California Institute of Technology
Pasadena, California 91125

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Caltech News

Volume 42, Number 2
2008

In This Issue

Techers . . .

In Transit

In Orbit

Near the Red Carpet

and

at the Campaign Finish Line

California Institute of Technology

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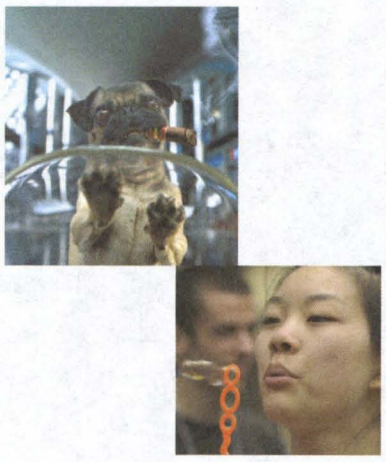
Caltech News



ON THE COVER
It needed a mathematician like Charles Dodgson aka Lewis Carroll to portray a through-the-looking-glass world in terms the 19th century could understand. Our cover photo offers a similar experience on the visual rather than the literary side, with its mirror-image view of Millikan Library as reflected in the waters of Throop Site. For a look at the other-worldly domain of special-effects wizardry, turn to page 10, and to take a trip with Caltech's out-of-this-world astronauts, see page 3.

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Also in this issue
The Institute welcomes new NAS members, new research initiatives, new Associates, and a new sundial, and showcases some artful science (on the back-page poster).

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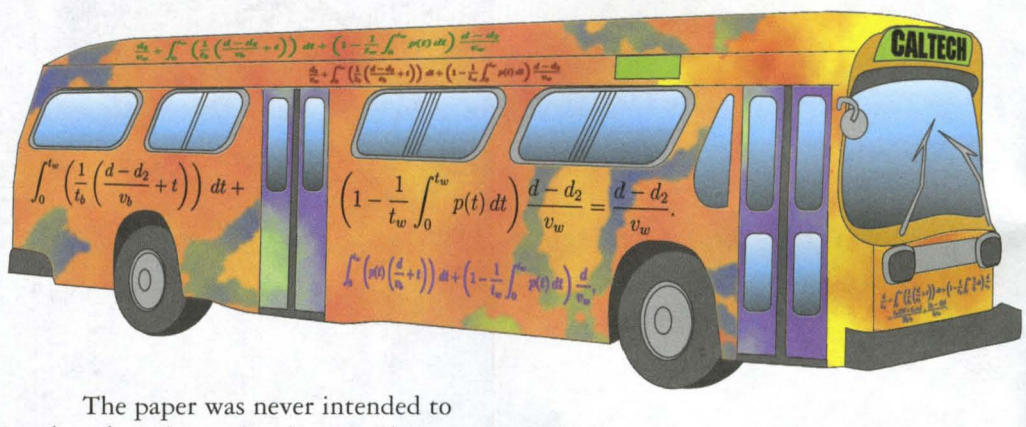
Up Front

Mathic Bus research puts Techer in driver's seat



It's a decision almost everyone has faced. You're waiting for a bus that never seems to come. Should you walk to your destination, if it's just a mile or two away? Or should you tough it out at the bus stop?

In January, a paper posted on an open-access preprint site offered a mathematical solution to this conundrum, implicit in the title, "Walk versus Wait: The Lazy Mathematician Wins." The article soon had everyone walking its way. First up was a piece in Britain's *New Scientist* that caught the attention of most of the British press. Soon the news spread to other regions of the world where buses play a large part in moving people around and are, presumably, often late, including Australia, India, Southeast Asia, South Africa, the United Arab Emirates, and Estonia. "Laziness Pays Off: It's Official," trumpeted one headline, while others proclaimed "The Waiting Game Pays Off at Bus Stop, Mathematicians Find," or "Why It's a Mistake Not to Wait Lazily for the Bus." The story even attracted attention in Germany and Switzerland, two countries known for their very reliable bus service.

Somehow lost in the initial coverage was the fact that the "university mathematicians" who had done this research were undergraduates. One of the authors was Caltech physics major Justin Chen '09, who acquired a doctorate in some of the reports. The other two, Scott Kominers, a math, music, and ethnology major, and Robert Sinnott, majoring in statistics, are juniors at Harvard. This misunderstanding caused some dissent among the rave reviews. One German blog, the Too Much Cookies Network, called the article "a very shallow analysis of the problem," writing, "With this paper mathematicians strive further to prove once more that they are, in fact, very disconnected from the real world."

The paper was never intended to be taken that seriously, says Chen, but he's gotten a kick out of all the publicity. (It was Chen who was interviewed for the BBC from the recording studios of NPR station KPCC at Pasadena City College.) In fact, he and his coauthors have plans to write a book in which they mathematically tackle other problems of everyday life, such as how to work out which line to stand in at a supermarket, and how to make your way through traffic congestion.

The students' inquiry started at a bus stop in Boston last fall, says Chen. "My friend Scott was trying to get from MIT to Harvard. He was waiting for the longest time for a bus and so he ended up having to walk the whole way. As he walked, constantly looking over his shoulder in case a bus came, he wondered what the best strategy is, whether to walk or to wait."

Chen and Kominers are friends from high school in Bethesda, Maryland. When they both went home for winter break, Kominers told Chen about his bus stop dilemma and suggested that they try to work out the optimal strategy mathematically. "So we thought about it and sat down one afternoon and wrote a paper," Chen says. To work out their equations, they "went online to the Massachusetts Bay

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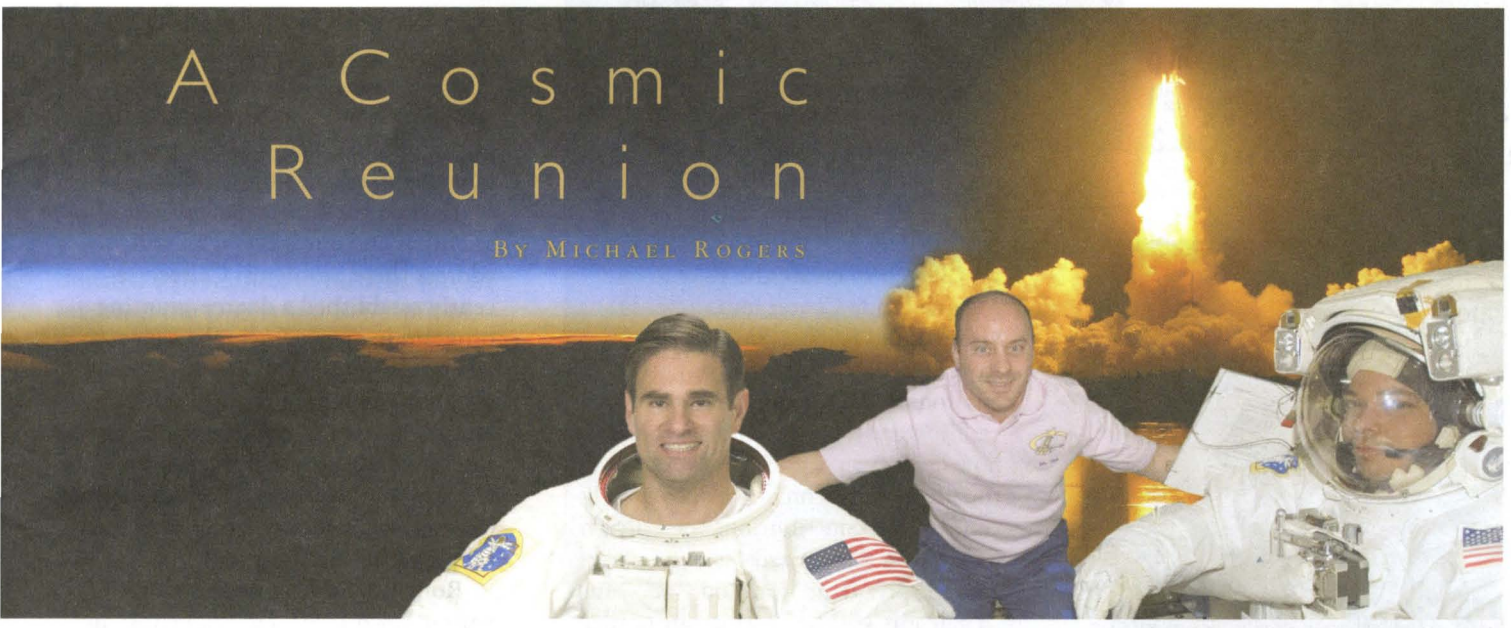
A Cosmic Reunion

By Michael Rogers



In a montage of images from the shuttle program (plus one taken by a launch spectator), Garrett Reisman (center) is shown with his fellow Caltech astronauts Greg Chamitoff (at left) and Bob Behnken.

Caltech has boasted a couple of alumni astronauts since humans started venturing off the planet 47 years ago, including the only scientist-astronaut to walk on the moon (geologist Harrison "Jack" Schmitt '57). Now the Institute has held its first alumni reunion in space.

On March 11, two alumni astronauts, Garrett Reisman, PhD '97, and Robert Behnken, PhD '97, rode into space aboard the space shuttle *Endeavour*. Behnken returned to Earth with *Endeavour* 16 days later; meanwhile his fellow alum, Greg Chamitoff, MS '85, was getting set to take a ride on the space shuttle *Discovery*—planned for launch on May 31—replacing Reisman at the International Space Station.

With the shuttles scheduled to be mothballed in 2010 and many candidates in the astronaut program still waiting for their first launch, Behnken, Chamitoff, and Reisman were fortunate to get seats on the shuttle and a place among the select group of men and women who can say that they've been in space. Not long after they reached the space station and started adjusting to round-the-clock life in zero-G, Behnken and Reisman also got to step out for some space walks, or what NASA likes to mundanely call extravehicular activity (EVA).

"The acceleration is a feeling I'll never forget," Behnken says. "About eight and a half minutes after liftoff, we had gone half way around the world."

Their main tasks outside the shuttle involved installing a section of a Japanese laboratory called Kibo and assembling and putting in place a Canadian-built robot called Dextre, which will help the space station's robot arm perform routine maintenance. On his third space walk during the 12-day shuttle stay at the space station, Behnken had to wield a hammer and knock a piece of equipment into place. While they're still on the ground, astronauts endlessly practice the types of operations that they might find themselves performing in space until they could probably do them in their sleep. Yet this particular procedure was not in the training manual.

"We had a case with a scientific payload with a couple thousand material samples" that had to be attached outside the European-built Columbus laboratory, said Behnken, who spoke with *Caltech News* as he wrapped up his postflight debriefings at the Johnson Space Center in Houston. He said that the experiment case needed to be installed in a particular orientation. "As I was fitting the pins in place, I noticed metal on metal interference that was generating metal shavings. NASA cleared me to give it a shot with a hammer." Behnken duly locked the balky piece into place. Although the Apollo astronauts used garden-variety tools like rakes and scoops on the moon years ago, Behnken says that this may have been the first time that a hammer was deployed in space.

For Behnken, a major in the U.S. Air Force and a graduate of the Air Force Test Pilot School, hammering a pin, even in space, was no big deal. But he reports experiencing two major thrills from the astronaut experience. "Probably one of the most exhilarating experiences was liftoff," he says. "We launched at night, so first we were illuminated by the bright lights on the launch pad. After launch, we went into darkness, then we went into a couple of cloud banks and the engine and motor lit up the clouds, so we saw a bright orange light and then darkness again. Plus, with all the vibration, the acceleration is a feeling I'll never forget. About eight and a half minutes after liftoff we were in orbit and we had already gone half way around the world.

"The second memorable moment was the first EVA," he says. "The view from space was really remarkable. While you are inside the shuttle, many of the windows are pointed at the space station, so the view of Earth is a little restricted. But while you are outside, you have the full view, and there will never be a better view of Earth than what you have through the space-suit helmet. For me, the most remarkable thing to see is the sunrise and sunset. You can really see the depth of the atmosphere, especially if there is a storm on the horizon."

Reisman treated Yankee fans to a first pitch from space.

Reisman also got to work on Dextre and on the Japanese lab during his space walk, but one of his biggest thrills involved an extracurricular activity inside the space station. On April 16, the lifelong Yankees fan, donning a Yankees' cap and T-shirt, threw out the ceremonial (and in this case, virtual) first ball at Yankee Stadium before the Bronx Bombers' game with the Boston Red Sox. Reisman's throw inside the space station was shown in a tape delay on the stadium's Jumbotron screens. "Flying in space is really great, but throwing out the first pitch in the Yankees–Red Sox game . . . I was very excited about it," Reisman said during a video press conference. Many celebrities and politicians

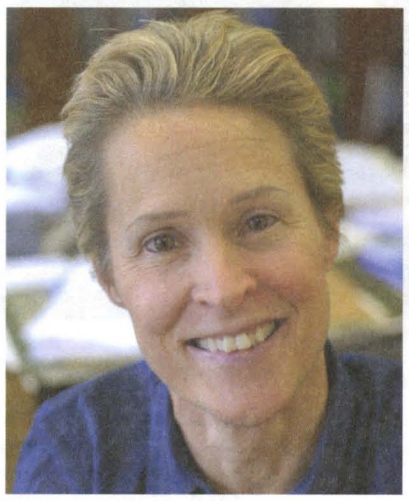
Continued on page 8 . . .

Behnken helped install part of a Japanese lab and a Canadian robot during his three space walks.

Campus Update

NAS names Caltech professor Frances Arnold and four alumni to membership

Frances Arnold has been elected to the National Academy of Sciences, one of the highest honors that can be bestowed on an American scientist or engineer. Arnold, the Dick and Barbara Dickinson Professor of Chemical Engineering and Biochemistry, is also a member of the National Academy of Engineering and the Institute of Medicine, making her one of only eight living individuals to have been elected to all three branches of the National Academies, and the only woman. Her election brings the current Caltech membership in the NAS to 75 faculty and three trustees.



With her election to the NAS, Caltech's Frances Arnold becomes the first woman named to all three branches of the National Academies.

Arnold was named to membership for integrating fundamentals in molecular biology, genetics, and bioengineering to the benefit of life science and industry. Her research has revolutionized protein engineering and its applications to biotechnology, addressing central issues in protein design and the evolution of new biocatalysts.

She is one of the pioneers in the use of "directed evolution" to improve proteins and other biological molecules for commercial applications. Directed evolution applies the principles of breeding, but to molecules rather than animals or plants. Using these methods, Arnold has been able to generate proteins with a variety of useful features, like improved stability and the ability to function in nonnatural environments.

The practical applications of this research are very broad and include making enzymes that can effectively break down cellulose, the key structural component of plant cell walls, which would allow the efficient production of cellulosic biofuels.

"Frances's work has changed the way we think about biological engineering, and her methods have been adopted by hundreds of laboratories around the world. It's a beautiful example of a new idea that proved to be almost immediately applicable to a broad range of fundamental and practical problems," says David A. Tirrell, the McCollum-Corcoran Professor and professor of chemistry and chemical engineering, and chair of the Division of Chemistry and Chemical Engineering at Caltech. "We're very proud of what Frances and her students have accomplished."

The National Academy of Sciences is a private organization of scientists and engineers dedicated to the furtherance of science and its use for the general welfare. It was established in 1863 by a congressional act of incorporation signed by Abraham Lincoln that calls on the academy to act as an official adviser to the federal government, upon request, in any matter of science or technology.

In additional to Arnold, four Caltech alumni were elected to NAS membership: Emily A. Carter, PhD '87, the Marks '19 Professor of Mechanical and Aerospace Engineering and Applied and Computational Mathematics at Princeton; Lars Hernquist, PhD '85, professor of astronomy, Harvard-Smithsonian Center for Astrophysics; Timothy Swager, PhD '88, the MacArthur Professor of Chemistry, and head of the department of chemistry, MIT; and Jack Wisdom, PhD '81, professor of planetary science, MIT.

Recognition

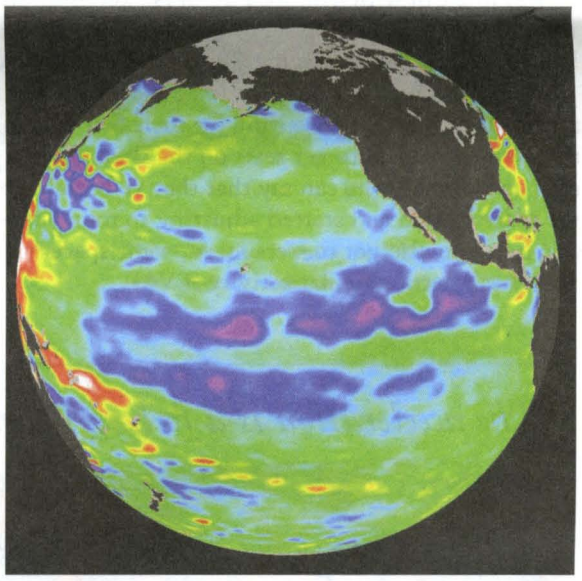
For an up-to-date list of awards and honors bestowed recently upon Caltech faculty and staff, go to http://today.caltech.edu/today/oncampus.tcl and scroll down to Honors and Awards in the right-hand column, as well as to the Archives link in that section.

Multidisciplinary Linde Center will address challenges in environmental science

To address the complex issue of global climate change from a wide range of disciplines, Ronald Linde, PhD '64, and Maxine Linde have established an $18 million endowment for Caltech to create the Ronald and Maxine Linde Center for Global Environmental Science, uniting faculty from chemistry, engineering, geology, environmental science, and other fields.

"Ron and Maxine Linde appreciate how critical environmental science is to the future of life on our planet and the tremendous contributions the Caltech faculty can make to society," says Caltech president Jean-Lou Chameau. "Their gift will help bring our faculty together and provide flexible support that is critical to creative thinking."

The new initiative will help Caltech achieve its vision of having an integrated program in global environmental science, spanning the many disciplines that must make up such a program. The new center will foster close collaboration among all six of Caltech's academic divisions—from chemists studying ozone-destroying reactions in the stratosphere, to fluid dynamicists and physicists studying atmospheric and oceanic flows, to biologists studying nutrient cycles, to geologists studying evidence of the effects of past climates, to social scientists (including economists) and humanists evaluating how society and institutions can respond to global change. The program will also benefit from Caltech's management of JPL, which regularly monitors environmental change through its numerous satellite-based observations of the atmosphere, oceans, and land surfaces.



Images like this satellite photo of La Niña conditions (the blue area in the center of the image along the equator) in the Pacific are among the many types of atmospheric, geological, and oceanic data that will be the focus of Caltech's new Linde Center for Global Environmental Science. The data that generated this image was collected by the U.S.-French oceanographic satellite Jason, whose U.S. component is managed by JPL for NASA's Science Mission Directorate.

Edward Stolper, Caltech's provost, explains that the Linde Center "will provide a central home and focus for researchers and students working on understanding natural variations in and the impact of human activity on the global environment. These are among the most important and most difficult problems facing our society, and this gift will help Caltech play an important role in addressing them."

To train the future generations of scientists and engineers who will address these problems, Caltech recently established a degree-granting program in environmental science and engineering. This interdivisional program offers training and research ranging from a large-scale understanding of the ocean/atmosphere system and climate to the local scale of developing engineering solutions for environmental problems.

Ronald Linde has been a Caltech trustee since 1989. He is a private investor and chairman of the Ronald and Maxine Linde Foundation, a private foundation that the Lindes established in 1989. He was founder, chairman, and CEO of Envirodyne Industries Inc. He also held various scientific research and management positions at Stanford Research Institute (now SRI International) and has authored or coauthored more than 50 publications in science and technology.

Maxine Linde is a private investor and president of the Ronald and Maxine Linde Foundation. She was involved in the early U.S. space program as a scientific programmer at JPL and subsequently served as Envirodyne's general counsel and chief administrative officer.

The Lindes have established the Ronald and Maxine Linde Professorship of Applied and Computational Mathematics at Caltech, currently held by renowned mathematician Emmanuel Candes. They also have funded a challenge grant to create the Ronald and Maxine Linde/Caltech Alumni Laboratories in Caltech's Broad Center for the Biological Sciences.

New Rosen center will spur advances in bioengineering

Seeing a burgeoning new research field at the interface of biology and engineering, the Benjamin M. Rosen Family Foundation of New York has donated $18 million to the Institute to establish the Donna and Benjamin M. Rosen Bioengineering Center.

Rosen '54 served as chairman of Caltech's Board of Trustees from 2001 to 2007.

"Ben and Donna Rosen are recognizing how critical bioengineering is to the future of Caltech, science, and society, and they also appreciate the power an endowment can have in sustaining such an initiative," said Caltech president Jean-Lou Chameau. "The Institute is fortunate to have them as friends."

The Rosen Center will advance both basic scientific exploration and development of engineering analysis and synthetic approaches. Innovations in these areas are resulting in rugged and inexpensive diagnostic devices, in new insights into the functioning of the heart, and in the engineering of molecular devices capable of recognizing and responding to disease processes in individual cells.

Bioengineering developed at Caltech in recognition of the fact that biology is becoming more accessible to approaches that are commonly used in engineering, including mathematical modeling, systems theory, computation, and abstraction-based synthesis. At each level of organization, from the molecule to the cell to the organ, the accelerating pace of discovery in the biological sciences reveals new design principles that are of fundamental importance in understanding living organisms, and that will have important practical applications in future synthetic biological and biomedical systems and devices.

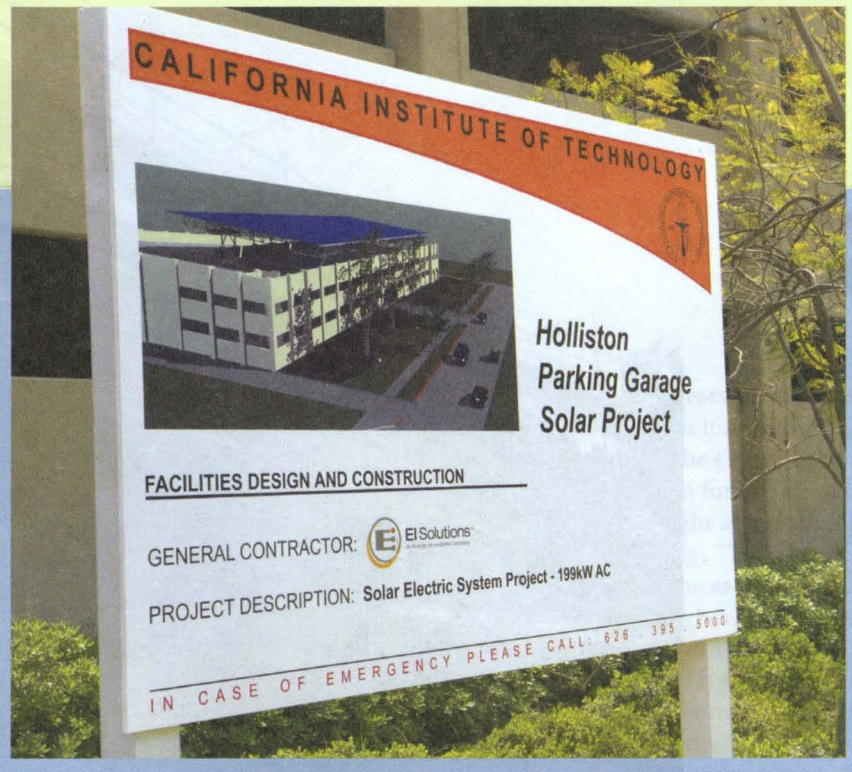
"Bioengineering arose at Caltech from the grassroots efforts of a handful of committed faculty coming together to establish a graduate option with great enthusiasm," said Scott Fraser, the Rosen Professor of Biology and professor of bioengineering, who will lead the new center. "This gift will endow the program, allowing it to foster the most innovative collaborative research. Such funding fuels innovation by offering support to venturesome efforts far earlier than would be possible through conventional granting agencies."

According to Ed Stolper, Caltech's provost, "Our current challenge is to provide an intellectual and programmatic focus for our growing teaching and research programs in bioengineering, spanning synthetic, systems, and computational biology; biomechanics and bio-inspired design; and development of novel biotechnologies. The Rosen Center will provide such a focus and critical support for these activities, which span many of the Institute's existing programs."

"Caltech's Bioengineering Center will foster the foundational work that will blossom into the next generation of tissue regeneration and diagnostic instrumentation," said Fraser. "The results of these innovations will make tools once considered too futuristic for anything but science fiction films into practical devices that can be carried in a physician's rear pocket."

A Caltech trustee since 1986, Ben Rosen was founding chairman of Compaq Computer Corp. and a founding partner of Sevin Rosen Funds, a venture capital firm that has provided initial financing for more than 100 technology companies. Previously, he was vice president and senior electronics analyst at Morgan Stanley & Co., and before that he was an electronics engineer at Raytheon and Sperry Gyroscope. In 1992, *Computerworld* chose Rosen as one of 25 people in the computer industry "who changed the world."

Donna Rosen was the owner/director of Galerie Simonne Stern in New Orleans for 23 years until she moved to New York in 2002. She pioneered the New Orleans Warehouse District as the "Art District of New Orleans." She is a national trustee of the New Orleans Museum of Art; vice chairman of the board of American Friends of the British Museum; board member of the Society of Memorial Sloan-Kettering Cancer Hospital; and trustee of Second Stage Theater.



In May Caltech began installing Pasadena's largest solar energy facility on the roof of the campus's Holliston parking structure. When it comes online this fall, the facility is expected to have an annual energy production equivalent to eliminating 527,000 pounds of CO_2 emissions from the air each year, removing 46 cars from operation, planting 72 acres of trees, or powering 38 average homes. Currently, the bulk of Caltech's energy (about 80 percent last year) is supplied by an on-site campus cogeneration plant and the rest by the City of Pasadena, which worked closely with the Institute to create the new facility. Ultimately, the campus hopes to install more solar facilities to further reduce its reliance on nonrenewable sources. Other sustainability efforts currently under way on campus include water-wise landscaping, an award-winning recycling program, the introduction of compostable food containers in the dining facilities, and an ongoing program to switch from incandescent lightbulbs to compact fluorescent bulbs. For a more comprehensive list of "green" initiatives, check out the Sustainability at Caltech website at http://sustainability.caltech.edu/.

One of the labs that will become part of the interdisciplinary Rosen Center is that of Christina Smolke, assistant professor of chemical engineering, whose research brings together elements of biochemistry, molecular biophysics, bioengineering, and chemistry. Above, small RNA molecules bioengineered in the Smolke lab offer a promising way to control gene expression by blocking the production of specific proteins.

"There are a few times in history when diverse sciences, technologies and researchers fortuitously come together at the same time and at the same place to make possible great achievements for mankind," said Ben Rosen. "This is one of those times, and Caltech is one of those places. We're honored to be able to play a small part in helping start this exciting new Caltech Bioengineering initiative."

A Grand Canyon as old as the dinosaurs?

How the Grand Canyon was carved has been a topic of scientific controversy for nearly 140 years, and in the end the question may prove somewhat easier to resolve than the eternal conundrum of how the camel got its hump. Armed with new geochronologic data from the canyon and surrounding plateaus, Caltech geologists have amassed significant evidence that the canyon formed nearly 50 million years earlier than previously thought.

Their findings were published in the May issue of the *Geological Society of America Bulletin* in a paper by Rebecca Flowers, a former Caltech postdoctoral scholar now on the faculty of the University of Colorado; Chandler Family Professor of Geology Brian Wernicke; and Keck Foundation Professor of Geochemistry Kenneth Farley.

The team studied the sedimentary rock layers, or strata, of both the canyon and a large area of the surrounding plateaus. These strata were deposited near sea level sometime in the Paleozoic era (540–250 million years ago) and were subsequently uplifted and eroded to form the canyon. But questions like when and why the canyon itself formed have remained open.

The long-held interpretation sets the first stages of canyon formation at about six million years ago, when the plateau that hosts it began to rise from near sea level to a current elevation of almost 7,000 feet. This view highlights the erosive power of the Colorado River, which cut into the plateau surface like a giant buzzsaw and progressively deepened the canyon at the same time the entire region was rising.

Now, using a radiometric dating method called uranium-thorium-helium [(U-Th)/He] dating, developed in Farley's lab, the researchers paint a different picture. They say that uplift and carving of a deep canyon took place more than 55 million years ago, above the present position of the Grand Canyon's Upper Granite Gorge, within strata much younger than the Paleozoic rocks currently exposed in the canyon walls.

"When this canyon was formed, it looked like a much deeper version of present-day Zion Canyon, which cuts through strata of the Mesozoic era," Wernicke says. Then from 28 to 15 million years ago, a pulse of erosion deepened the already-formed canyon and also scoured the surrounding plateaus, stripping off the Mesozoic strata to reveal the Paleozoic rocks that we see today.

The key to the discovery lay in the ancient sandstones of the canyon walls, which contain scant grains of the phosphate mineral apatite that in

Continued on page 13 . . .

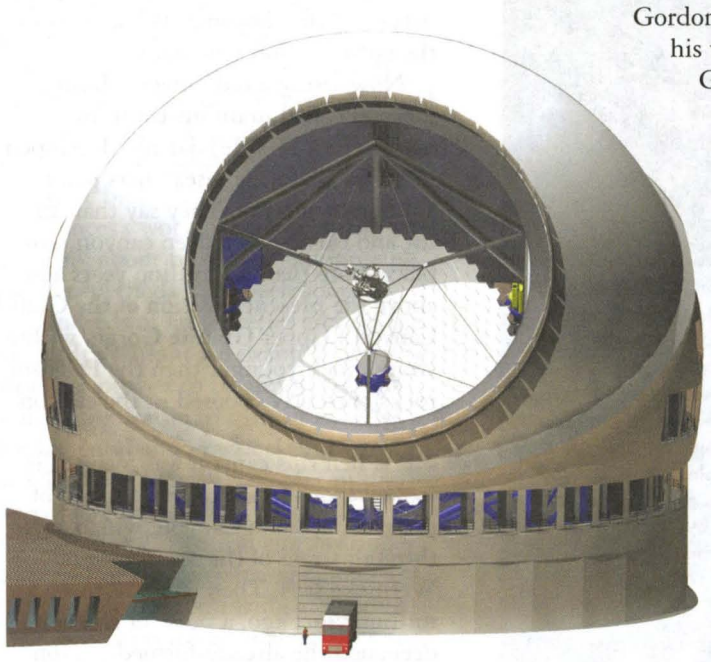
there's only **one.caltech**

THE CAMPAIGN

AND NOW THERE'S $1.4 BILLION, AS CAMPAIGN SURPASSES FINANCIAL GOAL

Lights blazed in offices across Caltech on December 31, 2007, as staff and faculty helped benefactors complete gifts to the "There's Only One. Caltech" campaign. That night, Caltech passed the campaign goal of $1.4 billion! But the even more resounding success was in the number of contributors, more than a third of whom gave for the first time. If all of the campaign contributors came to Caltech to celebrate, they would line the streets around campus and its athletic fields four deep (16,329 contributors, interval: 44 inches). There would be 10 benefactors for each word in this article.

"The end of a campaign is always a time for celebration and recognition—to celebrate achieving our goal, and to recognize the many people who made that possible with their financial contributions and wise counsel," said Caltech president Jean-Lou Chameau. "I want to offer my heartfelt thanks to everyone who so generously supported the most ambitious fund-raising effort in the Institute's history.



A $200 million gift from the Moore Foundation has taken the Thirty-Meter Telescope (artist's rendering above), a key campaign goal, one step closer to reality. At top right, the Cahill Center for Astronomy and Astrophysics nears completion. Made possible through a lead gift from Charles Cahill and his late wife, Anikó Dér Cahill, as well as gifts from the Sherman Fairchild Foundation; Michael Scott '65; trustee Fred Hameetman '62 and Joyce Hameetman; and the Kenneth T. & Eileen L. Norris Foundation, the new facility will fulfill Caltech's longstanding goal of bringing its astronomy and astrophysics programs together under one roof.

"This milestone means that Caltech researchers can focus their attention on what they do best—making groundbreaking discoveries that establish new frontiers in science and engineering," added Chameau. "This campaign gives them the freedom to think big and accomplish their dreams."

Among the newly funded dreams is the Thirty-Meter Telescope, which, when built, will be the largest telescope in the world. Dozens of projects have become tangible realities during the campaign, such as the Combined Array for Research in Millimeter-wave Astronomy—a radio observatory in the Sierras—and the Molecular Observatory synchrotron beamline, which produces intense X-ray beams to determine the structures of proteins.

The campaign raised more than $1.424 billion, including the largest private gift ever made to an institution of higher learning—$600 million in a combined gift from Gordon Moore, PhD '54, his wife, Betty, and the Gordon and Betty Moore Foundation. That gift will strengthen Caltech's endowment and support some 20 new initiatives and centers investigating cell regulation, molecular biology, astronomy and astrophysics, tectonics, geochemical and cosmochemical microanalysis, neurobiology, socioeconomics, sustainable energy, chemical synthesis, as well as achieving diversity in science and engineering, and more.

The campaign also raised $60 million to endow new professorships and funded 99 new undergraduate scholarships. The Summer Undergraduate Research Fellowships (SURF) program will continue to thrive with an infusion of more than $11 million, $8.5 million of which will go into SURF's endowment and provide permanent support.

The campaign's success is visible all over campus. A changing tableau of excavators, loaders, and cranes reflects the progress of the Schlinger Laboratory for Chemistry and Chemical Engineering, the Annenberg Center for Information Science and Technology, and the Cahill Center for Astronomy and Astrophysics. Renovations of the historic Dabney Hall of Humanities and the South House undergraduate housing complex are already complete.

More than 10,000 alumni donated nearly $455 million during the campaign, 78 trustees gave $379 million, and more than 700 foundations and corporations granted $671 million. (Some gifts and donors are counted in more than one constituency group.)

Gary Dicovitsky, vice president for development and alumni relations, points out one more important statistic: "Almost $23 million of the campaign gifts came from 572 faculty and staff members at Caltech and JPL. That employees, who contribute so much through their daily work, went the extra mile to support the Institute really conveys how positively people feel about Caltech."

Trustee Wally Weisman served as campaign chairman. "I'd like to thank Wally for his leadership of the campaign," said Chameau. "We couldn't have come this far without his energy, guidance, and encouragement."

Kent Kresa, chair of Caltech's Board of Trustees, acknowledged his predecessor Ben Rosen and President Emeritus David Baltimore for their vision, planning, and execution of the early days of the campaign. Kresa noted that reaching the goal is a historic occasion.

"Caltech is, in scientific vernacular, orders of magnitude smaller than other institutions undertaking such a large campaign," he said. "To have exceeded that goal is thrilling and gratifying."

Kresa acknowledged that there are financial challenges in the Institute's competition for the best and brightest students, faculty, and staff. As Chameau adds, "Right now, our resources are still very good—especially given the accomplishments of this campaign—but they need to be the very best if we want to keep working at the frontiers of knowledge. The best way to ensure that we will always be able to provide everything our researchers need is to keep growing our endowment."

As they look ahead to building Caltech's endowment, the Institute's administrators can feel buoyed by the outpouring of contributions during the campaign. Through their gifts, alumni, friends, faculty, and staff expressed powerful support for Caltech's mission: to expand human knowledge and benefit society through research integrated with education; to investigate the most challenging, fundamental problems in science and technology in a singularly collegial, interdisciplinary atmosphere; and to educate outstanding students to become creative members of society.

Alumni, who have personally experienced Caltech's mission and culture, contributed generously, in part because of the challenge, camaraderie, and respect they experienced here.

That freshmen would be respected and valued came as something of a shock to Kiyo Tomiyasu '40 when he arrived at Caltech in the 1930s, a self-described "scared rabbit." In a 2006 interview, Kiyo spoke about how his Caltech experience shaped his philanthropic goals. His two guiding questions were, "How did I get where I am today?" and "How can I benefit society as a whole?" He thought of Caltech's honor code and how well the collaborative environment had prepared him for his career (for his notable contributions in electrical engineering and communications technologies he received Caltech's Distinguished Alumni Award in 2002). He remembered the professors who took time to help him and other undergraduates grasp the mate-

rial they were studying, while also completing world-changing research. In 1977, he and his wife, Eiko, a chemist by training, began to fund scholarships at the Institute, eventually also endowing a professorship and helping push the campaign over its goal on December 31, 2007, by endowing a Presidential Discretionary Fund to advance Caltech priorities. The Tomiyasus have given annually for more than 30 years.

During the campaign, Kiyo and Eiko made lead gifts to the SURF program. In the years to come, campaign gifts to SURF will support hundreds of fellowships. SURF offers undergraduates unparalleled opportunities to pursue original, independent research, working one-on-one with Caltech faculty and JPL scientists. Many other "scared rabbits" will experience a warm welcome into this scientific community because of the gifts of a few who studied at Caltech years ago.

Top: Eiko and Kiyo Tomiyasu (center) are joined by (left to right) SURF students Caleb Ng, Parvathy Menon, and Daniel Chao, whose projects the Tomiyasus have helped support through gifts to the SURF program. Above, from left, Chemistry and Chemical Engineering Chair Dave Tirrell and Katharine and Warren Schlinger dig in at the groundbreaking ceremony for the new Schlinger Laboratory.

In 2006, four alumni issued a challenge to their fellow former residents of the South Houses. After nearly eight decades of occupation by highly creative undergraduates, the houses, untouched by advances from modern wiring to wireless, needed help. Caltech Trustee Alexander Lidow '75, Richard Beatty '77, Ray Sidney '91, and an anonymous alum put up a total of $1 million to match gifts made to the restoration of the four houses. Their challenge helped move renovations forward and enabled a thoughtful process with ongoing student and alumni input. Renovations preserved historic architecture, the tradition of distinguishing each residence with whimsical details, and two dozen outstanding examples of the houses' unique "wall art." The houses reopened in December 2006. Once again, alumni brought the best of their experience to a new generation.

Across campus, a very different building is under construction, thanks to Warren Schlinger '44, PhD '49, and his wife, Katharine. Warren, who spent 12 years at the Institute, earning degrees in chemistry and chemical engineering and staying for postdoctoral and teaching positions, met Katharine while she was working as a departmental secretary for chemical engineering. The Schlingers' lasting bond with Caltech chemists and chemical engineers led them to contribute $20 million to Caltech, enabling construction of the Warren and Katharine Schlinger Laboratory for Chemistry and Chemical Engineering, the first Caltech building to house both disciplines under one roof. The Schlingers have turned their colleagues' and friends' visions into reality by taking the lead on funding this new building, packed with labs and teaching and meeting facilities.

And then there's Michael Milder '59, who attended Caltech on a scholarship. In appreciation for the support he received as a student, Mike has established a permanent, endowed, need-based scholarship that will support such student-life–related expenses as room, board, and fees for four Caltech students each year. He named the scholarship in honor of George Mayhew, the MOSH (Master of Student Houses) during his years in Ricketts House. Mike drew on his memories of the rich student life he experienced at Caltech as inspiration for the scholarship. "I always thought about giving back," he said, adding, "The idea of this award came to me as a perfect way to remember Dr. Mayhew, who meant so much to my generation at Tech."

The stories behind these few gifts make the campaign numbers even more impressive—each of the 16,329 gifts has a story, a reason that someone chose to support the challenge and the promise of study and research at Caltech.

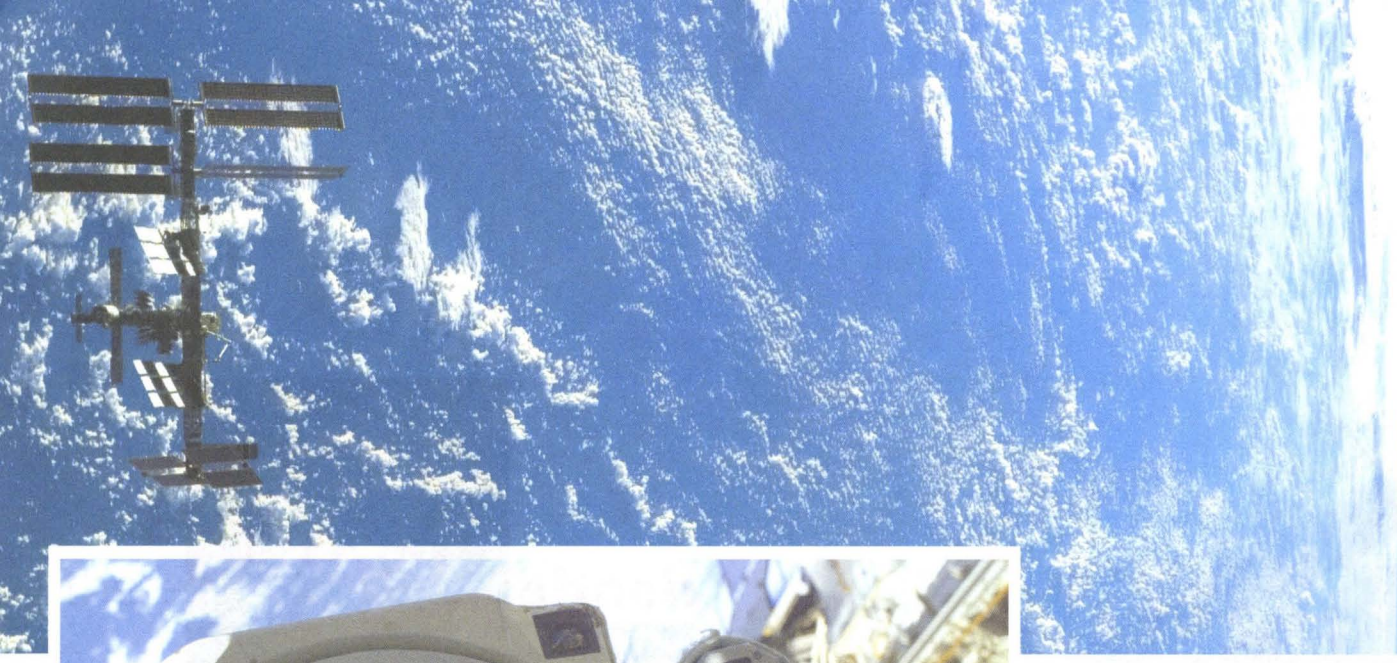
There hasn't been a campaign of this magnitude on Caltech's behalf since 1926, when railroad magnate and philanthropist Henry Huntington asked 100 of his closest friends to give $1,000 annually for 10 years to develop a "technical school of the highest class" in the heart of Southern California. That was a sizable amount of money to request, but Caltech's eloquent and visionary founder George Ellery Hale persuaded Huntington's friends of the wisdom of creating a scientific and technical institution second to none. That early funding was followed by decades of support from benefactors who expanded the Institute's leadership in science and engineering. Now, alumni and friends have once again demonstrated the power of individual people to make a big difference. Says Chameau, "With this kind of spirit and support, we can only succeed in building an even stronger foundation for the future of the Institute."

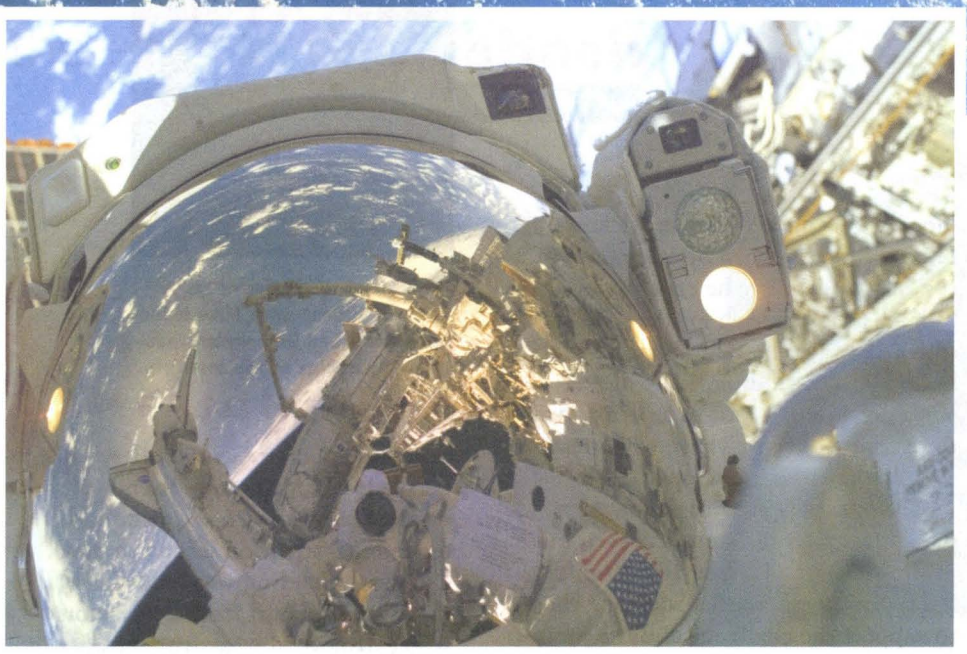
Inspired by memories of his Caltech student days, Mike Milder has established four undergraduate scholarships at the Institute.

ANN WENDLAND

ASSOCIATES WELCOME NEW MEMBERS

The Caltech Associates, the Institute's most venerable support group, welcomed new members at its annual New Member Dinner, hosted by Caltech president Jean-Lou Chameau and his wife, Carol Carmichael, on March 12. Above (from left) Sharon and James Plotkin, Chameau, and Carmichael enjoy the reception that the Caltech Employees Federal Credit Union hosted prior to the meal, and below, Associates Richard and Ann Ward (left) are joined by their friends and new Associates Bruce and Debbie Prout (center) and Cynthia and Alexander Ingle. The dinner recognized the 118 new members for 2007, as well as the friends who introduced them to the organization. In the past year, these new members have supported Caltech by bringing in a total of $843,250 to help fund new and current research. To learn more about the Caltech Associates, and the group's decades of support for Caltech's research and educational achievements, please visit http://associates.caltech.edu/ or call 626-395-3919.





At left, the International Space Station orbits Earth at about 200 miles above the surface. Inset: Showing off his creative talents, Reisman took a self-portrait on a space walk, capturing his helmet, the mirror image of the Space Station in his visor, and Earth below.

"The tears of emotion rolled uncontrollably down my cheeks as this magnificent machine roared into the night sky in a blaze of light, vibration, and thunder. This is dangerous business, and many things can go wrong, as we know only too well."

Reunion . . . from page 3

who have thrown out a first ball have embarrassed themselves by failing to reach home plate, but, even at about 200 miles above Earth, joked Reisman, "The best thing about throwing a first pitch up here, it's impossible to bounce it."

Reisman, who learned to fly through the Caltech Flying Club, feels a special kinship with the Institute, since it's where he met his wife, Simone Francis, MS '96, while they were graduate students. Francis, who is also a pilot, reports that, besides the opportunity to pitch to thousands, Garrett's most exciting moments so far have been the *Endeavour* launch and the space walk. But even ordinary tasks are extraordinary in space, Francis told *Caltech News*. "He says just floating around the station is the most amazing thing and makes everything he has to do—even boring or unpleasant things like rearranging cargo or drawing his own blood—loads of fun." During the space station's weekly video conferences, which Francis says she often attends with her sister, "he spends most of his time demonstrating his somersault technique, making funny faces, and showing us how he plays with his toys in microgravity. We had him juggle his rubber NYC sewer rat and two inflatable pirate cutlasses."

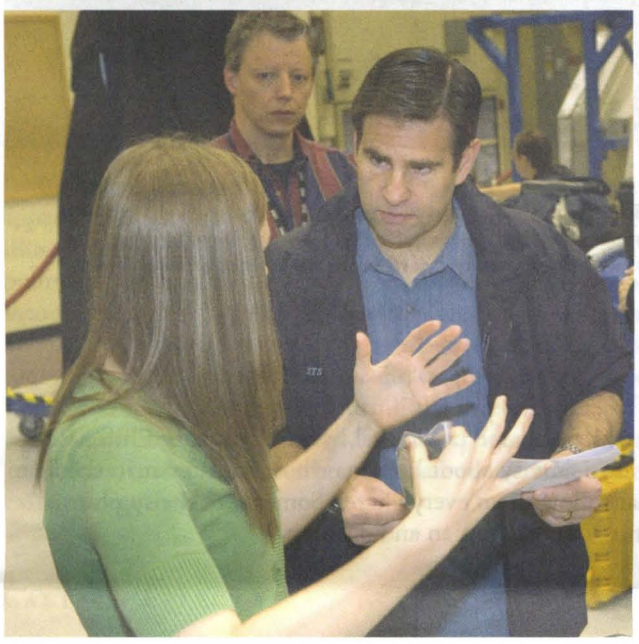
The often-changing sleeping schedule at the space station, where he's rooming with two Russians, has meant some adjusting for Reisman, Francis says. "As the sole American astronaut aboard the station, Garrett has primary responsibility for all of the U.S. station segments as well as the European and Japanese modules and the Canadian robotic arm. He spends a typical day performing routine maintenance on the various systems of these components, including life support, heating and cooling, etc., and conducting experiments within them (on fluid dynamics, plant growth, etc.). He must also exercise for two hours every day," says Francis, who applied once to the astronaut program herself, and says she "would go to space in a heartbeat."

As *Endeavour* rocketed away from Earth, ferrying Behnken and Reisman into the sky, the plume of smoke and flame propelling their ride may have struck them quite literally as a blast from the past. More than a decade earlier, they had been buddies at Caltech, both working in the basement of the Thomas Lab as graduate students in mechanical engineering. "For me, it was really great to fly with Garrett," says Behnken. "I had known him for years at Caltech and that made it pretty neat. When I arrived at the Johnson Space Center, Garrett was my sponsor (the guy who takes you out to dinner and makes sure you are getting settled during the first couple of months). We rarely worked together directly at NASA, but because we already had a friendship from years before, we could pick up where we left off and work or socialize like the time had never passed."

For at least one Caltech professor, watching Behnken and Reisman fly into space together summoned a range of emotions. Chris Brennen, the Hayman Professor of Mechanical Engineering, knew Behnken well and was not only Reisman's PhD advisor, but became a father figure to him after his own son, Patrick, was killed in an auto accident and Reisman's father died. An experienced mountaineer, Brennen often guided both Behnken and Reisman on hiking trips in area mountains during their Caltech years. On one such excursion, while Brennen and a group of students were preparing to rappel down a waterfall in the San Gabriel Mountains, Reisman tied the rope to a tree incorrectly, leaving Behnken, the first one in line, hanging upside down until he could be rescued.

In hindsight, that rappel misadventure was good preparation for Behnken and Reisman's latest joint effort. A decade later, they found themselves again in a precarious position—strapped in, flat on their backs in the shuttle—as they waited to lift off from Cape Canaveral. "It was a highly emotional experience for me," says Brennen, who watched the launch at the Kennedy Space Center. "The tears of emo-

Like his fellow astronauts, Reisman took a number of mementos into space, including the magical floating Institute pennant. On one of the shuttle's passes over California, he snapped the adjacent photo of Pasadena, with Caltech at the bottom, center.



The space shuttle *Discovery* (above) arrived at the launch pad at Florida's Kennedy Space Center on May 3. At left, Greg Chamitoff participates in a training session in the Space Vehicle Mockup Facility at the Johnson Space Center.

tion rolled uncontrollably down my cheeks as this magnificent machine roared into the night sky in a blaze of light, vibration, and thunder. I felt pride that I had some small part in the development of the incredible turbopumps at the heart of the space shuttle main engines, perhaps the most remarkable turbomachines ever built. Pride in the two magnificent young men who rode this monster into space. Fear, of course, for their safety and the well-being of Simone, who stood just a few yards away; this is dangerous business, and many things can go wrong as we know only too well. Sorrow because Garrett carried with him mementos of my son and my late wife, Doreen, symbols of lost loves being carried into the heavens. But also hope for the future—my eldest daughter, Dana, and her two children were also there to witness the launch."

While Behnken and Reisman were grabbing hammers, throwing baseballs, and enjoying other aspects of space travel, Caltech's next alumni astronaut was preparing for his turn. Greg Chamitoff, who earned his master's degree in aeronautical engineering before leaving for MIT to get specialized training in spacecraft guidance and control and his PhD, says that becoming an astronaut has been a lifetime dream.

"I was born in Montreal, and when I was six years old, my family took a trip to Florida," Chamitoff says. "My father was always interested in the space program," and he took his family to witness the launch of Apollo 11, the first mission to put humans on the moon. "When we saw the launch, my dad explained what they were doing, and I told him, 'That's what I want to do.' And I never looked back."

Chamitoff, who applied to the astronaut program several times over a 10-year period before he was accepted into the same class as Reisman, is scheduled to remain at the space station for six months, where he will help install a second section of the Japanese lab and conduct about 40 experiments. "One experiment is about duration in space and the effects on nutrition and health. There are also fluid physics experiments. Fundamental research will come out of that."

Chamitoff says that the toughest aspect of the trip will be the long separation from his wife and three-year-old twins. "I've been training for a long time and this is an incredible opportunity. When you live for a few weeks in a new place, you get a sense of the place. I'm looking forward to living there long enough to know what it's like to live in space."

Chamitoff says he's also looking forward to seeing Reisman, with whom he became close during their astronaut training. "Garrett's a great friend. When I get up there, he'll be the one to welcome me."

Mathic Bus . . . from page 2

Transport Authority (MBTA) website and looked up the distance between bus stops and how often the buses arrived." They didn't do any practical research in Bethesda, where "a screen at the Metro stations displays the arrival time of the next bus. Our equation doesn't matter then. Most of it depends on not knowing when the next bus is coming," Chen says.

When Kominers got back to Harvard he had his friend Robert Sinnott check the math, and on January 1 the trio submitted the paper to arXiv.org, Cornell University's open access e-print site (where you can see it online at http://arxiv.org/abs/0801.0297), stating clearly that it was a recreational mathematics note, a caveat that seems to have been trampled in the stampede of press coverage. The paper attributes the bus-stop adventure to Chen, but otherwise it's "pretty much the exact same problem that Scott had," he says. Early readers included Todd Kaplan '89, now an economics professor at the University of Exeter in England, who was one of two academics to contact the students with some corrections, which are in the current online version. The paper has now been submitted to the undergraduate research journal *Math Horizons*, with publication slated for later this year.

The gist of the study is a short series of increasingly complex equations that the authors say demonstrate that it's always best to wait patiently at the stop. If you do decide to walk, perhaps because you're cold, uncomfortable, or just plain bored at the bus stop, you should give up on the bus completely and plan to walk the whole way, without looking back in case there's a bus coming. "Of course, it all depends on the timing of the bus and the distance," Chen says. "There's no point in waiting if the bus only comes once an hour and the destination is a mile away, as it's always going to be quicker to walk." There's a distance constraint on the equation too. "It's for walkable distances, perhaps five miles max," he says.

Although Chen, who chose Caltech over Harvard "because of the weather," now has an international reputation as a public-transportation expert, he always uses his car. He did once try to get from Pasadena to Long Beach on the weekend using mass transit, but "it involved two buses and three different rail lines, and took two hours and fifteen minutes, compared to less than an hour by car." And although the final lines of the paper have Chen shouting "'Eureka!' . . . upon realizing that the laziest possible waiting strategy would prevail," he's far from indolent. As well as spending the weekends either surfing at Bolsa Chica State Beach or (weather permitting) snowboarding at Big Bear and Snow Summit, he wheels around campus on his longboard.

When Boston's *Daily Free Press* reported on Chen's work, they also contacted an MBTA spokesperson for comments. She insisted that the city's bus and trolley systems are generally on time. So how was it that Kominers walked all the way from MIT to Harvard, a distance of two miles, without seeing a single bus? Chen laughs: "It's really funny. When Scott got back to campus, he found out the buses weren't actually running that day. If he hadn't walked, he would never have gotten there."

Justin Chen doesn't often board buses, but he does get around on boards—surfboards, snowboards, and, above, the longboard that transports him around campus.

BARBARA ELLIS

FX MAN

When computer science meets amorphous art, an Oscar is born. Will the Techer claim it?

At right, Scott Townsend is able to bear a moment in the spotlight with his Oscar-winning supervisor, Bill Westenhofer (left), on the morning after *The Golden Compass* won the Academy Award for Achievement in Visual Effects.

By Hillary Bhaskaran

On a blustery day in early April, Scott Townsend sits outside a Westside coffee house, steam rising from the cup he holds firmly in his left hand. The Caltech graduate of 1995 is dressed head-to-toe in black. He looks very much the proud father following the birth of his second daughter just three days earlier.

Looking skyward, he considers the weather. "Yeah, it's kind of cold. Maybe we should go in. Sorry."

Once inside the coffee-infused establishment, between a glowing fireplace and an elevated television set, he considers his luck. Not only did he make it through Caltech, but he also landed a job in special effects (FX) that put him within a computer's reach of an Oscar, or closer.

As an FX animator at Los Angeles's Rhythm & Hues Studios (R&H), Townsend and his collaborators "handle all the tricky, computer-generated effects that can't be modeled or quantified easily." These include dust, smoke, and explosions, he recently told a reporter from the *Orange County Register*. His interview was published after Townsend created the "swirling, glowing mass of stars and dust" that helped the feature film *The Golden Compass* win the 2008 Academy Award for Achievement in Visual Effects.

But Townsend doesn't want a big deal made about the Oscar. He figures it was his mother who first leaked the news to his hometown *Register*. When *Caltech News* tracked him down, he asked his mom if she had had anything to do with that as well.

However it happened, Townsend now finds himself talking about his favorite projects. "I really did like *The Golden Compass*," he admits. "It was rewarding-ish." He created an aurora borealis for the movie *Frequency*, which was released in 2000. And for one of Classic Coke's now-classic polar-bear commercials, he made the Arctic waters ripple, splash, and bubble when a seal surfaced, and he made snow and mist rise as the polar bear plopped down in surprise on an ice floe.

Townsend jokes that his "most degrading two months ever" were spent concocting a stinkbug gas eruption for the 3-D movie *It's Tough To Be a Bug*, which is part of the "Bug's Land" attraction at Disney's California Adventure theme park. Although modeling the bodily effusions of a rogue insect might not be everyone's idea of a dream assignment, he has heard that "it delights audiences." (More recently, he found that it did not delight his three-year-old daughter, who decided she'd had enough by the time the animatronic black-widow spiders descended from the ceiling.)

"I'm most proud of the work I did on Frank the Pug in *Men in Black II*," says Townsend of the 2002 movie. "The pug's cigar smoke was my favorite because I nailed it, and in just a few days. I wasn't even using fluid-dynamics simulations at the time. I don't usually give myself a pat on the back, but this one was special."

To create the illusion of smoke, he used a computer to model layers of mesh that he could deform and roll past each other in a swirling fashion. He placed hundreds of "smoke" particles at the intersections of each of the tiny squares that made up his custom-designed mesh. Then he programmed them to rise at a particular velocity while subjecting them to artfully directed gusts of wind. As each group of particles rose and dissipated, it was replaced by a new group that also appeared to emanate from the pug's cigar.

The FX are both more complex and ambitious in *The Golden Compass*, which is based on a novel by British writer Philip Pullman. Both book and movie are a fantasy about humans whose souls exist in the form of animal-like "daemons" that follow them everywhere. Sometimes the symbiosis ends tragically, with the demise of both human and daemon.

Daemonic FX

"What had happened to the dead men's daemons? They were fading, that was the answer: fading and drifting away like atoms of smoke, for all that they tried to cling to their men."
—Philip Pullman, The Golden Compass

Townsend was asked by his effects supervisor to "make it so," to bring the so-called "daemon death effect" to life, as it were. "It's not my vision," says Townsend, who doesn't like to hog the credit. He does acknowledge responsibility for researching and developing the daemon death effect and leading the six-person team that created the film footage.

As a technical director, he first worked with programmers to refine fluid-dynamics programs and apply them to the creation of realistic-looking animation sequences. In the field of aeronautics, engineers use a variety of heavy-duty computer packages to map the pathways of air molecules as they flow around an airplane's wing. Building upon this and other fluid-dynamics work, says Townsend, in-house programmers at R&H have developed their own software using similar algorithms and approaches. Armed with these tools, technically savvy artists can simulate swirls of smoke as a daemon dissolves into thin air.

For *The Golden Compass*, Townsend and his team developed a test setup of a dog running along a straight path at a constant speed. "The dog's body is made up of a million points," he explains. In each frame of the animation, these points slough off the dog's surface, revealing a million more points on the surface of a now slightly smaller dog. These points in turn slough off, to be replaced by another million as the dog turns to dust from the surface of its skin inward, shrinking into a smaller and smaller shape surrounded by an ever-expanding ring of dust and embers.

You don't have to be a rocket scientist to turn a wolf daemon into dust. But Townsend drew on his Tech background to refine and use fluid-dynamics software to create "the daemon death effect" (at right), earning him his moment of Oscar fame. Readers can try this at home by Googling "free Houdini Apprentice," but *Caltech News* cannot be held accountable for the resulting effects, special or otherwise.

Townsend says that in particle systems such as the daemon dust cloud (depicted in the three illustrations below), each particle or point can be assigned "attributes including position, velocity, and life." In FX vernacular, the rarified "lives" of these particles can be described and modeled within a range of zero to one, with zero representing birth (life), and one representing death.

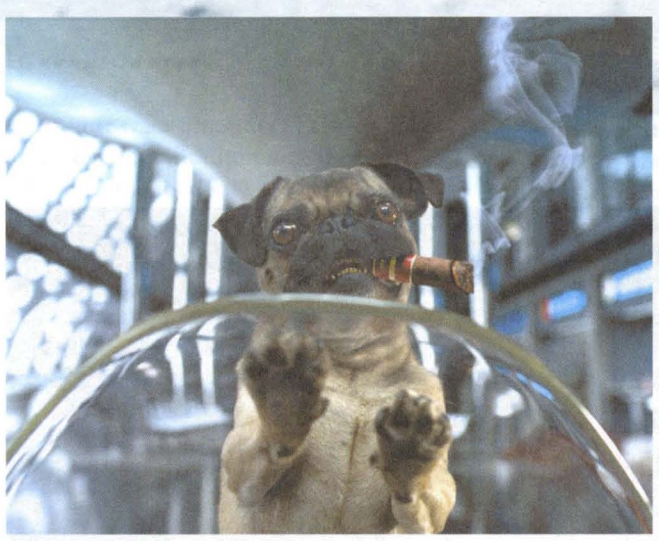
As the particle "ages" in successive frames, equations that link its size and opacity to its life cycle govern its evolution from robust and bright to expansion and fade-out. Tie these attributes together, says Townsend, and the particles will appear to fade away if opacity equals one minus life, and these fading particles will make up an expanding cloud of dust that becomes more and more transparent if size equals two times life.

"Then a sine wave can be used to cause the particle to pulse and flicker," he adds. "It's good fun."

Texture and dimension are added as well. The points are enlarged into spheres that are manipulated to fake a three-dimensional texture. "In the past, we just gave the spheres a texture on their surface or shell. But now we use mathematical functions in three-dimensional space to fill the spheres with patches of high and low density. This creates a noisy pattern" that mimics the variable density of a cloud. In *The Golden Compass*, these enhancements lent a more volumetric look to the clouds of starry daemon dust, creating the illusion of depth.

Townsend struggles to clarify this Hollywood version of rocket science, which is apparently a blast for those who understand it. He asks for a pen so that he can illustrate the process on a napkin, tapping the pen to paper to make a loose cluster of points, assigning a radius to each, and tracing circles around the points to turn them into spheres. All the while he searches for a way to make his thoughts more tangible.

"If I don't know a word, I say words around it," he explains. "I like buckshot logic, probabilistic meanings, shades of gray." A self-proclaimed perfectionist, Townsend spends his days capturing the imperfections of nature through art. "I'm suited to this line of work," he adds. He likes designing effects that are "nebulous, undefined, can't be put in a box . . . which is me. I don't want to be easily categorized."



"The best effects aren't noticed because they're so naturalistic," says Townsend. "You just think, 'Oh my gosh, this dog is smoking.'" The dog in question is Frank, who also sings in *Men in Black II*.

Caltech Effects

Looking back on his student days, Townsend thinks he was a little strange, even by Caltech standards. But in some ways he fit right in. "I was the weird guy with purple hair." In case that doesn't ring a bell with his fellow alumni, he adds that he skateboarded around campus wearing self-styled Genie pants, and he had his arm in a cast for a while after skateboarding off a patio. The accident occurred near the Red Door during a student film night that he had organized.

"I was the weird guy with purple hair…deriving proofs on faith…and skateboarding off the patio during our one-off film night."

While a student, Townsend also experimented with music. He played "percussive noises and additional rhythms" with a friend at the Red Door, and he organized two "musical" events: "Eve of Percussion" and "Repercussions." These featured students beating on pipes in the underground Student Activity Center.

Years later he would release an album incorporating "overlooked, everyday sounds like the humming of a light fixture, the clicking of an escalator, and the creaking of a dock." He's proud of this and of his experimental music concerts in Berlin, New York, and elsewhere. But as a student, he was just having fun and getting a needed break from math and physics, which he found to be "crushing."

His father had made it through Caltech, and his brother was doing well as a Techer, but Scott was not prepared for the fall he took from high-school salutatorian to "middle of the herd" student. "I was deriving proofs on faith," he says. "I was out of my depth. By sophomore year, it got to me." Townsend dropped some required classes and picked up a film class at Art Center College of Design. He started looking into full-time art programs and taking design and photography classes. "I didn't want to stagnate," he says.

He had also discovered that he didn't like majoring in mechanical engineering. Building robots had sounded cool, but the "perfect engineering" it required was agonizing. "I didn't want to build something that worked merely because it had been engineered to perfect tolerances," he explains. "I wanted a robot to be able to adapt if it had a rusty limb. I like imperfections.

"I needed to reevaluate my life," he says. Halfway through his Caltech education, he "sort of dropped out or took a leave of absence." Around that time, a waitress told Townsend about the San Francisco Art Institute, and within a month he was living in the Bay Area and studying film at "America's last pure fine-arts school."

At the Art Institute he found "a lot of people trying to say something who still had their lives to live before they would have something to say." But he found no classes in directing or lighting. "I liked the technical emphasis at Pasadena's Art Center and Caltech," says Townsend, who returned to Southern California after a year away to "get practical and be more grounded."

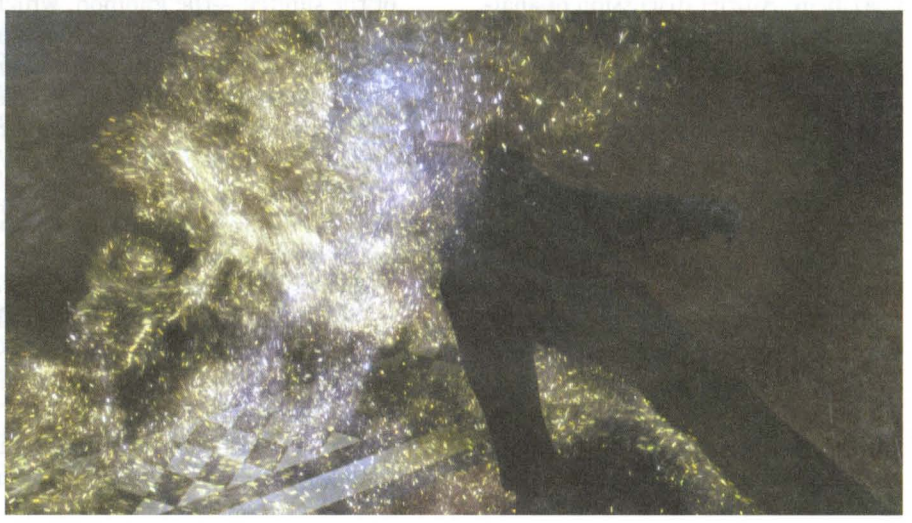
Back at Caltech as a veteran sophomore, Townsend switched his major to engineering and applied science with an emphasis in computer science. He says he was fortunate to be awarded two Summer Undergraduate Research Fellowships with Professor Nate Lewis '77, MS '77, with whom he worked on Caltech's Chemistry Animation Project. "That introduced me to professional animation packages and ultimately gave me some material for the demonstration reel that I would bring to Rhythm & Hues." Without that experience, Townsend says he might have become a programmer—perhaps "a rich guy working at Google," he jokes. But as it turned out, he says that he's "much richer inside" now that he's an animator married to a "beautiful programmer-turned-graphic-designer" from the Bay Area.

After graduating from Caltech, Townsend showed up for an interview at R&H with everything he could think of that might lead to a job there. He brought his Art Center and Art Institute films, his Chemistry Animation Project videos, self-styled clothes, musical recordings, and photographs. He left his nose ring at home.

"I was incredibly lucky to get a break," he says of landing a job. "Still, I didn't know what kind of work I was getting into. Upper management tried me out in FX, and it was a perfect fit.

"I've always straddled the art-technical line," says Townsend, who seems most at ease talking about the artistic aspects of his life. He is thankful that his job "relies

Continued on page 13 . . .



Association president asks, does anybody really know what time it is?

The 1969 hit "Does Anybody Really Know What Time It Is?" by the rock band Chicago was popular well into the early seventies, and I still hear it occasionally on classic rock radio. As a Tech student, I also heard a few students ask the same question when they awoke around lunchtime, bleary-eyed, from long nights of problem sets followed by Tommy's Runs.

Now your Alumni Association has presented the Institute with a new means for answering that question: an analemmatic sundial. This interactive time-keeping device has been installed in the plaza south of Winnett Center.

Several years ago, Ponzy Lu '64 noticed that our sunny Southern California campus lacked a good sun-drenched sundial and began researching the topic. About two years ago, during his term as Alumni Association president, he settled on an analemmatic design, in part because of its interactive aspect. (For an etymology of "analemmatic," go to http://www.worldwidewords.org/weirdwords/ww-ana1.htm. A brief discussion of analemmatic sundials can also be found midway through http://en.wikipedia.org/wiki/Sundial.) The CAA Executive Committee approved funds for the project, and work began.

The sundial, which has been installed flush with the concrete of Winnett Plaza, consists of two major elements. Its center is an eight-by-two-foot slab of granodiorite into which the months of the year have been etched. The center of this calendar contains the equinoxes, while the north and south ends mark the summer and winter solstices, respectively. Surrounding the calendar rock is the second key component, an ellipse of hour rocks.

(The companies that sell rock slabs for counter tops market this rock as "granite." Caltech has some very knowledgeable petrologists, however, including Associate Professor of Geology and Geochemistry Paul Asimow, PhD '97. He has identified the rock more precisely as the muscovite-bearing biotite granodiorite named "Granodiorite of Knowles" on Bateman et al.'s 1982 geologic map of the area north of Fresno, where it was quarried. The Cold Spring Granite salesmen call it "Sierra White.")

With the sundial in place, today's bleary-eyed student asking "Does anybody really know what time it is?" has only to wander out into the bright sunshine and stand on the appropriate date on the calendar rock. Fortunately, he doesn't have to know the date too precisely, since an error of a week won't affect the time much. He also doesn't have to realize that he has just become an integral part of the sundial—the gnomon, which is the part of the timepiece that casts the shadow. (I'm using the pronoun "he" because most of the bleary-eyed students I've met are men. I hope the bleary-eyed females among the *Caltech News* readership don't feel slighted. Your all-nighters are just as valuable as the male variety.)

By noting where his shadow falls on the hour ellipse, the student can read the local *solar* time. For many bleary-eyed students, this approximation to Pacific Standard Time will be close enough, at least from early November to mid–March. From mid–March to early November, he will have to add an hour to get close to Pacific Daylight Time.

The calculating Techer—yep, there are a bunch of those—will want to get a bit more accuracy. Since the sundial is a bit east of the Pacific Time Zone's central meridian, he will have to subtract 7.5 minutes from the shadow's position on the hour marks for a more precise reading.

And then there's the equation of time. It's not really an equation, of course. (What were those ancient astronomers thinking when they named the effect thus?) It's the amount of time that the sun is early or late compared to mean solar time, and it varies by as much as plus or minus 16 minutes from the mean. As the student casts a shadow on the sundial, he will notice that the Alumni Association has mounted a plaque on the wall of Winnett, a few meters in front of him. This plaque includes the equation of time as a function of date, which he can read and then add to the time he reads from the sundial.

As Ponzy notes, "The sundial is our first scientific instrument. It reminds us of the earth's motion relative to the sun. We hope that future generations of Tech students will occasionally ponder our position in the cosmos while pausing to tell the time."

But why let students have all the fun? The next time you're on campus on one of Pasadena's frequent sunny days, walk over to Winnett and try out the sundial yourself. And while you're there, recall the role that the sun played in Caltech's history. How did the modern Caltech get its start? George Ellery Hale enticed Robert A. Millikan to move west because of the sunshine!

More information about this sundial can be found on the Alumni Association website, http://alumni.caltech.edu/sundial. This site has links to other websites that explain the astronomy and geometry behind the analemmatic sundial.

Bob Kieckhefer

Jim Workman '57, MS '58 (top), and Bob Perpall '52, MS '56 (both shown with CAA president Bob Kieckhefer '74) were honored at the Caltech Athenaeum in February with the Alumni Association's new Excellence in Volunteering Award, established in recognition of the hundreds of alumni who give their expertise and enthusiasm—not to mention their free time—back to Caltech.

Jim Workman's dedication to alumni is exemplified by his many years of service to his classmates and fellow Caltech graduates, ranging from his role as reunion chair to his commitment to the Gnome Club to his past presidency of the CAA board. Some of his most visible efforts are focused on engaging and motivating "alumni to be"—current Caltech students—lending his hand across campus to all facets of student life, from the SURF program to the Caltech Y. He is a familiar face at many student/alumni events on campus, and takes time to meet each student personally, welcoming new undergrads, grad students, and postdocs to the Caltech community.

Bob Perpall has been a member of the Association board of directors, and has served as president of the Gnome Club and on the board of directors of the Caltech Associates. As the unofficial communications coordinator for the class of 1952, he has made it his personal responsibility to keep his class members in touch and up to date about one another and the Institute. His life membership on the SURF board and his dedication to the Caltech Y reflect his commitment to students and his interest in fostering both their academic pursuits and their involvement in "life beyond Caltech."

Alumni who are interested in becoming Association volunteers may visit http://alumni.caltech.edu/volunteering to learn more about the many volunteering opportunities.

FX Man . . . from page 11

more on artistry than computer science." He is also more likely to call himself a miserable programmer than an Oscar winner.

Does he even feel like an Oscar winner? "No. But I do feel like part of a team that won it. I've been thanked for my contribution. But everyone worked so hard."

Townsend points out that he was part of a group of 20 FX animators and a swirling mass of creature animators who made up the "hundreds of people" who had a hand in the high-tech fantasy film. The statuette was presented to Bill Westenhofer (the R&H visual effects supervisor) and representatives from collaborating companies in the early part of the televised Academy Awards ceremony, before Townsend tuned in. (When it comes to publicity, Townsend and fellow animators tend to be out of the media loop. "We're used to being listed after the caterers in the film credits," he says.)

Forays into the worlds of art and science give Townsend a unique perspective on both. Taking a year-long break from the Institute to attend art college in San Francisco, he discovered that students there were not that different from those at Caltech. His fellow Techers were pursuing reality through science, he noticed, while his art-school peers were pursuing their own version of reality.

Townsend did have the honor of being called "the galloping gourmet of special effects" at another Academy Award function, at which his explanation of *The Golden Compass*'s fluid-dynamics tools did help four of his colleagues win a Technical Achievement Award certificate. The movie also won a BAFTA for Special Visual Effects, awarded by the British Academy of Film and Television Arts.

While creating special effects, Townsend doesn't dream of golden statuettes. "I've never worked on a job and consciously thought that it could get us an Oscar. I always try to do my best work," he says.

His long-term dreams lie in creative ventures. He'd like to find a market for his photographs, like the ones he took of paint-splattered curbs and streets. He continues to take classes in furniture design and welding in hopes of starting companies that would reproduce and sell prototypes that he designs. "My fantasy is to someday support my family by making money from any creative impulse I have."

That said, Townsend glances at his watch, takes a last sip of coffee, and rushes off to tend to his newborn baby.

Watch for Townsend's effects in the upcoming Mummy *sequel. If you'd like to tell about your work in the biz, please e-mail hillarypb@earthlink.net, and note that you don't have to be an Oscar winner to do so. (Caltech's two known winners were already featured in 2007—Ray Feeney '75—and in 1992—Eustace Lycett '37.) Mothers are also welcome to contact* Caltech News, *but for the record, Townsend's mother did not.*

Alumni College to focus on technology transfer

Join us on Friday and Saturday, September 12 and 13, for the Alumni Association's 11th annual Alumni College, "From Research to Reality: Business Meets Technology at Caltech." This year's program will focus on the ways in which business, science, and innovation intersect as new technologies move from the laboratory to the marketplace.

Caltech faculty and administrators will be on hand to discuss the ways in which they partner with the private sector to transfer cutting-edge technology from the Institute to industry and beyond. Highlights include a keynote lecture by Caltech president Jean-Lou Chameau and a presentation by Robert Grubbs, 2005 Nobel Laureate in Chemistry.

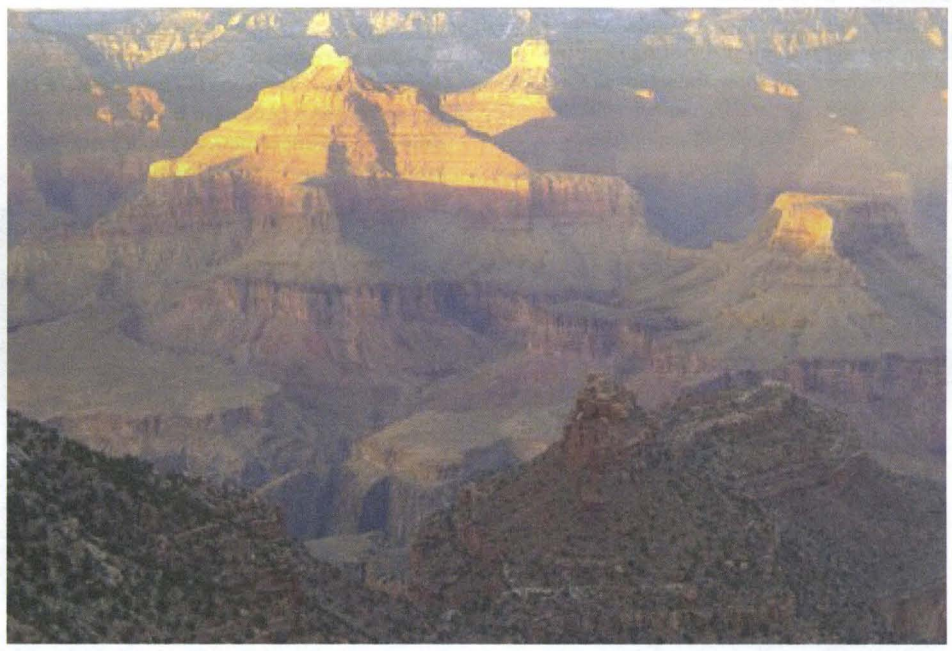
Confirmed speakers to date include Richard Andersen, Boswell Professor of Neuroscience; Frances Arnold, Dickinson Professor of Chemical Engineering and Biochemistry; Mark Davis, Schlinger Professor of Chemical Engineering; Fred Farina, MS '92, Caltech's assistant vice president for technology transfer; Yu-Chong Tai, professor of electrical engineering and mechanical engineering, and executive officer for electrical engineering.

Learn more about this year's program and get the latest information at http://alumni.caltech.edu/learning/alumni_college.

Grand Canyon . . . from page 5

turn host trace amounts of the radioactive elements uranium and thorium. These elements decay, spitting out helium atoms at well-constrained rates via alpha-particle emission. Although some of those atoms are lost through diffusion early in the grain's history, by measuring the abundances of all three elements, (U-Th)/He dating ultimately yields the time that an apatite crystal cooled below 70 degrees Celsius. Paired with information from boreholes about how Earth's temperature increases with depth, dates from apatite grains in rocks that are now at the surface communicate the last time those rocks were buried a mile deep.

A key finding of the Caltech team is that samples collected from the bottom of the Upper Granite Gorge region yield the same (U-Th)/He apatite dates as samples collected on the plateau surface nearby. "Because both canyon and plateau samples have resided near the same depth since 55 million years ago, a canyon of about the same dimensions as today must have existed at least that far back, and possibly as far back as the time of the last dinosaurs at the end of the Cretaceous period 65 million years ago," Wernicke says.



New research by Caltech scientists indicates that the formation of the Grand Canyon took place almost 50 million years earlier than previously thought, dating back to the age of the dinosaurs.

Wernicke says that the most surprising aspect of their new findings is that, since the Grand Canyon was originally cut, the adjacent plateaus have also eroded downward by about a mile, on average, every bit as fast as the bottom of the canyon. "And so the small, ephemeral streams that cover the arid plateau seem to be just as effective as the mighty Colorado at eroding away rock," he notes.

The erosional history proposed by the Caltech team jibes with other recent studies that also involve innovative radiometric dating techniques and speak to the early history of the canyon, Wernicke says. The first, undertaken by researchers led by Karl Karlstrom at the University of New Mexico and published last November in the same journal as the new Caltech study, demonstrated that the amount of downcutting of the Colorado in the Upper Granite Gorge was about 350 feet over the last 700,000 years. Extrapolated back in time, this rate is too slow to have carved the entire canyon in only six million years. Another University of New Mexico study, led by Carol Hill and Yemane Asmerom and published this March in the journal *Science*, demonstrated by dating cave deposits throughout the canyon that a water table, and therefore an erosion surface, lay somewhere near the canyon rim 17 million years ago, very close to the end of the pulse of erosion suggested by Caltech's (U-Th)/He dating.

The new work also echoes even earlier ideas of Richard Young of the State University of New York at Geneseo, Wernicke notes. In the 1980s, Young led a team that discovered that a group of ancient tributary canyons just south of the western Grand Canyon (Lower Granite Gorge region) were in fact originally formed between 63 and 50 million years ago, about the time the (U-Th)/He data suggest for initial cutting above the Upper Granite Gorge area. "The current wave of research thus strengthens the link between the formation of the tributary canyons and the evolution of the Grand Canyon proper, including the Upper Granite Gorge region," Wernicke says.

Wernicke credits many of the recent discoveries to cutting-edge dating techniques. "Although vigorous debate is sure to continue," he notes, "conventional wisdom about the history of the Grand Canyon in particular, and geology in general, is being challenged by these new, high-tech avenues of research."

Alumni Notes

1940

Abe M. Zarem, MS, PhD '44, strategic advisor for Knowledge and Information Technology Industries, has been named an AIAA (American Institute of Aeronautics and Astronautics) Honorary Fellow, the highest honor that can be bestowed by AIAA and its board of directors—those chosen are recognized "as being individuals of eminence with long and contributory careers in aerospace." The founder of Frontier Associates and developer of the "Zarem camera," a high-speed camera with no moving parts designated by the U.S. Navy as the world's fastest, Zarem's many honors include Caltech's Distinguished Alumni Award; election to the Hall of Fame of the Illinois Institute of Technology, where he earned his BS in electrical engineering; and induction as an Eminent Member of Eta Kappa Nu (HKN), the honor society for electrical and computer engineering. He is a member of the National Academy of Engineering and a fellow of the AIAA and IEEE. Throughout his career, Zarem has been involved in academic, civic, industrial, governmental, and professional activities, including positions as special advisor on technology transfer and the application of scientific research to many industrial, academic, and national leaders; as senior vice president of Xerox; as a private, technical, and management consultant; and as founder and chief executive officer of Xerox Development Corporation. He has served as distinguished visiting executive in science and technology and senior advisor in technology transfer and commercialization for JPL and as distinguished senior advisor for neuroscience technology transfer for the UCLA Brain Research Institute. A model of the "world's first practical space ion engine," which Zarem's company, Electro-Optical Systems, designed, now resides in the Smithsonian Institution in Washington, D.C.

1956

Tom Slanger, MS '57, writes that he "is alive and well and living in Palo Alto, playing tennis as often as possible." He is still with the Molecular Physics Laboratory at SRI International, and he has recently received a substantial NSF grant to build a large echelle spectrograph for studying upper-atmospheric airglow. This follows on terrestrial-atmosphere studies he has carried out over the past 10 years using similar instruments associated with major telescopes—for example, the Keck 10-meter telescopes in Hawaii, "among Caltech's treasures," as he notes. He and his colleagues have also used the Keck I telescope to study the nightglow of Venus. In addition, Slanger has recently become a Fellow of the American Geophysical Union. He and his wife, Diane, enjoy traveling the world to various conferences, and, "in particular, European travel gravitates towards Heidelberg, where daughter Tracy and 15-month-old granddaughter Olivia live. Tracy received her PhD at the University of Heidelberg in public health; son Daniel attended Cal State Northridge, and lives in West Los Angeles with wife Lexi, where he works as a professional photographer."

1960

Gary A. Flandro, MS, PhD '67, Boling Chair of Excellence in Space Propulsion and professor of aerospace engineering at the University of Tennessee Space Institute, has been named a Fellow of the AIAA (American Institute of Aeronautics and Astronautics), an honor bestowed by AIAA and its board of directors "upon those AIAA members who have made notable and valuable contributions to the arts, sciences, or technology of aeronautics or astronautics." His research interests include acoustics, aerodynamics, rocket propulsion, flight mechanics and performance, hypersonic aerodynamics, propulsion, and vehicle design. While at JPL in the 1960s he made the discovery that a rare alignment of planets on one side of the sun during the 1970s would permit a "Grand Tour" mission to explore the solar system's four outer planets, a discovery utilized by NASA in its successful Voyager missions. He was honored specifically for this work by the British Interplanetary Society in 1970 with its Golovine Award and by NASA in 1998 with its Exceptional Achievement Medal, and the gravity-assist method of the "Grand Tour" continues to be used by NASA missions, including Galileo, Cassini, and most recently New Horizons, scheduled to arrive at Pluto in 2015. The author or coauthor of 75 conference papers, Flandro has also written or coauthored 44 refereed papers, four books, and two book chapters. He currently lives in Tullahoma with his wife, Linnea, and a son, Troy. Another son, Tom, is a composite-structures engineer in Seattle, working on the Boeing 787 Dreamliner.

1965

William Goddard, PhD, Ferkel Professor of Chemistry, Materials Science, and Applied Physics at Caltech, has received the American Chemical Society's Award in Theoretical Chemistry. The awards ceremony took place in New Orleans in April at ACS's 235th national meeting. Renowned for his work in theoretical chemistry, computational materials science, and computational biochemistry, he was noted early in his career for his development of the generalized valence bond (GVB) approach to the quantum mechanics of molecules, which, according to ACS's weekly newsmagazine *Chemical and Engineering News* (vol. 86, no. 6), "combined the Hartree-Fock and valence bond theories to give accurate wavefunctions with simple orbital interpretations. GVB theory was used for the first accurate calculations of reactions and excited states of molecules such as ozone." A member of the National Academy of Sciences, Goddard has recently used quantum-mechanical methods to reformulate the foundation for high-temperature superconductors, has combined molecular dynamics and Monte Carlo techniques to achieve practical protein-folding predictions of membrane-bound proteins, and has discovered and explained the extremely enhanced thermoelectric properties of very thin nanowires. He has served as a consultant for numerous companies in the chemical, materials, electronics, and pharmaceutical industries, and he has cofounded several companies as well. His many honors include the Feynman Prize for Nanotechnology Theory, the NASA Space Sciences Award, and the Richard Chase Tolman Award.

1967

P. N. Shankar, MS, PhD '68, has authored *Slow Viscous Flows*, which was published September 2007 by Imperial College Press. It gives "a unified and systematic account of internal, external and unsteady slow viscous flows including the latest advances of the last decade, some of which are due to the author of the book." Shankar adds that although primarily for graduate students, academics, and research engineers, "diagrams and much discussion" acquaint the nonspecialist with "the qualitative features of these complex flows." After receiving his PhD from Caltech, Shankar joined General Electric, then moved to a teaching position at the University of Maryland, where he met his future wife, Priti Monteiro, who was working on her PhD in electrical engineering. Shankar's graduate thesis won the ASME's Robert T. Knapp Award for 1971, and he returned to India in 1972, where he went to work for India's National Aerospace Laboratories (NAL), Bangalore. (Two former directors of the lab are Caltech alumni: S. R. R. Valluri, PhD '54, and R. Narasimha, PhD '61.) Elected a Fellow of the Indian Academy of Sciences in 1992, Shankar retired from NAL in 2004 but retains the status of emeritus scientist. He also has taught math and science to students from socially and economically disadvantaged Bangalore families. Interested in science popularization, he has written three books on naked-eye star gazing, on how to build a telescope, and on using it to observe the night sky. He also plays the South Indian (Carnatic) flute—"although I reached a concert level standard, flute playing has only been a serious hobby." He and Priti married in 1974. Their son, Nachiket, is an assistant professor of anatomy at St. John's Medical College, Bangalore, and their daughter, Mridula, who graduated magna cum laude from Bryn Mawr College in biology, is currently working on a research project in public health, also in Bangalore. They have a granddaughter, Mallika, daughter of Nachiket and Niveditha.

1968

Erno S. Daniel reports that he is in his 30th year of practicing medicine at the Sansum Clinic in Santa Barbara, California. After completing his PhD work in magnetic resonance at UC San Diego in 1971 and receiving his MD from UCLA in 1975, he published papers and textbook chapters on a rare but deadly polyposis syndrome, then, later, on Alzheimer's disease and dementias. He lectures widely and has written over 200 medical newspaper columns, recorded educational CDs, and produced a health-information television program in Santa Barbara. His book, *Stealth Germs in Your Body*, has been published this year by Sterling Publishing—information can be found at www.stealthgerms.com. The book, says Daniel, "provides the reading public with an explanation of how medical diagnoses are made or missed, and how to collaborate with their physician to find hidden infections that may be the cause of chronic conditions hitherto attributed to noninfectious causes." He and Martha, his wife of 32 years, "are the proud parents of four successful children."

Martin L. Pall, PhD, writes that his book, *Explaining "Unexplained Illnesses,"* published May 2007 by Haworth Press, has generated much excitement, and since publication he has given 17 invited talks in five countries. The book maintains that each of a group of illnesses, including chronic fatigue syndrome, multiple chemical sensitivity, fibromyalgia, and post-traumatic stress disorder, is initiated by "short-term stressors such as physical trauma, exposure to several different classes of chemicals, psychological stress and even ionizing radiation." Each of these stressors, Pall suggests, "can act via increases in nitric oxide and an oxidant product peroxynitrite to initiate a complex biochemical vicious cycle which is the cause of illness. Because the cycle is basically local, depending which tissues in the body are impacted, you get a variety of different symptoms and therefore different diseases." He advocates a treatment approach "centered on using a series of nutritional supplements to down-regulate different aspects of the cycle." He has published 17 papers in this area, and believes "there may be many other diseases caused by this mechanism" and responsive "to the same basic treatment approach." Pall credits his Caltech training for giving him "the

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courage and breadth to tackle these daunting problems," and a part of the book is effectively a tribute to Nobel Laureate Max Delbrück, a professor in the Division of Biology when Pall was a student there.

1969

Charles Elachi, MS, PhD '71, Caltech vice president, director of JPL, and professor of electrical engineering and planetary science, has received the 2008 Goddard Astronautics Award, the highest honor of the American Institute of Aeronautics and Astronautics (AIAA), for his "outstanding engineering and scientific contributions to synthetic aperture radar technology and extraordinary leadership in American space science." The presentation ceremony took place at a black-tie gala in Washington, D.C., on May 14. 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 NASA Exceptional Scientific Achievement Medal, the IEEE Medal for Engineering Excellence, the NASA Outstanding Leadership Medal, and the UCLA Department of Earth and Space Science Distinguished Alumni Award. He is the author of two textbooks, *Physics and Techniques of Remote Sensing* and *Spaceborne Radar Sensors*, and he has been principal investigator on a number of NASA research and mission-development studies, as well as on the Shuttle Imaging Radar Experiments SIR-A and SIR-B.

Martin Israel, PhD, has received the 2008 Fellows Award, one of the 14th annual Outstanding St. Louis Scientist Awards presented by the Academy of Science of St. Louis at its annual dinner, held at the Chase Park Plaza on April 16 in midtown St. Louis. The award is "presented for excellence in communicating to and mentoring colleagues, future scientists/engineers and the general public," and the award citation reads: "Since his Caltech days, Dr. Israel has been an explorer of Space Physics. His work on cosmic rays and the tracking of cosmic ray nuclei have garnered him global recognition and appreciation and led to his design of new concepts and instruments. His is a constant source of expertise for NASA and the NRC, in addition to his responsibilities as Professor of Physics at Washington University."

1972

Steve Koonin, chief scientist for BP (formerly British Petroleum), received an honorary doctor of science degree from Michigan State University during commencement ceremonies May 2. A noted nuclear theorist, government scientific advisor, private-sector research leader, and university administrator, Koonin, who served as Caltech's provost from 1995 to 2004, is responsible for long-range technology, planning, and studies of alternative energy sources at BP, as well as for providing scientific and technical advice to senior executives and managing strategic university research relationships. He is also a leading advocate for alternate-fuel and renewable-energy research.

1973

Harold McGee and **Sharon Long** '73 write from San Francisco and Palo Alto: "Life and work are going well. Several years ago we decided to end our marriage, but we remain friends and continue to enjoy shared family get-togethers. Our son John will graduate in June from Stanford, with a chemistry major and Classics minor; in the fall he'll move east for graduate study in biochemistry at Harvard. Our daughter Florence is a sophomore at UC Davis, with interests including language, microbiology, and music." McGee published the second edition of *On Food and Cooking* in 2004, and is working on his *New York Times* column "The Curious Cook" and on a new book due to come out in 2009. He also received the 2008 Grady-Stack Award for Interpreting Chemistry for the Public, a journalism honor bestowed by the American Chemical Society. The award, which consists of $3,000, a gold medallion, and a bronze replica, recognizes "his contributions to food science, especially explaining the chemistry of cooking to both a scientific and a general audience." Long recently finished her term as dean of the School of Humanities and Sciences at Stanford, and has returned to a faculty life of research and teaching in the biological sciences. Both would enjoy hearing from Caltech friends, at e-mails mcgee@curiouscook.com and SRL@stanford.edu.

1974

David D. Ho has been appointed chair of a seven-member human immunodeficiency virus (HIV) scientific advisory board formed by Ardea Biosciences Inc., a biotechnology company headquartered at Carlsbad, California, that focuses on the discovery and development of small-molecule therapeutics in virology, oncology, and inflammation. The board will provide independent scientific advice and counsel regarding key company decisions relating to the development of drugs to treat HIV. Ho is the founding scientific director and chief executive officer of the Aaron Diamond AIDS Research Center and is in addition the Irene Diamond Professor at the Rockefeller University. He has been involved in AIDS research for 27 years, publishing over 350 papers and receiving numerous honors and awards.

1978

Louise Wannier has been named by Ernst & Young as a member of the independent judging panel for the 2008 Entrepreneur of the Year Awards for the Greater Los Angeles Area. The panel, which selects the Greater Los Angeles Area award finalists and winners, is made up of leaders from local businesses, academic institutions, and civic organizations. This year's award winners will be announced at the Beverly Hills Hilton on June 24. The awards program, now

[1]The Lipper/Barron's Fund Family survey uses an asset-weighted ranking system. Each fund's return was measured against all those in its Lipper category, and the resulting percentile ranking was then weighted by asset size relative to the fund family's other assets in its general category. The family's overall ranking was then determined by weighting the five fund categories in proportion to their overall importance within Lipper's fund universe. Due to the fund merger in April 2007, the TIAA-CREF mutual funds are no longer eligible for inclusion in the 5-year ranking. Ten-year rankings are not yet available. TIAA-CREF ranked 7th out of 67 in the 2006 Lipper/Barron's one-year survey and 38th out of 62 in the 2006 five-year survey.
[2]As of 12/31/07. For the 3-year period, 62%, for the 5-year period, 61%. Relative performance over other periods may vary. Past performance cannot guarantee future results. For more complete information about TIAA-CREF performance and rankings, visit www.tiaa-cref.org/performance.
[3]Funds refers to mutual funds and variable annuity accounts. For the past 3 and 5 years. The Morningstar median represents the midpoint of an index of comparable funds/accounts which is determined by factors such as asset class exposure and objective.
All TIAA-CREF investment vehicles are subject to market and other risk factors. TIAA-CREF Individual & Institutional Services, LLC, and Teachers Personal Investors Services, Inc., Members FINRA, distribute securities products. C41404 © 2008 Teachers Insurance and Annuity Association-College Retirement Equities Fund (TIAA-CREF), New York, NY 10017.
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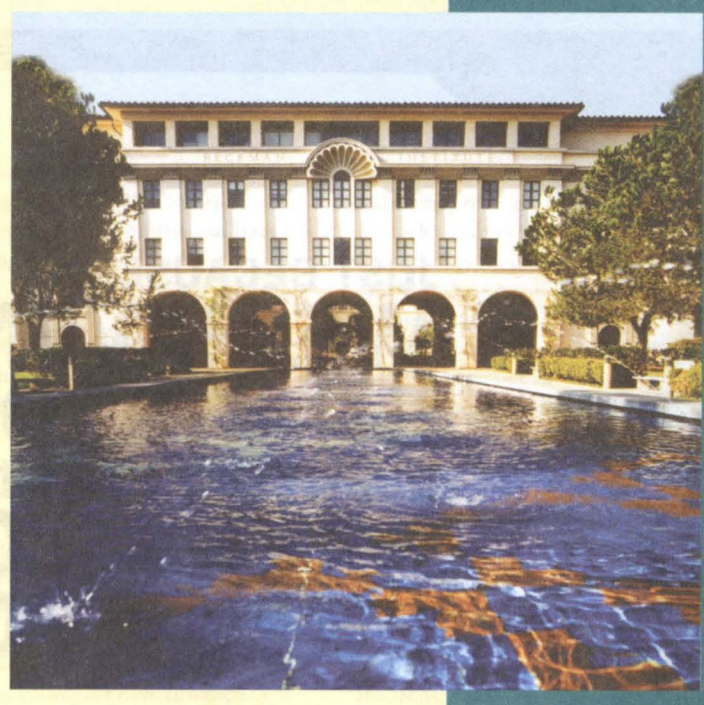

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1980

Mathew McCubbins, PhD '83, professor of political science at UC San Diego, has received an award for excellence in graduate teaching. Presentations of awards for excellence in teaching, research, and community service took place on the UCSD campus on March 25. The Chancellor's Associates, a program for donors who give an annual leadership gift of $1,500 or more to the university, recognized award recipients with a $2,500 honorarium. McCubbins was cited "for his contributions to the Department of Political Science graduate-level program as a teacher, mentor and advisor. His critical core classes and graduate workshops are considered challenging and rewarding by his students, and he is committed to nurturing students' analytical and practical skills. His work outside the classroom has also had a tremendous impact on the program. McCubbins serves as a dissertation advisor, research advisor and mentor to an impressive number of graduate students each year, and has been instrumental in revising the graduate curriculum to become one of the most groundbreaking programs in the country."

Charles K. Nartey writes: "After several years of working on self discovery I have finally settled for teaching in the computer engineering department of the University of Ghana, Legon. I am enjoying the excitement. I am also married with one son."

1981

Didier Lacroix, MS, has been named by MoSys Inc., a provider of high-density system-on-chip memory and analog/mixed-signal intellectual property, as its vice president of worldwide sales. With over 20 years of experience in areas ranging from consumer electronics to semiconductor intellectual property, Lacroix will oversee the MoSys worldwide sales organization. Prior to MoSys, he served as vice president of worldwide sales for Chipidea, and prior to that he cofounded NanoZilla of Los Gatos, a management consulting firm devoted to the adoption of electronic miniaturization technologies. Earlier, he was CEO of Discera, and vice president and general manager of MEMSCAP's wireless business. He has also held management positions at Synopsys and Cadence Design Systems.

Thomas Palfrey, PhD, Caltech's Flintridge Foundation Professor of Economics and Political Science, has been elected a fellow of the American Academy of Arts and Sciences. He specializes in the study of voting and elections, economic and political theory, public and experimental economics, and game theory, with a focus on how people devise strategies when faced with incomplete information. He has applied game theory to the analysis of voting behavior in committees and elections, and of bidding in auctions. He has founded or cofounded several experimental labs, including the California Social Science Experimental Laboratory at UCLA, the Social Science Experimental Laboratory at Caltech, and the Princeton Social Science Experimental Laboratory. The 190 new fellows elected to the academy join an assembly founded in 1780 by John Adams, James Bowdoin, John Hancock, and other scholars in order to provide practical solutions to pressing issues.

1988

John Wiltse and **Melinda Knox** '91 report that their first daughter, Piper Ione Wiltse, was born October 15, 2007. She was 19 inches long and weighed 5 pounds 15 ounces. The family lives with their dog and three cats in Lake Oswego, Oregon, where Melinda is a veterinarian and John is a systems engineer.

1991

Mahendra Rao, PhD, vice president, stem cells and regenerative medicine, at Invitrogen Corporation, has been named to the board of directors of ThermoGenesis Corporation, a leading supplier of products that process and store adult stem cells. Rao has been involved in stem-cell research for more than a decade, and at Invitrogen he heads the company's stem-cell research and development program, a position that he has held since January 2006. Before that, he was stem-cell section chief and senior investigator at the National Institute on Aging's Laboratory of Neuroscience, where he is currently a visiting professor. He has also held associate professor positions at both the Johns Hopkins University and the University of Utah schools of medicine, and at the National Center for Biological Science in India. He has served as chair of the FDA's Cell and Gene Therapy Advisory Committee and is the founder of Q Therapeutics, a company working on the development of a cellular therapy for the treatment of multiple sclerosis. Rao has coauthored approximately 250 primary articles, reviews, and editorials on different aspects of stem-cell biology.

1993

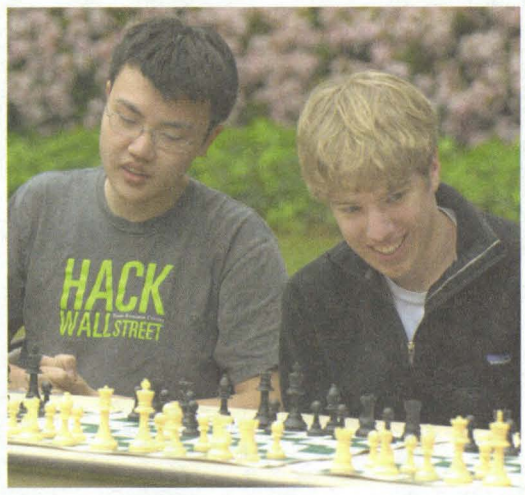
Eric Weisstein, MS, PhD '96, married Fei Lee, a fourth-year doctoral student at the University of Illinois College of Business, on December 21, 2007, in Beck Chapel at Indiana University, Bloomington. A native of Hong Kong, Lee earned a bachelor's degree in material science and engineering at National Cheng Kung University, Taiwan, and a master's degree in managing information systems at San Francisco State University. Weisstein is the creator of mathworld.com and a senior research fellow at Wolfram Research Inc., in Champaign, Illinois. He is also editor of *The Concise Encyclopedia of Mathematics* and is a consultant for the CBS television series *Numb3rs*. He and Lee live in Champaign.

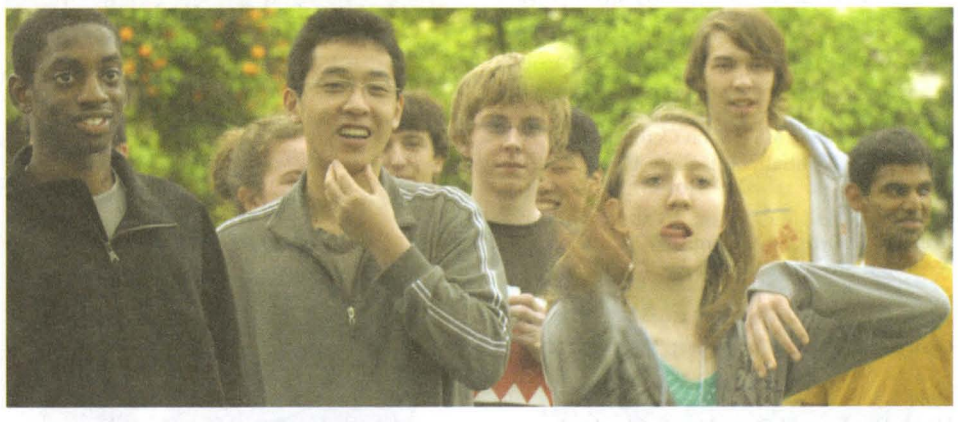
1997

Carter Moursund and his wife, Elizabeth, welcomed their son, Robert Paul Moursund, into the world on March 5 at 12:20 a.m. He was 20 inches long and weighed 6 pounds 10 ounces. "Mom, Dad, and baby are all doing well."

1998

Marie Csete, MS, PhD '00, has been named chief scientific officer by the California Institute for Regenerative Medicine (CIRM), the state's stem-cell research program established in 2004 by the passage of Proposition 71. As a key member of the CIRM's senior management team, she will participate in defining and executing the strategy for achieving the Institute's goals. Prior to joining the CIRM, Csete was John E. Steinhaus Professor of Anesthesiology at Emory University, with an adjunct appointment in cell biology, and program faculty appointments in biochemistry, cell and developmental

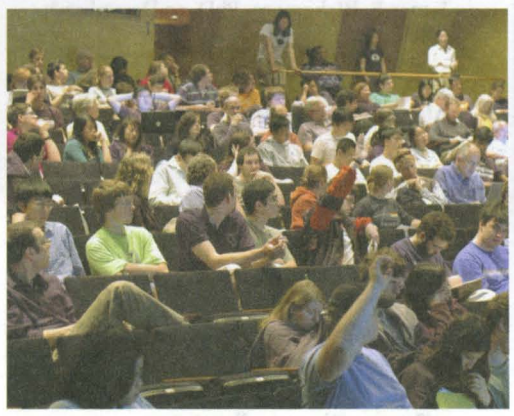




TODAY'S HOTSHOTS KEEP CALTECH MOVING INTO THE FUTURE

Taking a clockwise tour of Caltech offers a view of campus from the perspectives of past, present, and future. In early spring, potential students converged on campus for Prefrosh Weekend. They got a taste of student life through tours, games, a campus carnival and, to top it all off, fireworks. With classwork out of the picture, the weekend was a big hit, with prefrosh pitching tennis balls that ultimately pitched Caltech president Jean-Lou Chameau, among others, into deep water in the carnival dunk tank.

Also this spring, classwork was definitely *in* the picture at a student-faculty conference convened to address "the Caltech experience." A wide cross section of the Caltech community got together to canvass, among other topics, the perpetual question of whether Caltech undergraduates place unduly high expectations on themselves and, if so, what can be done about it. Discussants included former VP for Student Affairs and mathematics professor Gary Lorden '62, who joined student leader Tzong-Lian Tsay '10 to field questions from the crowd.



Spring activities that helped students unwind and recharge included the 2008 Caltech Dance Show and the annual ME72 contest, whose challenge this year was to design and build a catapult-like contraption capable of pitching a projectile as far as possible across the Braun Athletic field. At the end of a long and lively afternoon, the victory went to Jimmy Paulos and Matthew Feldman of Team Savage Rabbit. This year's contest theme of "fire and fly" had been selected to honor NASA astronauts and Caltech alumni Garrett Reisman, PhD '97, and Robert Behnken, PhD '97, who lifted off that same day on the space shuttle *Endeavor*, bound for the International Space Station. For a full view of *their* story, turn to page 3.

biology, neurosciences, and the Emory/Georgia Tech biomedical engineering program. She was also the director of liver transplant anesthesiology at the Emory University Hospital in Atlanta and director of the Emory/Georgia Tech human embryonic stem cell core, and codirector of the Emory MD/PhD program. Csete graduated from Princeton University with a degree in music and received her MD from Columbia University's College of Physicians & Surgeons. After residency and fellowship training at Massachusetts General Hospital and St. Elizabeth's Hospital in Boston, she served as an assistant professor in residence at UC San Francisco, where she directed the liver transplant anesthesiology team. Her PhD work at Caltech focused on the role of physiologic gases in stem-cell fate, and her laboratory at Emory continues to study the role of gases in the differentiation, death, and migration of stem cells.

Michele Ostraat, MS, PhD '01, has joined RTI International as director of engineering research for the Center for Aerosol Technology. In that role she will manage 25 staff members who are conducting a wide range of research on aerosol technology and nanotechnology platforms. She will also work to commercialize technologies developed by the research team. With more than 10 years experience in the aerosol and nanoparticle synthesis field—creating, managing, and leading programs designed to establish new products—Ostraat has served as a technical team leader for DuPont Engineering Research and Technology, and as a member of the technical staff at Bell Laboratories. She has earned five patents and received several awards, including a National Science Foundation Graduate Research Fellowship, a 2001 National Science Foundation Young Researcher Travel Award, and the 2000 Materials Research Society Graduate Student Gold Medal.

2001

Christopher Hirata, an assistant professor of astrophysics at Caltech, has been selected to receive a Sloan Research Fellowship from the Alfred P. Sloan Foundation. Established in 1955, the fellowships were set up to "support the work of exceptional young researchers early in their academic careers." Each award provides a grant of $50,000 for a two-year period, and recipients are free to pursue whatever lines of inquiry are of the most interest to them. Hirata received his PhD from Princeton in 2005 and joined Caltech's faculty in 2007. His area of research is cosmology—the study of the origin, structure, and evolution of the universe.

Ralph Weeks '81, rumors of whose demise were greatly exaggerated in the last *Caltech News*, writes that he "is not back from the dead, he has merely been hacked!" Ralph is alive and well, managing money at Citi Smith Barney, where many of his clients are Caltech alumni. Weeks adds that he is "active in the San Diego alumni group and arranges local events of interest such as briefings and tours of world-class facilities, including the UCSD Radiology Imaging Laboratory and the DIII-D fusion energy research facility at General Atomics."

Obituaries

1933
Edwin R. Kennedy, MS '34, PhD '36, on May 9.

1935
Clyde Chivens, on February 27.

1937
Charles F. Gates, MS '38, on October 10, 2007; **Dorr Kimball**, on January 17.

1939
Robert M. Kyte, on September 22, 2007; **Arthur J. Stosick**, PhD, on April 9.

1940
George H. Arvin, on February 27.

1941
Hugh Bradner, PhD, on May 5; **Charles L. Dailey**, MS '42, PhD '54, on March 25; **Willis E. Dobbins**, MS '46, on January 21.

1943
Irl Mowery, MS, on February 22; **Ralph Willits**, on April 14.

1944
Cran H. Barrow, on September 1, 2007; **Frank T. Edwards Jr.**, CAVU, on October 1, 2007; **Neville S. Long**, MS '48, on April 11; **Don S. Martin**, PhD, on March 6; **George M. Osgood**, on November 28, 2007.

1945
Mark M. Macomber, on March 16; **Donald K. Traverse**, on March 11.

1946
Charles W. Griffing, MS, Eng '47, on February 1.

1947
Paul Linam, on March 15.

1948
William S. Johnson, MS, on January 24; **Edward F. Roskowski**, on May 31, 2007; **Joseph W. Wechsler**, MS '49, Eng '50, on February 3.

1949
Wayne Herzig, on March 29; **Joseph W. Schmit**, MS, on January 28.

1950
Warren G. "Fritz" Whiting, on March 8.

1953
James R. Kliegel, on January 10; **Norman Patrick "Pat" Wilburn**, MS '54, PhD '58, on January 10.

READ COMPLETE *CALTECH NEWS* OBITUARIES ONLINE

The full Caltech News *obituaries may be found at http://alumni.caltech.edu/network/obituaries, where readers can browse expanded content and additional biographical information about the alumni listed here.*

1954
Thomas E. Feuchtwang, MS, on December 31, 2007; **John Keith Rowley**, PhD, on October 29, 2006.

1957
Donald S. Lopez, MS, on March 3.

1962
Stanley M. Flatte, on November 4, 2007; **Julian V. Noble**, on March 1.

1964
Donald Harlow, on January 27.

1967
Steven R. Tyler, on March 19.

1970
James E. Blakemore, PhD, on December 5, 2007.

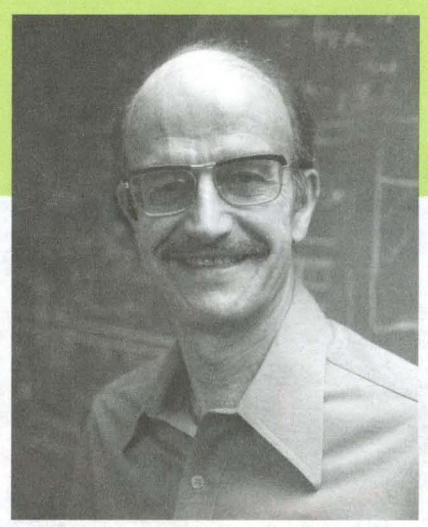
1973
Ahmed M. Abdel-Ghaffar, MS, PhD '76, on April 17.

1977
Stephen Taylor, MS, PhD '86, on January 6.

FOR THE RECORD

Ralph Weeks '81 was erroneously reported as deceased in the last issue of *Caltech News*. For further details, please see page 17.

GIUSEPPE ATTARDI 1923–2008



Giuseppe Attardi, whose work linked degenerative diseases and aging to genetic mutations in mitochondria, died at his home in Altadena on April 5 at the age of 84.

Attardi, the Steele Professor of Molecular Biology, was one of the first scientists to study the genome of mitochondria, a small, rod-shaped organelle present in every cell in which respiration occurs. Believed to be the descendants of free-living bacteria engulfed by nucleated cells nearly two billion years ago, they still retain a small bacteria-like circular chromosome. Beginning in the 1960s, Attardi showed that the mitochondrial DNA (mtDNA) of this chromosome was functional. He identified 37 mitochondrial genes, isolated the messenger RNA of each of them, and found out the proteins they produced. He then developed techniques for investigating genetic diseases associated with malfunctions in mtDNA and went on to discover a relationship between mtDNA mutations and aging.

Born in 1923 in Sicily, Attardi earned an MD from the University of Padua in 1947 and remained there as an assistant professor in the Institute for Histology and General Embryology for almost 10 years. He also spent time at the Karolinska Institute in Stockholm, Sweden, as a research fellow in cell research and genetics, and at the Washington University in St. Louis School of Medicine as a Fulbright Fellow. Still on the Fulbright Fellowship, Attardi came to Caltech in 1959, and joined the faculty as an associate professor of molecular biology four years later. He became a full professor in 1967 and the Steele professor in 1985.

Associate Professor of Biology David Chan credits Attardi with being a leading figure in identifying the products and functions of the mitochondrial genome. He was also the first to show that mutations in mtDNA contributed to disease. Attardi and a student developed a technique in which they removed the mtDNA from a healthy human cell line and replaced it with the mtDNA of sick patients, which allowed them to distinguish whether the mtDNA or the DNA of the main genome, in the nucleus, was causing the disease. They also examined the relationship between mtDNA mutations and changes in cell function. Using this technique, Attardi showed that a rare form of dementia was caused solely by mutations in mtDNA. Many labs have since used his approach to understand how mutations in mtDNA diseases affect mitochondrial function.

"Giuseppe was one of the founders of what is now a central and still-expanding area of molecular cell biology," says Gottfried Schatz, emeritus professor of biochemistry at the University of Basel's Biozentrum, in Switzerland. "His unique insights bore magnificent fruits with the landmark description of the transcription map of mammalian mtDNA, as well as the precise characterization of the mechanism of mitochondrial diseases and the dynamics of human mitochondrial genomes."

In recent years, Attardi's lab at Caltech, in which he was still active until less than a year ago, has focused on how mtDNA replicates and on the relationship between mtDNA and the aging process. The team discovered that people over the age of 65 carry a significantly greater number of genetic defects in a specific region of their mtDNA, which suggests that cell aging may begin in the mitochondria.

In 2003, in collaboration with several groups in Italy, Attardi's lab studied the mtDNA of 55 unrelated Italian centenarians to see if there was a relationship between their mitochondria and their longevity. They found that the centenarians were five times more likely than the general population to have a mutation in a region that controls mtDNA replication. This may provide a survival advantage by speeding the replication of mtDNA, allowing aging cells that carry the mutation to produce more energy than those that do not.

"One of the things I will always remember about him is his constant excitement for all types of biological questions," says Chan. "I think his intense curiosity is one reason he accomplished so much as a scientist." Schatz adds, "To him, science was everything and he never tired of discussing the latest experiments. Yet he also embodied a vanishing breed of scientists whom I would define as 'gentleman intellectuals.' He had a superb grasp of European history and world culture, had mastered French and German to a very high level of proficiency, and even in his most spirited discussions refrained from personal invective or overt aggression. To me, he was an example of how science can keep us young in spirit, and ennoble us."

Elected to the National Academy of Sciences in 1984, Attardi also received the Gairdner Foundation International Prize, the Antonio Feltrinelli International Prize for Medicine from the Accademia Nazionale dei Lincei, and the Passano Foundation Award.

He is survived by his wife, Anne Chomyn, a senior research associate, emeritus, at Caltech; a son, Luigi; a daughter, Laura; and a grandson.

J. Kent Clark
1917–2008

J. Kent Clark, professor of literature, emeritus, died March 6. He was 90 years old.

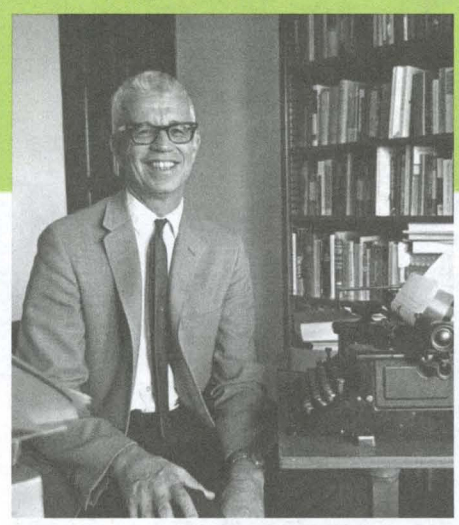
A biographer, novelist, and writer of musical comedies, he taught at Caltech from 1947 to 1986, and throughout those decades he played an active and still widely remembered role in setting a cultural standard and tone for the campus.

Clark was born on a large wheat ranch in Utah, but the post–World War I agricultural depression forced his father to sell the farm and become a wheat buyer for Globe Mills (now Pillsbury) in Brigham City and Ogden, where Clark attended school. After graduating from Brigham Young University (BYU) in 1939 with a major in English and a minor in history, he went to Stanford for his PhD. In 1943, before he could start his dissertation, he was drafted into the army as a radar technician and instructor in Tampa, Florida, then trained to be an officer in the Air Force. By the time he graduated as a second lieutenant in May 1945, the war in the Pacific was drawing to a close, and Clark was posted to a radar outfit in the Philippines, where he became the de facto supply officer for the whole 85th Fighter Wing of the 13th Air Force.

Resuming his graduate studies in 1946, Clark found that Stanford did not have the historical documents he needed for his thesis on the politics of Jonathan Swift, so he became a reader at the Huntington Library in San Marino, a position that was fortuitously combined with an instructorship at Caltech. After earning his PhD in 1950, he stayed on at Caltech as an assistant professor of English, becoming an associate professor in 1954, full professor in 1960, and professor of literature in 1980. He retired as professor emeritus in 1986.

In the 1950s, Clark revised Caltech's freshman English course to align it with the Institute's European history course, so that both began in the 17th century. He also introduced the formidable "double jeopardy" essays that were graded by both the history and English professors. "It was unconstitutional," Clark said in an interview with the Caltech Archives Oral History Project, "but it was a fine education." He was a popular teacher, affectionately teased for the similarity of his name to Superman's alter ego, Clark Kent. Although he didn't mind being called "Superprof," "Man Super," or "Namrepus," he began using the initial of his first name, Justus, to make the comparison less obvious.

Clark's publications include a scholarly article, "Swift and the Dutch," a historical novel, *The King's Agent*, and two biographies, *Goodwin Wharton* and



Whig's Progress: Tom Wharton Between Revolutions, as well as a drama anthology written in the 1960s with English professor Henry Dan Piper called *Dimensions in Drama. Six Plays of Crime and Punishment*.

He chaired the Committee on Standards and Honors, served as an officer of the Friends of the Caltech Library, and chaired the Committee on Programs, which oversaw Beckman Auditorium and other venues. With the help of fellow professor David Smith, he obtained funding for a visual arts program, recruited an artist in residence, and arranged art exhibitions and visiting artists.

But it is as the writer of witty songs, and the founder, director, and producer of a musical troupe, that Clark will be most fondly remembered. Having honed his entertainment skills as a student at BYU and at a Bryce Canyon lodge where he worked during the summers as a bellhop and program director for the nightly entertainment, Clark loved putting on shows at Caltech. From the 1950s through the 1970s, his troupe, the Caltech Stock Company, staged 10 musicals and performed at many special campus events, singing hilarious songs written by Clark and set to music by his friend, Pasadena lawyer and musician Elliott Davis. Some of these songs are still popular today, including "The Richter Scale," which can be heard at http://archives.caltech.edu/exhibits/earthquake/mod3/1024x768/html/pg14.html#.

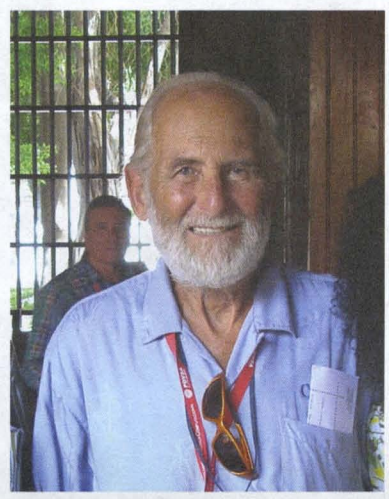
Clark is survived by his wife, Carol; three children by his first wife; three stepdaughters; and four grandsons.

Herbert Keller
1925–2008

Herbert Keller, professor of applied mathematics, emeritus, and a leader in numerical analysis and scientific computing, died in his Pasadena home on January 26, after his routine morning bicycle ride. He was 82.

The son of a bartender who loved numbers and puzzles, Keller was born in Paterson, New Jersey. He studied electronics at Georgia Tech and joined the Naval Reserve Officers Training Corps. During World War II, he became a fire-control officer in charge of the guns on the USS *Mississippi*, where he trained future president Jimmy Carter to be a gunnery officer.

Keller later went to New York University and received his PhD in mathematics in 1954. He eventually became a professor of applied mathematics at the Courant Institute of Mathematical Sciences at NYU. In 1965, he came to Caltech as a visiting professor and returned as a full professor two years later, joining the newly formed applied-mathematics group. He later became the executive officer for applied mathematics and director of Caltech's branch of the Center for Research on Parallel Computation.



Keller made significant contributions toward techniques for solving complex problems with a computer, including several innovative techniques to solve two-point boundary-value problems, which arise in such diverse areas as fluid mechanics, quantum physics, and electromagnetism. He also made strides in bifurcation theory, which looks at how changes in parameter values influence a system. One simple example is the problem of how changing the number of fishing licenses given out each year affects fish population dynamics. Keller's methods are the basis for computer software that is widely used to derive numerical solutions to nonlinear equations. He remained an active researcher even after his retirement in 2000.

Colleagues described him as a mathematician with chutzpah, unafraid to speak his mind and to go after whatever problem interested him—advice that he doled out through the years as an influential mentor to dozens of students and postdocs. His fearless approach to research mirrored his other passion in life—cycling.

His brother recalled a cycling trip they took in the south of France in 1948, when they inadvertently joined the Tour de France after riding through roads lined with cheering spectators. Keller rediscovered the sport in the early 1980s, and despite suffering countless accidents—many with serious injuries—never stopped riding. In one of his most oft-told stories, he said a collision he had with a pile of lumber in Germany fixed his nearsightedness. Typically biking 100 to 150 miles a week, Keller didn't allow age to slow him down—he finished a 1,250-mile European tour when he was 68. He completed several centuries and double centuries, which are rides stretching 100 or 200 miles; he said he rode his last double century when he was 72.

In addition to serving on numerous committees and councils, he was a fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and the Guggenheim Foundation. He was the president of the Society of Industrial and Applied Mathematics, and later won its von Kármán Prize. With Eugene Isaacson, he coauthored a textbook that became a classic in numerical analysis.

His brother, Joseph, a retired professor of mathematics and mechanical engineering at Stanford University; his son, Steve; his daughter, Debra; and four grandchildren survive him.

SMART ART

The spacey, surreal world on the back-page poster may look like the virtual environment for a new cosmic video game, but it's actually an amalgamation of art projects by four members of the Caltech community, who recently showed their work at New York's Museum of Modern Art (MOMA). The scientific imagery appeared in a major, critically acclaimed show called Design and the Elastic Mind, which was on view this spring, and which the *New York Times* called "an exhilarating new show [that] makes the case that through the mechanism of design, scientific advances of the last decade have at least opened the way to unexpected visual pleasures." The background of the poster is a view of dark matter around galaxies across time and space, created by former Caltech postdoctoral scholar Richard Massey and his colleagues. The creatures crawling across the planes of the dark-matter graphic are intricate origami sculptures created by Robert Lang '82, PhD '86, a pioneer of computational origami, in which mathematical techniques are used to design the folded paper creations. In the foreground of the horizontal plane, and somewhat resembling crop circles as seen from an airplane, is an image of a minuscule device created by a team led by Michael Roukes, professor of physics, applied physics, and bioengineering. Roukes used the nanosized instrument to discover a fundamental limit to the amount of heat that can be conducted by objects of atomic dimension. Also on the atomic scale are the objects floating above and below the dark matter and adorning the plane in the upper right created by Paul Rothemund '94, senior research associate in bioengineering, computer science, and computation and neural systems. Rothemund's playful designs come from molding strands of DNA into useful and often decorative shapes, a technique that eventually could be used to shrink the wires and switches inside computer chips.

Caltech News