltech, Honor Code) against my profession (consultant, scurrilous mercenary) and evidently decided that it was worth giving me a chance. I subsequently got a whole series of contracts from this company, but I never would have gotten in the door except for Caltech.

Another Caltech involvement over the years has been serving as an undergraduate admissions representative. I enjoy talking to eager young high-school students setting out on life. I recently had the opportunity to go to Freshman Camp for the first time, since I transferred to Caltech as a sophomore the year that the Institute began admitting undergraduate women. It was truly inspirational to listen to the new freshmen talk about their dreams, take in some of their very impressive performances at an evening talent show, and see the boats that they constructed out of piles of junk for the design contest.

So why this long ramble down memory lane? Because in thinking about why I've chosen to be involved with the Institute over the years, I've gotten a better handle on what sort of alumni association best serves my interests. It is an association that offers social events, educational opportunities, and career networking, an alumni association that gives me opportunities to interact with alumni and students, an alumni association that helps me stay in touch with the campus.

But let me ask you: What sort of Alumni Association do you want? I've described my thoughts, but I'd be interested in yours. You can reach me at sjcharles@alumni.caltech.edu if you'd care to share your ideas with me.

Stephanie Charles



Save the Date!

Here is the schedule for the 2005 Alumni Reunion Events and Seminar Day.

May 13–15—*Chemistry & Chemical Engineering Division Reunion.* Contact Sallie Manson at 626/395-6091 or at SallieM@caltech.edu

May 19—*Reunions for the Classes of '35, '40, '45, '50, '55.*

May 20—*Half-Century Club Luncheon.*

May 20—*Reunions for the classes of '60, '65, '70, '75, '80, '85,'90, '95, '00, '04.*

May 21—*Alumni Association's 68th Annual Seminar Day.*

For more details, and updates on additional events in cities around the country, visit the CAA website at http://alumni.caltech.edu/.

Check out Alumni Career Connections

Whether you're looking for a new job, a way to boost your career to new levels, or an opportunity to hire fellow Caltech alumni, the Alumni Association Career Services website is the place to go. Check it out at http://alumni.caltech.edu/careers/. You'll find a wealth of resources to assist you, which include:

- Caltech Job Connection, a free online job-posting service for exclusive viewing by Caltech alumni;
- Links to current academic and staff positions available at Caltech;
- The Career Development Center (CDC) site, offering a full range of career-counseling, life-planning, and employment-related services;
- The Alumni Network, an online directory, where you can search for other Caltech grads with specific job experience and expertise;
- Access to Caltech eProNet, a free online recruiting and career management service;
- A link to the Southern California Higher Education Recruitment Consortium, an association of educational institutions promoting careers in higher education.

Take advantage of your Caltech connection! For more information, contact Karen Carlson at 626/395-6593 or karen@alumni.caltech.edu.

INTRODUCING THE BASCOM LIBRARY

The Caltech Alumni Association has a new benefit for Association members visiting campus: the Bascom Alumni Library (photo left) at the Caltech Alumni House. Named to honor a gift from the late John Bascom '32, it provides a convenient work area with amenities that include internet access, a phone for local calls, and a collection of Caltech memorabilia and publications. Use of the room is available on a first-come basis. Contact Minerva Smith at 626/395-6592 or e-mail minerva@alumni.caltech.edu.



Three members of the Caltech community who have contributed significantly to the quality of campus life were elected honorary members of the Alumni Association. The 2004 honorees, from left, are Gaylord "Nick" Nichols, director of Caltech's Industrial Relations Center; Ed Stolper, Leonhard Professor of Geology; and Tom Tombrello, chair of the Division of Physics, Mathematics and Astronomy, Kenan Professor and professor of physics, and Technology Assessment Officer.

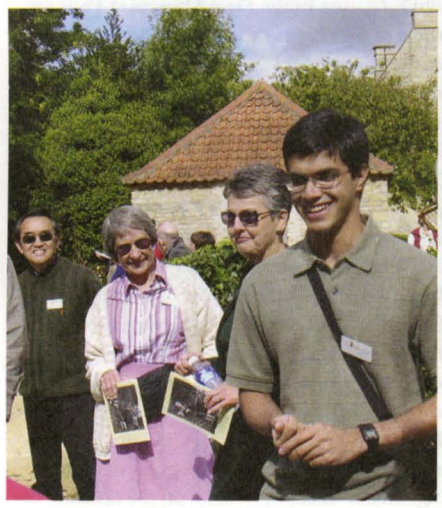
New alumni e-mail system goes live!

The Caltech Alumni Association is pleased to announce a new, improved system for alumni e-mail! It has faster support and less downtime, thanks to professional management and upgraded hardware for improved reliability. E-mail accounts are available as a benefit of Alumni Association membership.

If you are not already a member of the Alumni Association, please visit our membership site at http://alumni.caltech.edu/membership, or call 626/395-8364. If you are a member and would like to activate your account, please fill out the New Account Request Form located on our e-mail services page at http://alumni.caltech.edu/email_services. For questions, contact email@alumni.caltech.edu or call 626/395-8365.

TRAVELERS' TALES

Woolsthorpe Manor (right), the birthplace in 1643 of Isaac Newton, was among the many sites visited by Caltech alumni, family members, and friends during the Association's September travel/study program "From Newton to Crick: England and the History of Science," led by Caltech history professors Jed Buchwald and Diana Kormos-Buchwald. Participants included (left to right) Jackson Ito '63, Dot Nicholson, Janet Van Kirk, and Neil Tiwari '05, who accompanied the group thanks to a fund established by an anonymous donor to allow students to travel on Alumni Association and Associates educational tours. And this past summer, an alumni group traveled with geobiology professor Joe Kirschvink '75, MS '75, and two undergraduates to the Canadian Rockies. Their itinerary included an enjoyable morning visit to the Columbia Ice Field, where the participants took time out for a commemorative photo op (below).



Make a Name for Yourself!

The wait is almost over: a new edition of Caltech's *Alumni Directory* will be published in just a few months! This handy reference is filled with data on the whereabouts of your classmates, contact information for alumni in your area, and more. But you only have until February 15, 2005, to ensure that your listing is correct. So do that now—it's as easy as taking these steps:

One: Go to http://alumni.caltech.edu/network, log in, and fill out your online profile as completely as possible.

Two: Watch for an e-mail with instructions on how to confirm the information that will be published as your personal profile.

Three: If you don't have an e-mail address or Internet access, fill in the form below (print clearly!) and mail it to: Caltech Alumni Association, Attn: Alumni Directory, Mail Code 1-97, Pasadena, CA 91125. If you have questions, call 626/395-8365.

A print copy of the directory is available only to members of the Caltech Alumni Association. If you are a member, you must request a copy using the coupon below.

Alumni Directory Information Form

Name (include your name while a student if different)_____

_____

Caltech Degree(s) and Year(s)_____

Undergraduate House_____

Home (Street Address)_____

City, State/Province, Zip/Postal Code_____

Country, if other than U.S._____

Phone_____E-Mail_____

Job Title _____

Company_____

Street Address_____

City, State/Province, Zip/Postal Code_____

Country, if other than U.S._____

Phone _____E-Mail_____

Please use an asterisk (*) to indicate whether you prefer your home or company mail and e-mail addresses for contact purposes.

A print copy of the *Alumni Directory* is available only to members of the Caltech Alumni Association. If you're a CAA member, you must request a print copy. Would you like a copy? Yes_____ No _____

Become an Association member! For more information, visit http://alumni.caltech.edu/membership or call 626/395-8364. Remember, you must be a member of the Alumni Association to be eligible to request a copy, so don't miss out!

Alumni Notes

1948
Kenneth Hedberg, PhD, met his wife, Lise, in the fall of 1952 in Norway, when they were both working in the Chemical Institute of the University of Oslo and undertook a research problem of interest to both. They married in 1954, and in 1956 joined the faculty of Oregon State University, where they engaged in joint research, frequently collaborating with foreign scholars. Though they retired to emeritus status in 1987, they have maintained an active research program in the chemistry department. They have also spent time traveling and taking family vacations. They recently celebrated their 50th wedding anniversary during a three-day family get-together at the summer home of their son Erik and his wife, on Orcas Island in the San Juans. Attendees included their daughter, Katrina, her husband, and their four children, and Lise's cousin, Jan Dahl, and his wife, who traveled from Norway for the occasion.

Erdal Inönü, MS, PhD '52, a faculty member of Sabanci University, a member of the Feza Gürsey Institute, and an honorary member of the Turkish Academy of Sciences, has been awarded the Wigner Medal by the Group Theory and Fundamental Physics Foundation "for his outstanding contributions to mathematical physics through group theory." He is particularly known for his development, with E. P. Wigner, of the group-contraction concept, and for his work in the area of neutron-transport phenomena. The son of Mevhibe Inönü and Ismet Inönü, who served as the president of Turkey from 1939 to 1950, and educated at Ankara University before studying at Caltech, Inönü held positions as university president and faculty dean while serving as professor of theoretical physics at the Middle East Technical University in Turkey, a school he helped found. Starting in 1983, he became active in politics, and from 1991 to 1995 he served consecutively as minister of state, vice prime minister, and minister of foreign affairs. He has published his memoirs in two volumes.

1950
Philip J. Closmann, MS, was one of three persons awarded the 2004 IOR (Improved Oil Recovery) Pioneer Award by the Society of Petroleum Engineers in Tulsa, Oklahoma, in April. This award recognizes the development, application, and/or management of enhanced oil recovery. He was employed by the Shell Development Company for 33 years and was active in laboratory studies of steam injection, the simulation of steamfloods, and research and performance analysis of projects involving heavy oils and oil shale. After retiring, he consulted and taught courses in Thermal Recovery of Petroleum at the University of Houston and in Basic Steamflooding for the petroleum industry. Closmann is the author or coauthor of 27 publications and 32 U.S. patents. He and his wife, Madeline, live in Houston, Texas, and have six children and six grandchildren.

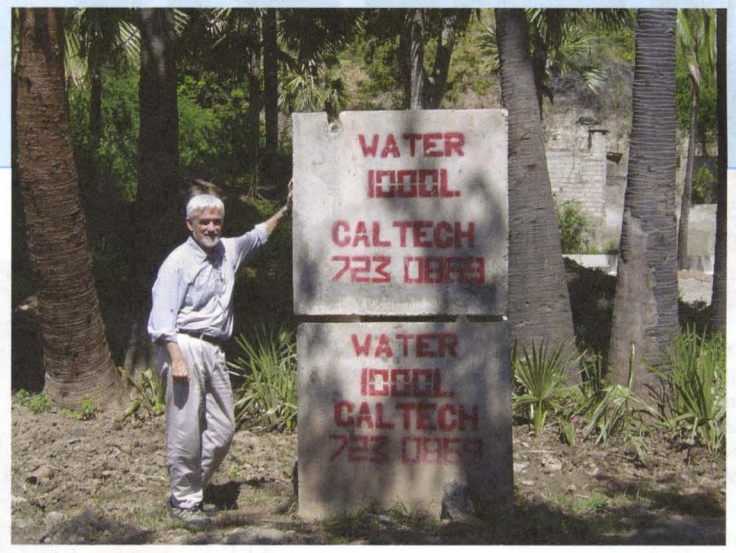
1952
Theodore Yao-Tsu Wu, professor of engineering science, emeritus, at Caltech, was awarded the American Society of Civil Engineers' 2004 Theodore von Kármán Medal on June 15 at the annual Engineering Mechanics Division Conference. He was cited for "his pioneering leadership and inspiring creative studies on fluid dynamics, forced nonlinear and dispersive waves, biofluid and environmental mechanics, hydrodynamic stability theory, and for his generous mentorship." He also received the American Society of Mechanical Engineers' 2004 Lifetime Achievement Award on June 22 at the International Conference on Offshore Mechanics and Arctic Engineering, "in recognition of his significant contributions to engineering mechanics." A fellow of the American Physical Society (APS), among other organizations, Wu's memberships include the National Academy of Engineering and the Academia Sinica, and he was the recipient of the APS's 1993 Fluid Dynamics Prize.

1954
Gordon E. Moore, PhD, chairman emeritus of Intel Corporation and of the Caltech Board of Trustees, has been named by the Society of Chemical Industry (America Section) as the winner of the 2004 Perkin Medal, which is considered the highest honor that the society bestows on an individual. A pioneer of the semiconductor industry, Moore is noted for his key role in the creation of the first integrated circuit at Fairchild Semiconductor, and the world's first microprocessor at Intel Corporation—companies that he cofounded in 1957 and 1968, respectively. He is also known for "Moore's Law," which predicted the exponential increase in the number of transistors that could be placed on a silicon chip. Currently director of Gilead Sciences Inc., a member of the National Academy of Engineering, and a fellow of the IEEE, Moore received the National Medal of Technology in 1990 and the Medal of Freedom in 2002. He was elected a foreign member of the Royal Society of Engineering in 2003.

1955
Ray Hefferlin, PhD, a physics professor at Southern Adventist University, writes: "I combined a lecture and consultation tour with a 50th anniversary trip with my wife, Inelda. The last leg of the trip, in Uzbekistan, was superbly interesting. I lectured at the Tashkent Chemical and Technology Institute." Earlier, he adds, he gave a week of lectures at the University of Pamplona, Colombia.

1957
Matthew Meselson, PhD, Cabot Professor of the Natural Sciences at Harvard University, has been selected by the Albert and Mary Lasker Foundation as the recipient of the 2004 Lasker Award for Special Achievement in Medical Science, "both for his scientific achievements in molecular biology and for his public-policy leadership aimed at eliminating chemical and biological weapons." Director of the Harvard Sussex Program on Chemical and Biological Weapons Limitation, Meselson is also a member of the board of directors of the Belfer Center for Science and International Affairs. The Lasker Awards are sometimes referred to as America's Nobels, because a number of recipients have gone on to win Nobel Prizes.

1963
Nicholas J. Turro, PhD, William P. Schweitzer Professor of Chemistry at Columbia University, is one of 12 New York scientists selected to receive Mayor's Awards for Excellence in Science and Technology, an annual program administered by the New York Academy of Sciences. The awards were presented October 13 by Mayor Michael R. Bloomberg, with Turro being corecipient (with Andrew Majda, professor of mathematics at the Courant Institute) of the award for mathematical, physical and engineering sciences. Turro was cited as "a pioneer in the research of photochemistry and spectroscopy."



On a visit to the new nation of Timor Lesté (East Timor), John Webb, PhD '72, whose Alumni Note appears below, found himself in oddly familiar territory.

1969
Charles Elachi, MS, PhD '71, Caltech vice president, director of the Jet Propulsion Laboratory, and professor of electrical engineering and planetary science, has received the NASA Outstanding Leadership Medal for "outstanding leadership of the Jet Propulsion Laboratory, whose legacy of excellence in planetary exploration continues with the awe-inspiring Spirit and Opportunity missions to Mars." A member of the National Academy of Engineering and a fellow of the IEEE and the American Institute of Aeronautics and Astronautics, Elachi is the recipient of numerous honors, including the Takeda Award, the Wernher von Braun Award, the UCLA Department of Earth and Space Science Distinguished Alumni Award, the Dryden Award, and the NASA Distinguished Service Medal.

1970
Thales M. Papazoglou, MS, a professor and the director of the Electric Power Systems Laboratory, Crete, writes that he and **Sebastien Candel**, PhD '72, met in the Latin Quarter of Paris for three or four hours over dinner and made a "tour of the horizon." He continues: "We had not met since the summer of 1977 (my late father was fighting acute leukemia at that time in a Paris hospital), and we had a lot to talk about. This time the occasion was the General Session of CIGRE in Paris, which I was attending." He adds that back in the late 1960s at Caltech, he and Candel were two of a trio, the third friend being **Charles Elachi**, PhD '71. "Since then, Sebastien and Charles met on several occasions, but I never had the chance to see Charles. So, during this dinner in Paris, Sebastien brought me up-to-date on our friend's personal news. I also told him that Charles and I are going to meet again, after so many years, next year in September in Cork, Ireland, on the occasion of the Universities Power Engineering Conference '05, where Charles is to be the keynote speaker—and undoubtedly he will be telling about the exciting adventures at Titan."

1972
Phoebe Dea, PhD, Fletcher Jones Professor of Chemistry at Occidental College, has been selected to receive the American Chemical Society's Award for Research at an Undergraduate Institution. The $5,000 award, which will be presented at the ACS national meeting in March, recognizes her "extraordinary contributions to the lives of students as their research mentor and to the advancement of undergraduate research nationwide." Dea, whose undergraduate students have made more than 100 presentations of their work at local, national, and international professional meetings, often publishes her own research findings with undergraduate coauthors. In 2000, the Occidental College board of trustees presented her with the Graham L. Sterling Award "for her dedication to teaching and undergraduate research." She has taught instrumental chemistry at Occidental since 1993.

John Webb, PhD, offers "a little piece of CAL TECH from an unlikely place." Both he and **Bob Kieckhefer** '74 have visited, "separately over the past few months, Timor Leste (East Timor), the newest (and quite poor) member of the international community of nations and close by my home, in Perth, Western Australia. Bob's son was working there for a while, and I am involved in a science education project with the National University of Timor Leste, developing a peer tutoring program whereby university students support science and math education in schools by tutoring in the classrooms and beyond. We each took a photo of a pair of concrete water tanks, stacked by the side of the road. They were near an incomplete building site (a not uncommon sight in Dili, being reconstructed after the chaos, destruction and bloodshed of 1999) and blazoned with CAL TECH in red paint. Bob enquired further with the help of **Tom Tisch** '61 to decipher the Tech connection back to some grads now based in India. My enquiries led only to the name of the owner, Senor De Caldas, as a possible source of the name. Whatever, it was a pleasure to see CAL TECH far from home, so to speak!"

1974
Tom Herman, director of IC technology development at International Rectifier Corporation, and **Alex Lidow** '75, the company's chief executive officer, have been inducted by the magazine *Electronic Design* into its Engineering Hall of Fame. The honor is "for their invention of the HEXFET(r) power MOSFET." According to Mark David, editor in chief of *Electronic Design*, "International Rectifier's invention of the HEXFET power MOSFET in 1978 not only advanced the state of the art in power semiconductors but also produced a fundamental change in power technology that advanced the ability of the semiconductor industry to manage power efficiently." Lidow received his PhD in applied physics from Stanford University, where he was a Hertz Foundation Fellow, and he joined International Rectifier in 1977. The holder of nine patents on power semiconductor technology, he has published numerous times on related subjects. He serves on the Caltech Board of Trustees. Herman also joined the company in 1977. He earned his MS in electrical engineering from Stanford, and he holds 20 patents on semiconductor and integrated circuit technology. *Electronic Design*, which was founded in 1952, is a trade magazine for electronics engineers and engineering managers.

1978
Joseph Katz, MS, PhD '82, Whiting School Mechanical Engineering Distinguished Professor at Johns Hopkins University, has been selected to receive the ASME Fluids Engineering Award. "Conferred upon an individual for outstanding contributions over a period of years to the engineering profession and, in particular, to the field of fluids engineering through research, practice or teaching," the award was presented last July at the 2004 ASME Heat Transfer/Flu-

ids Engineering Summer Meeting, in Charlotte, North Carolina. Katz, a resident of Baltimore, Maryland, joined Johns Hopkins in 1988. He cofounded the Center for Environmental and Applied Fluid Mechanics in 1996 and served as codirector until 2001. A fellow of the ASME, he has served as associate and then technical editor of the *Journal of Fluids Engineering* and has organized numerous symposia and forums. His publications include more than 65 peer-reviewed journal articles and over 100 conference proceedings, and he holds six patents. ASME was founded in 1880 as the American Society of Mechanical Engineers.

Ajit P. Yoganathan, PhD, writes that he has just completed 25 years of service on the faculty at Georgia Tech. He has served since 1997 in the School of Biomedical Engineering as the associate chair for graduate programs, which tied for second place in the latest *U.S. News & World Report* rankings of graduate biomedical-engineering programs. "A symposium was held in my honor on May 17, 2004," he adds, "to celebrate my contributions and achievements to Georgia Tech and the field of biomedical engineering." At the end of the symposium the dean of engineering announced that Yoganathan would be awarded the Wallace H. Coulter Distinguished Chair in Biomedical Engineering.

1979

Byrwec Ellison writes: "Leonard Slatkin conducted the BBC Symphony in the world premiere of his newly compiled edition of Mussorgsky's *Pictures at an Exhibition* on September 1 at London's Royal Albert Hall. His edition was unusual in that each movement of the piece was drawn from orchestrations by 15 different arrangers, including Maurice Ravel (whose version is the best known), Leopold Stokowsky, Vladimir Ashkenazy, Sir Henry Wood and others. I was honored that Mr. Slatkin, who unveiled the work on his 60th birthday, commenced with the Promenade No. 1 movement from my orchestrated version of *Pictures*—a deviant opening salvo in what turned out to be an intriguing showcase for the distinctive musical voices that followed. The London Proms performance was broadcast live on BBC Radio 3 and was well received by the audience in the hall. Mr. Slatkin will lead the U.S. premiere of the work in the season final concert of the National Symphony Orchestra at the Kennedy Center in Washington, D.C., on June 16–18, 2005."

1981

Carla J. Casewit, PhD, reports that her thriller, *Cold Logic*, has been published by Metropolis Ink. When she's not busy thinking up huge lies for her next novel, she serves as president of General Molecular Inc., a computational chemistry firm she cofounded with Anthony K. Rappé, PhD '81. "Tony has been appointed chairman of the chemistry department at Colorado State University. He continues to develop and use bleeding-edge theoretical methodologies to study nanomaterials and industrial catalytic processes."

1982

Brian Muirhead, MS, previously chief engineer on NASA's Mars Science Laboratory mission, has been named to the newly formed office of chief engineer at the Jet Propulsion Laboratory, where he has over 26 years of experience.

Continued on page 22 . . .

Tech Talk

Dear Editor,

In his article "The End of the Age of Oil" [Caltech News, 38, no. 2], David Goodstein discusses some of the research activities of the "Power the Planet Group" at Caltech. Has any consideration been given to the power of the "restless sea"? My 25 years (1941–66) in the Navy, working on carrier aviation, has shown me the power that exists there to lift huge tonnage with a fraction of the swell and wave energy available.

—Jean B. Stevens '40, Eng '47

David Goodstein is not the only author to warn the American people about the danger of our ever-increasing dependence on foreign oil. We face two interrelated problems. One is that the supply of all fossil fuels is finite. Technology can improve the economics of finding more fossil fuels, but on a longer timescale we must use something else. The second issue is the potential for global warming caused by CO_2 emissions from burning fossil fuels. Too many authors equate hydrocarbons with fossil fuels and see no way to avoid the greenhouse problem other than to stop using hydrocarbons. This is not true.

Burning hydrocarbons in our cars and electric power plants need not cause a greenhouse effect. The problem only occurs because we now burn fossil fuels. The world's fuel industry is 10,000 years behind the times, mired in a hunter-gatherer mentality. We no longer get our food by hunting mammoths or picking berries. The fuel industry needs to modernize.

Nobelist Melvin Calvin found a Brazilian rain forest shrub related to the rubber tree. It produces high-grade diesel fuel instead of rubber. Calvin correctly realized there was not enough rain forest land to grow commercial quantities of this plant. Using only selective breeding, he tried to adapt the plant to grow in the desert. His efforts failed, and the project died. Today's genetic engineering tools might bring his vision to reality. I propose that a genetically engineered fuel-plant can solve our energy crisis.

The fuel-plant eliminates any greenhouse gas problem. It consumes atmospheric CO_2 while it grows. The CO_2 emitted by burning its hydrocarbon merely regenerates the CO_2 it previously fixed. Over the course of a year there is no net CO_2 emission. It solves the energy storage problem without batteries or dams. Hydrocarbons store integrated solar energy in a very compact and easy-to-use form. It puts OPEC out of business. Why pay a cartel when you can grow your own?

Parts of the energy industry would change beyond recognition. Exploration and drilling for oil would disappear, as would coal mining. The tanker fleet would remain to harvest the individual fuel containers. Refineries would shrink. Tank trucks, gas stations, and cars could remain unchanged. Americans could drive guilt-free SUVs.

An essay describing these ideas in more detail is at http://alum.mit.edu/ne/whatmatters/200111.

The research to create an economically viable fuel-plant certainly involves risk. No single corporation can expect to retain all the benefits in this new field. A government project like the Human Genome effort might be the appropriate research vehicle. Sun-powered biology has to compete with physics and chemistry research, such as nuclear fission and fusion or clean coal. Political lobbying by entrenched interests should not direct long-range research away from potential gold-mines to protect previous investments.

Readers, help refine this proposal into one policy makers will implement. The long-range future of human society depends on it.

—Frank Weigert, PhD '68

I enjoyed David Goodstein's article, and I do plan to read his book. However, in one paragraph he writes: "To produce enough nuclear power to equal the power we currently get from fossil fuels, you would have to build 10,000 of the largest possible nuclear power plants. That's a huge, probably nonviable initiative, and at that burn rate, our known reserves of uranium would last only for 10 or 20 years."

Not so. If we used uranium only to produce plutonium in breeder reactors, we would have enough fuel for eons. Breeder reactors work by using the neutrons from uranium-235 (the uncommon isotope) to convert U-238 (the common isotope) into plutonium-239.

The main objections? Terrorism, accidents, and waste disposal.

Turning first to terrorism, while it is true that a breeder reactor produces the primary ingredient of a nuclear bomb, Pu-239, if the breeding process is continued, the heavier isotopes Pu-240, 241, and 242 are the results. With sufficient security around the breeder reactors, only these heavier isotopes would actually be transported to power plants. Unfortunately, these could still be used in so-called dirty bombs.

As for accidents, these do happen, but the public underestimates the human cost of coal-mining. It is something like comparing airplanes to automobiles: air travel is safer per mile, but an airplane crash is a horrendous event.

With regard to waste disposal, even in France, where a nuclear power plant is not only tolerated but welcomed by locals (because it brings good jobs), nobody wants the waste in their backyard.

These are strong arguments, but because of the lack of alternatives (not to mention the problem of greenhouse gases produced by burning fossil fuels), it is clear that nuclear power will produce most of our energy in the not-too-distant future.

—Christopher Dunn '93

Caltech News welcomes letters from readers, while reserving the right to select and edit them for publication. Send your correspondence to Editor, Caltech News, Caltech 1-71, Pasadena, CA 91125, or to hja@caltech.edu.

Alumni Notes . . . from page 21

The chief engineer will support both the associate director for flight projects and mission success, and the director of the Engineering and Science Directorate, and his responsibilities will include assuring engineering standards for JPL missions, chairing the new JPL engineering board, representing JPL to NASA's Office of Chief Engineers and Engineering and Safety Center, and overseeing the independent review process. He will also advise JPL's director and associate director on technical issues and the launch readiness of projects.

1986

Soo-Jong Rey, MS, PhD '88, a physics professor at Seoul National University, has been selected by the Alexander von Humboldt Foundation to receive a Humboldt Research Award. According to its website, the foundation "grants up to 100 Humboldt Research Awards annually to scientists and scholars from abroad with internationally recognized academic qualifications. The research award honours the academic achievements of the award winner's lifetime. Furthermore, award winners are invited to carry out research projects of their own choice in Germany in cooperation with colleagues for periods of between six months and one year." The award can amount to a maximum of 75,000 euros.

Samuel Wang, PhD, an assistant professor of molecular biology at Princeton University, has been named by the W. M. Keck Foundation as a recipient of a 2004 Distinguished Young Scholars in Medical Research grant. According to the foundation, "Under the program, each grant recipient's sponsoring institution receives an award of up to $1 million to support the scientist's research activities for a period of up to five years, as well as to enable the institution to purchase necessary equipment and resources to facilitate the scientist's ongoing study." Wang is studying the design and function of the cerebellum, specifically the neural circuits and how their design contributes to plasticity, or the brain's ability to learn and adapt to changes. "With a fundamental understanding of cerebellar function and dysfunction, he hopes to develop insights into movement disorders, such as those associated with autism."

1988

Bette Korber, PhD, a chemist in the theoretical biology and biophysics group at the Los Alamos National Laboratory, has been chosen by the U.S. Department of Energy as one of seven recipients of the 2004 E. O. Lawrence Award. She has been honored "for her studies delineating the genetic characteristics of the HIV virus and for her development of the Los Alamos HIV database, a foundation for HIV research for the scientific community," according to the Department of Energy's press release.

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Keep us informed so we can keep your fellow alums informed! If you're a Caltech graduate (BS, MS, Eng, or PhD) *Caltech News Alumni Notes* is the place to let us know what you've been doing. Send us news about you and your family, about a new job, promotion, awards, etc., that you'd like to see printed in *Caltech News.* All Personals submitted to *Caltech News* will also be posted quarterly on the Alumni Association's Online Notes website, unless the writer specifically requests otherwise. Please return this coupon and any additional materials to *Caltech News*, 1-71, Pasadena, CA 91125.

Name_____

Degree(s) and year(s)_____

Address_____

_____New address?_____

Day phone _____ E-mail_____

NEWS_____

1995

Mark Nelson writes that he received a PhD in chemical engineering from New Mexico State University in spring 2004. His dissertation research involved experiments related to nonlinear optics of metal-dielectric composite materials. He is currently working for Ball Aerospace & Technologies Corporation, in Albuquerque, as a senior applied-research engineer, performing experiments involving high-energy laser–materials interactions.

Steve O'Connor, PhD, was recognized as one of the 2002 TR100, the top 100 young innovators for that year worldwide as chosen by MIT's *Technology Review* magazine. O'Connor is currently chief executive officer of Nanostream, a Pasadena, California, biotech company he founded in 1999 that allows pharmaceutical companies to bring drugs to market faster. Prior to that he was chief scientist at Clinical Micro Sensors, another company he founded, which was acquired by Motorola for $300 million. He holds nine patents and is the author of 15 scientific articles.

1998

Melissa Sáenz, a postdoctoral scholar in biology at Caltech, and Christof Koch, Caltech's Troendle Professor of Cognitive and Behavioral Biology and professor of and executive officer for computation and neural systems, have been selected by the Mind Science Foundation to receive a 2004 Tom Slick Research Award in Consciousness. Named after the late entrepreneur, explorer, philanthropist, and author Tom Slick (1916–1962), the awards were initiated "to fulfill his vision of studying the mind as a means for improving the condition of humankind." Sáenz's current research interest is visual attention—how the visual system uses selective attention as one strategy for focusing its resources on the most relevant information. More details on her work can be found at her website, http://www.klab.caltech.edu/~saenz.

2002

Patrick Piccione, PhD, was chosen to participate in the National Academy of Engineering's 10th annual Symposium on U.S. Frontiers of Engineering, "in honor of his innovative applied research and technical work within the area of polymer science." The symposium, held September 9–11 at the academy's Arnold and Mabel Beckman Center, in Irvine, California, explored topics in multiscale modeling, designer materials, engineering for extreme environments, and engineering and entertainment. Piccione is a research chemical engineer working in the field of fuel-cell membranes at Atofina Chemicals' Research Center in King of Prussia, Pennsylvania.

1999 Notes

Matt Gregori

Matt Dawson writes, "After Caltech, I came back to the east coast to earn my Playa-Hata Degree. I lasted two years at MIT before being demoted to high school. Now I teach earth and space science to about 80 of the 1,400 ninth-graders in the city of Brockton (30 miles south of Boston). I live in East Boston with my fiancée, Jennifer Teece. We fell in love with Arizona in the summer of 2003 while I was working at the National Solar Observatory in Tucson, and we hope to get jobs and move out there (or vice versa) in the near future. When I'm not busy teaching science to kids, I'm either at home brewing beer or outside playing old-school baseball as it was in the 1860s."

Adrienne Bourque says, "I've basically been doing the same thing since graduation (except for those three months before I found a job, when I was a beach bum). I've turned into a fogey—work a lot, golf as much as possible, and in between I'm a regular at the golf course bar. Seriously, though, I found a great job in San Jose as a mechanical engineer, developing new and upgraded armored vehicles (okay, tanks). This past winter, I spent five months going back and forth to Spain, supporting a vehicle in a competition for the Spanish Army. (And all I learned to say in Spanish was, "Mas vino, por favor.") And then there was the smashing time we had at our five-year reunion—hopefully the Ath lets our class back in for our ten-year reunion!"

This in from **Gabe Miller**: "Well, I quit Duke's nerdobiology [sic] program recently and am working for the USDA—radio-tracking Mormon crickets in Colorado and Utah this summer. This fall I am moving to Oxford, UK, to study locust swarming as a zoology grad student. Life is good—I scared the living s*** out of my summer boss by jumping out of a bush in my gorilla costume."

Tom Collier is happy to announce that he married his high school sweetheart, Denise. They were blessed to welcome a daughter, Yoshimi, into the world in October 2003, and have moved up to Portland, Oregon, where Tom works for Oracle.

Ben Wu sends word that "I've been living in East Pasadena (Hastings Ranch area) for the past four years. I'm working as a design engineer for a government/military contractor in La Verne, California, and also working for my financial advising certification. I try to spend my weekends hiking all over the southwest and am in the midst of picking up rock climbing, but work intrudes more often than I like."

Dave Goulet is currently a PhD candidate at Caltech, where his thesis is focused on the mathematical modeling of coordinated cell fate and cell differentiation in the nematode *C. elegans*. In June, ASCIT selected him to receive an outstanding teaching award for his role as head TA of ACM 95; and he was selected to attend a three-week intensive study program at the Mathematical Biosciences Institute in August. Lately he's been reliving childhood at the roller rink, commenting that the only thing that's changed in 20 years about rental skates is that they have 20 more years of stink in them. He also recently won a stripping contest, giving him a career to fall back on should his research not bear fruit.

Rory McKenna writes, "I've been around Pasadena since I graduated, and have been working for Overture for the past couple of years. Well . . . . I started at GoTo.com, then it became Overture, and now we're part of Yahoo! When I've got spare time, I usually go hiking or go for a drive in the mountains either in a car, or on a motorcycle. Recently, I've also been learning how to surf, but the waves have not been kind. And, of course, I always enjoy trying new eateries, and finding sodas that I haven't tasted yet. I've also been traveling a bit (to Italy, Hawaii, India, hopefully the UK soon), have enjoyed it thoroughly, and soon hope to have the opportunity to travel more!"

Matt Vanderzee writes, "I am a big fan of grassroots political activism, and that is why this year I was working with the Internet's 2004 presidential campaign. Visit www.theinternet2004.com."

Eric Bogs reports, "I've flailed around in the dot-com economy for a bit and find myself in London, starting up a new gay youth magazine called *Qr*. Looking back at Tech through

rose-tinted glasses, I definitely miss my insane Lloydies and those damned fine parties."

Lisa Biswal writes, "I have just finished up my PhD in chemical engineering at Stanford. My thesis was about using micron-sized magnetic particles and placing them in microchannels to control fluids. I have now moved on to a postdoc at UC Berkeley, in collaboration with HP, developing a biosensor for protein calorimetry."

Nasim Afsarmanesh writes, "I just started residency in internal medicine at UC San Diego. With all the free time on my hands, I'm getting to enjoy the beautiful San Diego weather. Before that I was traveling for two months to Peru, Costa Rica, Belize, and the Virgin Islands. Life's been pretty good. Come visit me in SD (619/578-3532)."

Phyllis Chen reports, "In the past few months, I've quit my job, my boss gave me a severance kitten, I learned to ice skate, am now working part time at the Berkeley public library, and taking classes in apparel design."

Brian Collins has been bitten by the travel bug and spent August in Alaska, fishing and backpacking with the likes of Max Kullberg (Page '00), Tim Doyle (Page '98), and Dana Vukajlovich (Dabney '02).

Jason Briceño and **Mike Astle** are planning a trip around the world, and this time the revolution *will* be televised. You can monitor their activity on their web log http://headjobfilms.com/machandranath.com.

As your humble class agent, I, **Matt Gregori,** am proud to announce some advancement in my life and career. In July, I was promoted to the position of instrumentation engineer, handling all of Nanostream's nationwide customer and field support. I am traveling a lot in this new role, and it's allowed me to see the many wonders of America. I've walked the canals of Indianapolis, eaten Skyline chili in Cincinnati (it's sweet and served over spaghetti), and toured the Biosphere 2 facility (made famous by Pauly Shore). I was recently recommended by Governor Schwarzenegger for, and subsequently appointed to, my local Selective Service Board. I had a blast at the five-year reunion. I didn't know many of the people who attended, but I think I walked away from it (actually I sort of stumbled away from it) with some new friends. Of course, you can always keep up with my exploits at www.matthewgregori.com.

Politzer . . . from page 9

for their antimatter counterparts.) All observable hadrons, starting with the protons and neutrons, are "colorless"—composed of quarks whose colors cancel one another out. Although theorists originally came up with it to avoid a problem of having two or more quarks occupying the same quantum state, the extremely powerful, short-range color charge would gradually emerge as the defining property of the strong interaction.

With its whimsical vocabulary and intimations of the ice-cream truck, construction paste, and primary colors, quark/gluon theory sounded pleasingly like an outtake from *Sesame Street*. However, the mathematics was fraught with complications, and the real-world implications anything but clear. If quarks existed, experimental physicists wanted to know, why hadn't they surfaced with all the other rogue particles that had been pouring out of their cloud chambers and particle accelerators since the 1950s? What would a fractionally charged particle even *look* like, or, at least, how would it register its presence? Were quarks a concrete physical entity within protons and neutrons, or were they just an immensely useful mathematical device? At some point, Gell-Mann obtained a doctor's note purporting to state that these "philosophical" disputations were bad for his health.

Then, in the late 1960s, investigators at the Stanford Linear Accelerator Center (SLAC) began to see empirical evidence that protons might indeed have an internal structure. Firing electrons into protons at speeds approaching those of light, the experimenters were startled to observe many more electrons than predicted rocketing out of the collisions as if they had struck something hard inside the protons. It was Feynman, passing through from Caltech (where he and Gell-Mann had offices on the same floor), who suggested that these results were consistent with the idea that at the high energies equivalent to very short distances, a proton acts like it is made up of freely moving, point-like subparticles. Feynman was not inclined to call these objects quarks—yet. Instead he called them partons—Gell-Mann in some annoyance referred to them as "Dick's put-ons." Whatever the nomenclature, Feynman's insight posed a puzzle: if quarks were in some sense "real," how could the strong force be powerful enough to permanently confine them, yet weak enough to account for the SLAC experiments?

Enter asymptotic freedom, which a handful of theorists had by then put forward as the solution to the quark confinement riddle. The speculation centered on the so-called beta function, which basically relates to a coupling constant, which basically refers to how strongly objects interact. An asymptotically free theory would have a negative coupling constant, that is to say, a negative beta function, and would explain why, at short distances and high energies (same thing in this context) quarks acted almost like liberated particles, while at greater distances (corresponding in this case to the diameter of the proton) and lower energies, they became strongly, indeed eternally attached. But no one, including the theory's proponents, had offered a convincing formula for how a negative beta function might work, and most strong-force physicists dismissed the idea.

The scene now shifts to springtime at Harvard, where the curtain rises on David Politzer investigating the beta function as it applied to an aspect of electroweak theory. What happened next is described in *The Second Creation*, a lively account of the history of quantum physics (1986, Collier Books). "It comes out," he told the book's authors, Robert Crease and Charles Mann, "that it's totally useless for the purpose that I had in mind." Twenty-four hours had not passed, however, when it flashed across him that he had, in effect, been looking through the wrong end of the telescope. "Within the next sort of day it dawned on me" that his results were consistent with a negative beta function (that is to say, an asymptotically free model) for quarks.

Forces of Nature. Between them, Caltech's Murray Gell-Mann (left) and Richard Feynman dominated the landscape of post-war theoretical physics and laid much of the groundwork for the current work on unification.

Politzer got in touch with Coleman, who was spending the term at Princeton, and from here *Constructing Quarks* takes up the tale. "Hey, Sidney, this is stupendous!" exulted the student. Coleman wasn't so sure. It seemed that Coleman's Princeton colleague David Gross, and Gross's graduate student Frank Wilczek had just wrapped up a calculation that reached precisely the opposite conclusion—the type of field theory Politzer was looking at could not be asymptotically free.

It was spring break, so Politzer went to Maine, taking his own voluminous calculation with him. On vacation, he reviewed his work. "I came back," he told the *Second Creation* authors, "and said, 'Sidney, I got the same numbers.'" The news did not exactly come as a shock to Coleman. In the interim, Wilczek and Gross had discovered a sign error in their math. Once they made good their mistake, their results and Politzer's lined up. The twin solutions of different fathers were published back to back shortly afterward in the June 25, 1973, issue of *Physical Review Letters*. Politzer was 24. It was his first publication.

With asymptotic freedom established as key to quark confinement, the last major piece of the strong interaction puzzle fell into place. Physicists determined that the strong force that holds protons and neutrons together is in essence a subgenre of the more fundamental color force that binds quarks permanently into hadrons. Genies sealed in a quantum bottle, they conjure up the world.

Predictably, it was Gell-Mann who had the last word, or who at least took best advantage of the terrific naming opportunity that now presented itself. In homage to the color force at the heart of matter, he christened the strong-force model quantum chromodynamics, or QCD. Of course the name, quarklike, stuck.

As for the rest of us, what does it all mean? Well, as the Nobel Prize committee would comment: "Progress in particle physics or its relevance for our daily life can sometimes appear hard to grasp for anyone without a knowledge of physics. However, when analyzing an everyday phenomenon like a coin spinning on a table, its movements are in fact determined by the fundamental forces between the basic building blocks—protons, neutrons, electrons. In fact, about 80 percent of the coin's weight is due to movements and processes in the interior of the protons and neutrons—the interaction between quarks."

Convincing evidence that QCD is, so to speak, on the money, has been obtained during more than two decades' worth of particle accelerator experiments. QCD and QED now constitute two of the three pillars of the Standard Model, which also describes the weak nuclear force and ultimately seeks to unite all three, along with a quantum treatment of gravity, into the unified framework originally envisioned by Einstein. (A unified quantum theory that encompasses gravity does now exist in the form of superstring theory, which posits that nature consists of ten dimensions instead of the usual four—the remaining six are folded up into a kind of space-time origami—and the fundamental building blocks of matter are not after all quarks, or at least not merely quarks, but tiny vibrating strings.) In the meantime, physicists are hoping to experimentally verify more aspects of the Standard Model when the next generation of particle accelerators comes on line later this decade.

During an interview some years back, David Politzer was asked for his thoughts on how closely QCD, the Standard Model, and some of the more exotic theories just then coming up over the horizon, physically approximate anything that goes on "out there"—how close they come to describing what is generally thought of as reality. The question itself was not easy to frame, and the response was an expressive shrug. There is a remark attributed to Politzer that has apparently floated for a while through cyberspace: "English," it says, "is just what we use to fill in between the equations."

HEIDI ASPATURIAN

For more on Caltech's latest laureate, go to http://pr.caltech.edu/periodicals/CaltechNews/archive.html on the Web and click on the Archive link "Our Man on the Manhattan Project."

Obituaries

1924

Morris Goldsmith, of Los Angeles, on December 14, 2003; he was 101. An aeronautical engineer at Lockheed during World War II, he afterward worked on the structural engineering of many major L.A. structures, including the Hollywood Bowl and the City of Hope. On retiring, he was appointed by L.A. mayor Tom Bradley to the Los Angeles Building Commission. He is survived by his wife, Sarah; a son, Jerry; five grandchildren and a great-great-granddaughter; and two stepsons, David Naistat and Richard Naistat.

1929

L. Reed Brantley, MS, PhD '30, of Honolulu, on August 14, 2003; he was 96. He was professor of chemistry, emeritus, at the University of Hawaii and Occidental College. He is survived by his wife, Ruth; a stepdaughter, Edith McCafferty; and a grandson, Jacob McCafferty.

Donald Booth Milliken, of Rancho Santa Fe, California, on January 29, 2004; he was 94. After graduating from Caltech, he went on to receive an MBA from Stanford University. The founder and president of D. B. Milliken Company, he achieved worldwide renown for his application of high-speed cameras to space research, for which he received the George Goddard Award from the Society of Photographic Instrumentation Engineers. Teledyne acquired his company, and Milliken retired in 1970 to become a skilled gemologist who won many awards and whose collection of self-faceted gems was donated to the Gemological Institute of America in 2002. He is survived by his wife, Ruth.

1930

Emory Ellis, MS '32, PhD '34, of Santa Maria, California, on October 25, 2003; he was 97. While a research assistant at Caltech, he helped introduce Max Delbrück to bacteriophages as an area of research, and it was for his work with bacteriophages that Delbrück went on to win a Nobel Prize. During World War II, Ellis led the first group of scientists, engineers, and technicians sent by Caltech to China Lake to establish a rocket-testing center for the U.S. Navy. During his career he also served as director of planning for the Rheem Ordnance Laboratory Government Products Division and as a member of the Institute for Defense Analysis at the Pentagon. In 1970 Caltech named Ellis the recipient of a Distinguished Alumni Award in honor of his achievements in both rocketry and genetics. He is survived by a nephew, Bob Walsh, and by many friends.

1934

Edwin J. Core, of Portland, Oregon, on November 9, 2003; he was 91. A civil engineer, he was regional director of engineering for the U.S. Soil Conservation Service. He is survived by his wife, Margaret; a son, John; a daughter, Judith Core-Gondy; and five grandchildren and three great-grandchildren.

1935

James H. Jennison Sr., MS '36, of Encinitas, California, on March 19, 2004. During the first six years of his career, he worked for the California State Bridge Department. World War II brought him to Caltech as part of the group under Fred Lindvall that undertook building facilities at Morris Dam and improving the Mk-13 aircraft torpedo. Following the war, he joined the Naval Ordnance Test Station, where he was the structural engineer responsible for the design and construction of the variable-angle launcher, at the time the longest all-welded bridge span. He was awarded three prizes in international competition, sponsored by the Lincoln Arc Welding Foundation, for welded-bridge design. For over 33 years Jennison worked in research and development at naval laboratories, retiring in 1979 as head of the engineering department at the Naval Ocean Systems Center, San Diego. A life fellow of the American Society of Civil Engineers and a life member of the Structural Engineers Association, he was a registered civil and structural engineer who credited Caltech engineering professor R. R. Martel with inspiring a lifelong interest in earthquakes and structural engineering. Jennison is survived by Dorothy, his wife of 61 years, and by three children, eight grandchildren, and three great-grandchildren.

Chester W. Lindsay, on November 8, 2003, in West Covina, California; he was 90. He began his career as a food technologist with the Maui Pineapple Company, which triggered a lifelong attachment to the Hawaiian Islands. In 1946 he moved to Ontario, California, and joined the Orange Products Division of Sunkist Growers as production superintendent. He later served as the division's technical director and as head of quality assurance for overseas production. A former chairman of the Southern California Section of the Institute of Food Technologists, he remained active as a consultant after retiring. Eleanor, his wife of more than 25 years, died in 1978.

1937

George Y. Tsubota, MS '38, MS '39, on June 25, 2003.

1940

Robert A. Gewe, on August 11, 2003.

David Henry Steinmetz III, of Corona del Mar, California, on October 22, 2003; he was 85. Known as an engineer, investor, and art collector, he spent a year at Harvard Business School after graduating from Caltech, and worked as an engineer at Douglas Aircraft during World War II. In the early 1950s he inherited Standard Lumber Company, later United Lumber, serving as its president until his retirement in 1970. After retiring he became a stockbroker for Morgan Stanley Dean Witter. A passionate collector of contemporary art, Steinmetz served on the board of the former Newport Harbor Art Museum for many years and played a key role in fund-raising for the Orange County Museum of Art, and he was well-known for his generosity in loaning and donating to museums and exhibitions pieces from his personal collection. He is survived by his wife, Margarita; four children from his first marriage, Donald Steinmetz, Julia Breckenridge, Diane Wolfe, and George Steinmetz; and nine grandchildren.

1941

Louis S. Stivers, MS, of San Jose, California, on December 4, 2003; he was 87. During World War II he served with the National Advisory Committee for Aeronautics (NACA), the predecessor of NASA, and worked for several years at the Langley Research Center, in Virginia. In 1946 he transferred to what became the NASA Ames Research Center, at Moffet Field in California, where he remained until retiring in 1976. In retirement, Stivers enjoyed gardening and helping with various projects at the Campbell Church of Christ. He also played the organ, an expression of his lifelong interest in classical music. He is survived by his two sons, Richard and Douglas.

1942

Edward Rice "Ted" Bartlett Jr., MS '47, of Mansfield, Ohio, on December 8, 2003; he was 85. During World War II he served in the Pacific as a radar officer on board the cruiser USS *Springfield*, leaving active duty with the rank of lieutenant and remaining in the Naval Reserve until 1955. After the war he worked for Dupont and for Paul Edwards Consulting, and he retired in 1983 after 20 years with Empire-Detroit Steel. His community involvements included serving on the boards of Planned Parenthood and the YMCA and volunteering at MedCentral/Mansfield Hospital. He also taught at North Central Technical College and in the Ashland University program at the Mansfield Reformatory, was a member of the Mansfield Kiwanis Club and Hermits Club, and served in a variety of positions with the First Congregational Church, including as a member of its choir for 40 years. In addition, he loved skiing, sports, bridge, travel, and spending time with his family. He is survived by Helen, his wife of 54 years; two daughters, Susan and Margaret; two sons, Edward and Andrew; six grandchildren; and a brother, David.

1943

Bertram Arthur Nelson, MS, of Fort Collins, Colorado, on October 14, 2003; he was 85. As an Army officer during World War II, he served as a strategist and forecaster at various meteorological stations in Africa and Italy. After the war he went to work for the Great Western Sugar Company, first in Billings, Montana, and then in Fort Collins. Retiring after 38 years with Great Western, he remained active in his community, serving on the board of directors of several water-conservation projects, as a founding member of the Poudre Landmarks Foundations, and as a key player in the procurement and development of Sky Ranch and Sleepy Owl Ranch for the Lutheran Youth Ministry. Active in the Trinity Lutheran Church, he was also a supporter of Colorado State University, Poudre High School athletics, and the Republican Party. He founded and served as president of the Northern Colorado Chapter of the Friendship Force, and in the promotion of global goodwill he traveled to 18 countries, hosted dozens of families in return, and met with four U.S. presidents. Predeceased by his wife, Anne; a son, Craig; and his daughter, Carol, he is survived by his son Clark and by four grandchildren and two great-grandchildren.

1944

David Robert Appel, CAVU, of Longview, Texas, on October 14, 2003; he was 80. He was one of a group of students during World War II who received certification after completing an accelerated training program in meteorology, and who referred to themselves as Ceiling and Visibility Unlimited. A graduate of Purdue University, he served in the Army Air Forces during World War II. His professional career included management positions with FE&I Steel, in Pueblo, Colorado; the Blaw Knox Foundry, in East Chicago, Indiana; and Lone Star Steel and Conroe Pipe, in Texas. While in Colorado, he officiated football for the Rocky Mountain Football Association. Following his retirement from business, he engaged in international consulting in the tubular pipe industry. He was a member of the American Iron and Steel Institute and the American Petroleum Institution, as well as the Delta Tau Delta fraternity and the Pinecrest Country Club. He is survived by Dorothy, his wife of 53 years; a daughter, Julie Appel Parker; a son, Stephen; five grandchildren; a brother, Barry; and a sister, Elizabeth Horner.

Raymond A. Saplis, on January 12, 2004. He was pastor emeritus of St. Euphrasia Catholic Church, in Granada Hills, California.

George F. Smith, MS '48, PhD '52, on November 8, 2003; he was 81. A former director of the Hughes Research Laboratories and senior vice president of the Hughes Aircraft Company, Smith received a Caltech Distinguished Alumni Award in 1991. He earned his BS at Caltech as part of the Navy's V-12 program, in which he and a handful of other upperclassmen graduated four months early in order to receive their degrees before entering the service. Smith served in Washington, D.C., in a classified section developing code-breaking technology. After the war he joined the leader of his section in founding a company, Engineering Research Associates, where Smith conducted research into memory devices for digital computers. Returning to Caltech for his graduate work, he married his wife, Jean, in 1950, and was recruited to Hughes in 1952 by classmate **Ruben Mettler** '44, PhD '49. Smith first conducted research on the secondary emission properties of insulating powders and thin films, which led to the successful development of direct-view storage tubes and to Hughes establishing a new division to market the devices. This, plus pioneering laser range-finding experiments and other successes, propelled Smith into his upper-management career. He retired in 1987. A fellow of the Institute of Electrical and Electronics Engineers and the American Physical Society, he was a member of Sigma XI and Tau Beta Pi and served as a member of the Army Scientific Advisory Panel from 1975 to 1978. He published many technical papers and held six patents. He and his wife lived in Westchester, California, "raising three children (a doctor, a lawyer, and an electrical engineer) all of whom shared their parents' fondness for the outdoors, passed on in weeklong backpacking trips in the Sierras. And the Smiths kept hiking (with the Sierra Club) and biking well into their retirement." They joined the Caltech Associates in 1987, and Smith was named to the board in 1990, became vice president in 1992, and served as president for two years, 1993–94. He is survived by a daughter, Sharon; four grandchildren, and a brother, Donald.

1945

James H. Drake, MS '47, of San Pedro, California, on January 14, 2004; he was 79. A lieutenant commander in the U.S. Navy, Drake was an avid boater and a longtime member of the Cabrillo Beach Yacht Club. He was also a philanthropist toward higher-education causes. He is survived by his wife, Lyn; a son, David; two daughters, Judy Gale and Jennifer Zabatta; four grandchildren; and "his beloved cat, Captain Nemo."

Richard F. Neerken, on December 28, 2003. He is survived by his wife, Eleanor; a daughter, Nancy; and two sons, Fred and Thomas.

1946

Stanley William Kerkering, MS, Eng '46, of TidePointe, South Carolina, on October 22, 2003; he was 87. A 1939 graduate of the U.S. Naval Academy, he served in the Pacific during World War II, receiving a Purple Heart. A pilot and an aeronautical engineer, he retired from the Navy in 1959 and went to work for industry. Eventually he returned to the Department of Defense, where he became the project manager for the development of the F-18 Hornet. On his own time he was a watercolor artist and drew caricatures, and he enjoyed golf, bridge, and singing. Predeceased by a daughter,

Patricia; a brother, Richard; and a sister, Mary, he is survived by his wife, Anne; three daughters, Jane Reed, Dian Kerkering, and Becki Schreiber; a brother, John; a sister, Maureen Fisher; and five grandchildren and a great-grandson.

1947

Felix A. Kalinski Sr., MS, of Manchester, New Hampshire, on October 3, 2003; he was 82. A graduate of West Point, he also received a master's degree and a doctorate in international relations, from Georgetown University and the University of Madrid, respectively. He spoke six languages. He served during World War II as a B-17 pilot based in England, and remained in the military for 18 years, retiring as a full colonel in the Strategic Air Command following a tour as the air attaché to Spain. He was a recipient of the Distinguished Flying Cross, among other honors. Following his military career, he worked as an engineer and an executive for a variety of companies in fields ranging from architecture to aircraft to publishing, in both the United States and Europe. In 1975 he returned to Manchester, his place of birth, to start Baeder Kalinski International Group, which he continued with his son. He was a lifelong member of St. Hedwig Church and the St. Joseph Society of St. Hedwig Church. Predeceased in 1990 by Barbara, his wife of 45 years, he is survived by a son, Felix Jr.; three daughters, Nancy Kalinski, Carole Bubb, and Felisa Kalinski; six grandchildren and one great-grandson; and a brother, Alexander.

John Andrew Kelly, MS, of Oakland, California, on October 29, 2003; he was 76. A NASA research scientist, he also had a passion for sports, including boxing, bowling, sailing, and golf, but most particularly baseball, playing, coaching, and umpiring at all levels from little league to high school to college and professional. He devoted a great deal of time to the Mormon Church, and he enjoyed camping, fishing, and sailing with his family. Predeceased in 1979 by Gayle, his wife of 29 years, he is survived by a son, Russell; three daughters, Eileen Kelly, Janet Kelly, and Sharon Brown; and three grandchildren.

1948

Carl B. Cox, MS, on November 8, 2003, in Mount Vernon, Washington; he was 90. He worked for Boeing for 30 years, first in the aircraft division, where he participated in the design of the 707, then in the missile division, and finally in the aerospace division, where he specialized in orbit calculation. Those who knew him felt that he had an extraordinary gift for mentoring, tutoring, and encouragement. He is survived by two daughters, Carolyn Gregg and Elinor Robinson, and by four granddaughters and two great-grandchildren.

Jess, of San Francisco, on January 2, 2004; he was 80. Born Burgess Collins, he originally planned to become a scientist, and became involved in the Manhattan Project as a chemist after being drafted during World War II. After graduating from Caltech he went to work for the Hanford Atomic Energy Project in Washington State, but developed concerns about both the direction of science and the dangers of nuclear weaponry. He attended the California School of Fine Arts in San Francisco, and dropped his surname when he undertook a career as an artist. He was known for his "paste-ups"—large collages made from pieces of jigsaw puzzles, illustrations, and discarded engravings. His works have been exhibited nationwide, including at the Museum of Modern Art in New York City, the National Gallery of Art in Washington, and the Museum of Modern Art in San Francisco.

1949

William Emerson Lamb, Eng, of Annapolis, Maryland, on October 31, 2003; he was 87. A graduate of the U.S. Naval Academy, he served as a naval aviator in the Pacific during World War II, receiving the Navy Cross for extraordinary heroism in the Mariana Islands, and surviving being shot down in the Philippines, where he managed a water landing and spent several weeks with guerillas before being rescued by a U.S. submarine. During the Korean War he commanded a squadron and was credited with the first downing of a MiG. Later he served at the Armed Forces Staff College in Norfolk, Virginia; at the Bureau of Aeronautics in Washington, D.C.; and as a staff officer in Naples, Italy. During two tours at the Naval Academy he served as executive officer of the aviation department and commander of the department of engineering. After heading the Naval ROTC unit at Rensselaer Polytechnic Institute and serving for a year at the Department of Defense, he retired. He then taught mathematics for 13 years at Arundel Community College, eventually serving as department chairman. He is survived by his wife, Maureen; two sons, Bill Jr. and Peter; two daughters, Carol Hopkins and Maureen Weems; and 11 grandchildren and nine great-grandchildren.

Donald W. Peterson, of Albuquerque, New Mexico, on December 12, 2003; he was 78. A geologist and an expert in volcanoes, he worked for the U.S. Geological Survey and was for many years scientist in charge at volcano observatories in Hawaii and at Mount St. Helens. He earned his PhD from Stanford University, based on research in the Superstition Mountains of Arizona. An avid hiker and bird-watcher, he had a lifelong passion for the outdoors, and he was known as an enthusiastic member of the choir at St. Paul Lutheran Church. Predeceased by his youngest daughter, Susan Herring, he is survived by Betty, his wife of 55 years; two daughters, Karen and Kristine; five grandchildren; and a sister, Ruth Barker.

Robert A. Weatherup, Eng, of Portola Valley, California, on December 6, 2003; he was 86. A graduate of the U.S. Naval Academy, he served in the Navy for more than 20 years. He saw combat in the Pacific, receiving a Commendation Ribbon with Combat V (for valor) and a Purple Heart, and, after flight training on the East Coast, served as executive officer for a fighter squadron, receiving two Distinguished Flying Crosses, four Air Medals, and a Navy Unit Citation. During the Korean War he commanded an antisubmarine squadron, and he later served as operations officer for the aircraft carrier *Boxer*, captain of the icebreaker *Burton Island*, engineering representative to a manufacturer, and professor of naval science at MIT. After retiring in 1961 he worked as an aerospace engineer for Douglas Aircraft, McDonnell Douglas, and Lockheed, and was active in his church and community. Predeceased in 1997 by Kathryn, his wife of 54 years, he is survived by a daughter, Ann Gage; two sons, Roy and John; and six grandchildren and one great-grandchild.

William J. West, PhD, on December 14, 2003, in St. George, Utah; he was 83. After receiving his doctorate from Caltech, he worked for 10 years at Standard Oil's La Habra research facilities, and then for 37 years at Autonetics, North American Aviation, Rockwell International, and, finally Boeing Aircraft, as the companies merged. He worked on the Minuteman missile, the B-1 bomber, Polaris submarines, and avionics for the F-104 fighter jet. Active in the Mormon Church, he served in many positions over the years. He is survived by Helen, his wife of 61 years; three sons, Mike, Jeffrey, and David; two daughters, Natalie (Nedra) and Anne Jeanette; 15 grandchildren and three great-grandchildren; a brother, J. Robert; and a sister, June Christensen.

1951

Robert G. Adler, of Salt Lake City, Utah, on October 19, 2003; he was 74. After graduating from Caltech, he received his MS from USC and his PhD from UC Riverside. He served for two years in the Army Medical Corps, then taught chemistry and physics for three years at Mennonite-affiliated Bethel College in North Newton, Kansas. In 1972 he took a position as chemist with the U.S. Occupational Safety and Health Administration, in Salt Lake City. A member of various chemistry societies, he also enjoyed classical music and was church organist and a choir member. He is survived by Marilyn, his wife of 40 years; two sons, Charles and Paul; a daughter, Amelia Scott; and four grandchildren.

Donald W. Clarke, PhD, of Toronto, on April 16, 2004; he was 84. Before attending Caltech, he was a radar officer with the Royal Canadian Naval Reserve on convoy duty in the North Atlantic. After receiving his doctorate, he joined the physiology department at the University of Toronto, becoming acting chair, acting chair of the Banting and Best department of medical research, and associate dean of medicine. Active on the boards of a number of community organizations, he was elected to his local board of education. Following his retirement he continued his lifelong interests in "ham" radio and in soaring, rising as high as 30,000 feet over Pike's Peak, Colorado. His interest in traveling took him to all seven continents, including a Caltech alumni voyage to the Antarctic. He is survived by Patricia, his wife of 53 years; two sons, Hugh and Donald; a daughter, Catherine; and a granddaughter.

Bruce B. Hedrick, of Costa Mesa, California, on May 11, 2004; he was 77. Active in Caltech student affairs, he had a fine voice and was a prominent member of the Dabney House quartet. "Caltech baseball was at its best when Bruce roamed the outfield and his brother, Lang, pitched." He worked at ITT Cannon in 1962 with fellow Caltech graduate **Carlos Beeck** '49, then moved on to Hughes Aircraft, where he worked in electronics, and then in the late '60s worked in building design and construction with another fellow Caltecher, **Hugh Carter** '49, at Carter Engineers. In the '70s he worked for Pactel Mobile. Continuing his interest in electronics and construction, he concluded his career in Orange County's construction department for electronics and signals. Upon retiring in 1997, he contributed to his community as a nearly full-time volunteer to the Costa Mesa Police Department. He is survived by his wife, Bobbie; a son, Bruce; two daughters, Nancy and Susan; two grandchildren and a great-grandchild; his brother, **Langdon C.** '47; and two sisters, Shirley Lutz and Patricia Henderson.

John W. Morrison, of San Bernardino, California, on April 15, 2002; he was 72. After graduating from Caltech, he worked for Litanium Metals Corporation of America as an industrial and project engineer, responsible for the development, implementation, design, and installation of plant equipment in Henderson, Nevada. Returning to California, he became a sales engineer for Reliable Bearing Company, responsible for the sale and service of power-transmission equipment; he served as technical liaison as well. As president, general manager, and part owner of Highland Machinery for 17 years, he handled steel-fabrication of his own design or to client specifications for heavy industry. He worked most recently for his own engineering company, Macro, and in sales of bulk material systems. He was a life member of the Caltech Alumni Association, and his special interests were model railroading, photography, golf, and using the CAD system. He is survived by his wife, Dorothy; two sons, John and Charles; and a brother, James.

Charles T. Paulson, of Jacksonville, Florida, on November 6, 2003; he was 76.

1952

Harold James Woody, of Oceanside, California, on October 10, 2003; he was 73. He served with the U.S. Coast and Geodetic Survey in the Aleutian Islands before going to work for the California State Division of Highways. After passing the California Structural Engineering exam, he went to work for Hillman & Nowell, Holmes & Narver, Parsons Corporation, and John Case & Associates. As chair of the Steel Code Committee of the Structural Engineers Association, he carried out studies of structural failures in Anchorage after the 1964 earthquake and at the Olive View Sanitarium after the 1971 earthquake. He gave his talk "Earthquakes—Which Way to Run" frequently to civic groups. Starting his own firm, Hal Woody Associates, he worked on buildings in Walt Disney World and on a five-story wing for Children's Hospital in Los Angeles. After his two associates retired, Woody became a principal at Building Forensics, where he was in high demand as an expert witness. About this time he moved to Big Bear, learned to fly, bought an airplane, and commuted to work by air. When he retired he sold the airplane, gave away his engineering tools and books, and moved to Oceanside. A skilled water and snow skier, he crewed in several Ensenada sailboat races. He enjoyed fishing and backpacking, and he was very involved in Indian Guides and Scouting with his sons. He is survived by his first wife, Jean; their three sons; and six grandchildren. His second wife, Lori, lives in Oceanside.

1953

Robert Houston Alexander, MS, of Boulder, Colorado, on October 23, 2003; he was 76. He went on to earn a PhD in geography from the University of Washington. He worked as an engineer for Shell Oil from 1954 to 1957, as a geographer for the U.S. Office of Naval Research from 1960 to 1972, and as a research geographer for the U.S. Geological Survey from 1972 to 1994. His memberships included the American Association of Geographers, Urisa, the First Presbyterian Church in Boulder, and PLAN–Boulder County, and he was active in Eco-Cycle and the Institute of Behavioral Science at the University of Colorado. He is survived by a daughter, Maura Engel; his former wife; and three granddaughters.

Richard Jaffe, on June 2, 2003. **Leon Vickman** '53 writes: "Richard Jaffe transferred to Caltech from MIT, joining the class of '53, the physics majors, and the Dabney Student House ranks. His jazz piano playing brightened up the house lounge, he did off-campus piano gigs, and even wrote some music for a short very-experimental student movie. He sported a heavy Boston accent, a sharp wit, and even looked and

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Obituaries . . . from page 25

sounded and acted a bit like the other Richard . . . Feynman. Our Richard was a Caltech cheerleader, a guy in search of the 'ideal woman,' and the author of two books on Fortran. He did the aerospace corridor after graduation, from Hughes Aircraft to solo consulting. He found true but brief love with an Irish lass who lived near Tech on Allen. He married another, and lived in Aptos (Northern California), where he had a son. On returning to Southern California he continued his piano, played financial markets, and found a soul mate. Richard was always ready to help a friend, eager to engage in deep discussions (including Far Eastern philosophies), and brought an electric charge to every personal encounter. He even did a bit of marriage turnaround work for a classmate . . . effectively and gratis."

1955
William J. Creighton Jr., MS '56, of Costa Mesa, California, on January 13, 2004; he was 70. He is survived by his wife, Pamela; two daughters, La Vae Peysak and Maureen Ball; and three grandchildren.

1961
William Kenji Tabata, MS, of Cambridge, New York, on November 5, 2003; he was 67. He worked for NASA for 43 years. One of his projects brought him to Latham, New York, and he discovered the Battenkill River, which is famous for fly fishing. When he retired from NASA in 1998 he moved to Cambridge specifically to be near the Battenkill, where he then spent five years indulging his passion for fly fishing. Predeceased by a brother, George, he is survived by his wife, Barbara; two sons, David and James; and two grandchildren.

1966
M. Olayide Adegbola, MS, PhD '71, of Lagos, Nigeria, on July 30, 2002; he was 61. He is survived by his wife, Anike; four sons, Gboyega, Femi, Yinka, and Tunde; and a granddaughter.

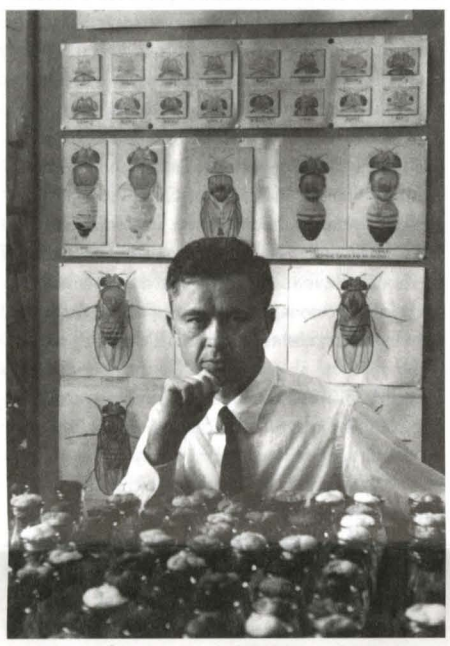
1973
Stephen L. Ryland, MS, of Los Angeles, on February 15, 2004; he was 54. A Pasadena resident for 33 years and a longtime member of the Prospectors' Club of Southern California, he worked as a consulting geologist/seismologist and owned Cal-Gold/Pasadena Map Company. He is survived by his wife, Rose, and by a daughter, Amanda.

1978
Robert E. Sheridan, PhD, of Catonsville, Maryland, on February 7, 2004. He is survived by his wife, Susan; a son, Brendan; a daughter, Ariadne; and many friends at the United States Army Medical Research Institute of Chemical Defense.

Edward Lewis, 1918–2004

Edward Lewis, PhD '42, winner of the 1995 Nobel for his groundbreaking studies of how genes regulate the embryonic development of organisms ranging from flies to humans, died July 21 in Pasadena after a long battle with cancer. He was 86.

A Caltech faculty member since 1946, Lewis spent his life working on the genetics of the drosophila fly, more



Fifty fruitful years: Above, Ed Lewis in the midst of his drosophila research in his Caltech lab in the 1950s and, at right, receiving the Nobel Prize from the King of Sweden in 1995.

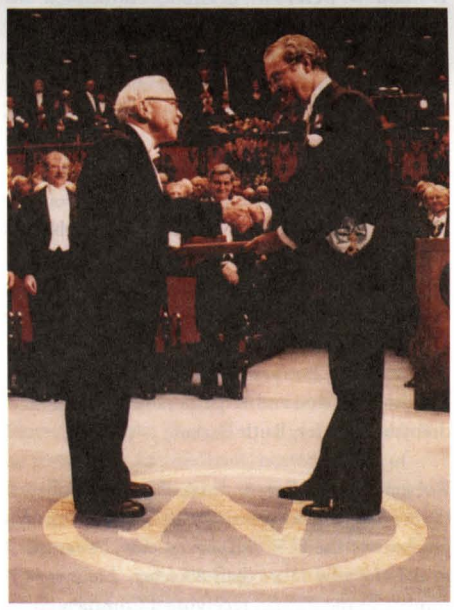
colloquially known as the fruit fly, with special attention to the ways in which the insect's genes direct embryonic development and determine the order in which body parts are laid down in the organism. At the time of his death Lewis was the Morgan Professor of Biology, Emeritus, and until very recently he had maintained an active schedule in his campus laboratory.

In a book published on Lewis earlier this year, his longtime collaborator Howard Lipshitz wrote that Lewis's scientific research was "the bridge linking experimental genetics as conducted in the first half of the 20th century, and the powerful molecular genetic approaches that revolutionized the field in its last quarter."

Lipshitz also praised Lewis's less well-known but extremely important research during the 1960s into the relationship between radiation and cancer, and the health issues associated with nuclear-weapons testing. (More information on this research can be found in a recent *Engineering & Science* article, "Biology and 'The Bomb.'" Go to http://pr.caltech.edu/periodicals/EandS/, and click on the "archive" link.)

Born in 1918, in Wilkes-Barre, Pennsylvania, Lewis was barely in his teens when he became interested in the genetics of the fruit fly, *Drosophila melanogaster*, which was being touted as an excellent animal for heredity research by Caltech's Thomas Hunt Morgan (who some years earlier had moved his "fly room," lock, stock, and bottles, from Columbia University to Pasadena). As a high school freshman, Lewis performed genetics experiments on *Drosophila* and after taking a bachelor's degree in 1939 at the University of Minnesota, he came to Caltech for his PhD. He remained at the Institute for the rest of his life, save for four years in the U.S. Army Air Force during World War II, when he worked as a meteorologist.

Lewis published several research papers while still a college student, and soon after the war had established himself as a recognized expert in the field of fly genetics. Returning to Caltech in 1946 as an instructor, he was named an assistant professor in 1948 and became a professor of biology in 1956. He was named the Thomas Hunt Morgan Professor of Biology in 1966 and retired as Morgan Professor emeritus in 1988.



In a campus article appearing in 1957, Lewis described his success in creating mutant flies with four wings (they normally have two), saying "We now have a working model for picturing the genetic control of development." His formulation was indeed correct, and nearly four decades later the Nobel Committee, in awarding Lewis the Nobel Prize in physiology or medicine, cited his achievement in identifying and classifying "a small number of genes that are of key importance in determining the body plan and the formation of body segments." The Nobel Committee also lauded Lewis for his central discovery of "how genes were arranged in the same order on the chromosomes as the body segments they controlled."

In the same 1957 article, Lewis discussed his good fortune in becoming an active geneticist at a revolutionary time in biology. After the war, the gene was still treated as an abstract entity because the techniques needed to ascertain its molecular nature were yet to be developed, he explained. "You could begin to try to see how a gene is constructed, even though DNA hadn't yet been determined to be the hereditary material. The laws of genetics had never depended upon knowing what the genes were chemically and would hold true even if they were made of green cheese."

Although the modern techniques of molecular biology were yet to be invented, Lewis was never reticent about using novel methods to better understand the genetics of the fly. His work with mutant flies led him to make key discoveries concerning what are now known as homeotic genes—genes that influence how the undifferentiated cells in a drosophila embryo separate into a head and a tail end, and how the eyes, legs, antennae, and other organs all form in their correct positions.

As early as 1952, Lewis had proposed that the "regulator" genes he was finding had arisen very early in the history of life on Earth, and were therefore likely to be "highly conserved"—that is, found in similar form—throughout almost the entire animal kingdom.

The power of this insight was not well-appreciated at the time, but more than two decades later, molecular biologists began to turn up stretches of homeotic DNA almost identical to that found in fruit flies in numerous animals, ranging from sea urchins to mice to humans, and determined that this ubiquitous and very ancient region of genetic bar code plays a key role in governing the hundreds of genes that sculpt organisms. By then, anyone who was familiar with Lewis's work was looking toward the day when he would receive the call from Sweden. It came in October 1995, while he was at a genetics conference in Switzerland.

Lewis had become a legend on the Caltech campus, and when he returned home from Europe after his 1995 Nobel Prize was announced, he was celebrated for his 60 years of dedication to his work and his long, lone pursuit of his chosen research in an era when "big science" had begun to play an increasingly prominent role.

Lewis is survived by his wife of 57 years, Pamela Lewis; and two sons, Keith Lewis of Redwood City, California, and Hugh Lewis of Bellingham, Washington.

JAMES WESTPHAL
1930–2004

James Westphal, who parlayed a bachelor's degree and extraordinary technical aptitude and ingenuity into a major scientific career as a Caltech professor, died Wednesday, September 8, after a long illness. The leader of one of the original instrument teams on the Hubble Space Telescope and former director of Caltech's Palomar Observatory was 74.

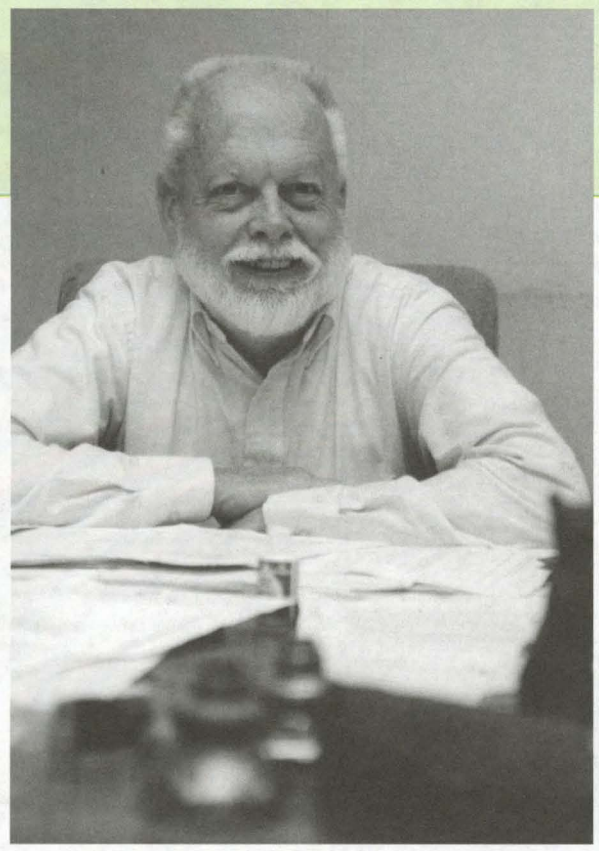
A native of Dubuque, Iowa, "Jim" Westphal earned his bachelor's degree in physics from the University of Tulsa in 1954, a year after he went to work as geophysical research group leader at Sinclair Research Lab in Tulsa. In 1961 he took a job as a senior engineer at Caltech and remained at the Institute for the rest of his career. He joined the Institute's planetary science faculty as an associate professor in 1971 and was named professor in 1976.

Westphal's mechanical genius was the linchpin of many of the projects he took on after arriving at Caltech. He once told a reporter that his mechanical skills were hereditary, his father having been "a shade-tree mechanic of the first order." Westphal the son first got into the business of scientific instrumentation right after high school, when he did well-logging in Texas and Gulf Coast oil fields. His work at Sinclair Research Labs involved devising unorthodox methods for oil discovery, and it was his discovery of a new way of processing seismic data that first brought him to the attention of Caltech professor Hewitt Dix, who is often referred to as the father of exploration geophysics.

Westphal arrived at Caltech on what was supposed to be a four-month leave of absence, to devise a data processor for Dix, and never left. Before long, he had teamed up with Professor of Planetary Science Bruce Murray (who later became director of JPL) to do thermal infrared scans of the moon in an effort to determine if humans could walk on the lunar surface without sinking below it (the answer was in the affirmative). Westphal and Murray also collaborated on the first infrared imaging of Venus and Jupiter.

"He was the most talented instrument designer I ever knew at Caltech or at JPL," says Murray of his late colleague. "That's why he could move through so many fields: he could figure out what was needed, and how to build it simply and cheaply."

Other projects at Caltech led to Westphal's being hired on permanently by Bob Sharp '34, PhD '35, at the time the geology division chairman. Westphal once said that he at first thought he was in over his head at Caltech, but after deciding that everyone working at the Institute felt the same way, he gave up his position at Sinclair and moved to Pasadena.



Jim Westphal in his Caltech office in the mid-1990s, during his years as director of Palomar Observatory.

In the years that followed, Westphal involved himself in novel ways of investigating volcanism at Mount St. Helen in Washington state; in the development of a high-pressure aquarium for studies of deep-ocean animals; and in the creation of instruments for tracking glacial ice flows and capturing starlight.

Caltech astronomers working with the Institute's 200-inch Hale Telescope—at the time the most powerful optical telescope in the world—were pleased to discover that Westphal had an idea for a night-vision camera that could measure the brightness of galaxies with 20 times greater accuracy than had previously been possible. He built various other instruments for the Hale Telescope, including a Silicon Intensified Target camera, which was a sort of transitional device between the photographic emulsion plates of the day and modern charge-coupled devices (CCDs) and which produced pictures with unparalleled clarity. That instrument is now in the Smithsonian's National Air and Space Museum's collection.

Westphal and Caltech astronomer Jim Gunn, PhD '66 (now at Princeton), recognized early that CCDs would revolutionize astronomy, and in the process of obtaining them for Palomar became involved in the planning for the Hubble Space Telescope. Westphal was later named principal investigator of the Hubble's Wide Field and Planetary Camera, which proved to be an enormously successful part of the telescope's scientific mission. Among other accomplishments, Westphal's instrument was used to diagnose the now infamous "spherical aberration" in the main 94-inch mirror, which caused the Hubble's initial focusing problems until it was repaired by space shuttle astronauts in 1993.

Once the Hubble was safely in orbit, Westphal and his collaborators began receiving data on a regular basis. One of the early images of distant galaxies provided especially compelling evidence for the phenomenon known as gravitational lensing. "When this picture came in," Westphal said in a 1995 interview, "I put it under [Caltech physicist] Kip Thorne's door with a note saying, 'If you ever have any doubt about gravitational lenses, here's your proof.'"

The author of scores of journal articles, and the creator of 15 patented inventions, Westphal was named director of Palomar Observatory in 1995 and served for three years. In 1997 he published a paper with geologist Sue Kieffer, PhD '71 (now at the University of Illinois), after lowering one of his custom-designed instruments into Old Faithful at Yellowstone National Park to study the geyser's cycling mechanism. The experiment, which received a good deal of media attention, confirmed previous assumptions about the geyser and also uncovered new details about its eruption cycle.

Westphal took emeritus status in 1998, but remained active in research endeavors until recently. The Caltech professor and master builder is survived by his wife, Jean Westphal of Altadena; a son, Andrew Westphal, a daughter-in-law, Kim Taylor, and two granddaughters, Theresa and Laura Westphal, all of Richmond, California; two stepdaughters, Robin Stroll of Agoura Hills, California and Susan Stroll of Eagle Rock, California; and an uncle, Eddy Westphal of Indiana.

A QUAKE OF MANY COLORS

On the ground, earthquakes and the damage they cause are none too pretty, but viewed from outer space, they can display dramatic beauty. The striking image on the back-page poster was created by Mark Simons, associate professor of geophysics, and his colleagues after the October 16, 1999, Hector Mine Earthquake, which occurred northwest of Los Angeles in the Mojave Desert and registered a magnitude of 7.1.

With the help of a European Space Agency satellite, the investigators used interferometric synthetic aperture radar (InSAR) to comprehensively image the epicenter and surrounding area of the temblor. Comparing one image taken 30 days before the earthquake to one taken a few days after the Hector Mine event, Simons and his co-investigators made the strange discovery that faults can move backwards, which they announced in the September 13, 2002 issue of *Science*.

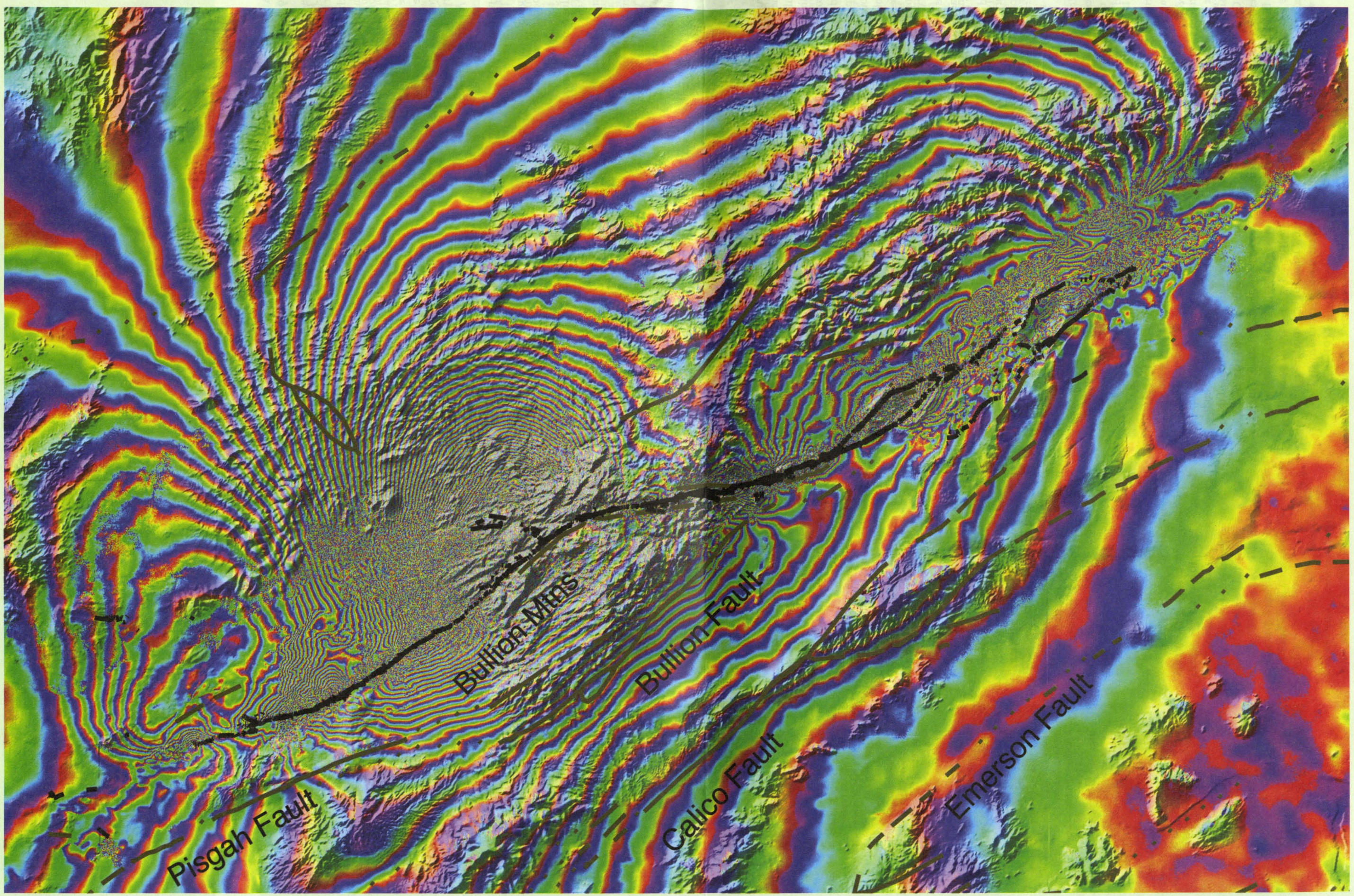
Besides offering new insights into the behavior of earthquakes, Simons's quake data also inspired a recent art project at Pasadena's Art Center College of Design. Artist Steve Roden took Simons's data and, with help from a Caltech graduate student, created a musical sculpture that was featured in a Pasadena arts festival. (For more on that, see page 3.)

As for the image itself, the 938-square-mile area is like a contour map of ground motion, says Simons. Colors represent different amplitudes of motion.

"The first earthquake imaged in this way was in 1994, but the Hector Mine temblor continues to be the best-imaged earthquake because of the amount of data. The recent Parkfield quake in central California will be one of the best-observed earthquakes, but there's a big difference between a 6.0 quake like Parkfield, and a 7.1 like Hector Mine."

The satellite data, says Simons, proved to be an excellent method for determining the exact location of a fault line. Unexpectedly, the data showed that parallel faults about 20 miles away did not rupture, but instead exhibited a backward motion showing an increase in strain, as if the fault lines were like rubber bands being pulled back.

"That indicates that those faults must have different material properties," says Simons. He adds that satellite images taken shortly after a quake occurs could also be of very practical benefit in helping emergency relief officials make a rapid damage assessment.


Bullion Mtns
Bullion Fault
Calico Fault
Emerson Fault
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