Susan and swirling is done, if you’ve ever dinner guests by filling an empty bottle professor of economics Antonio Rangel of a premium Cabernet Sauvignon with vestigators, including Caltech associate wondered whether you could fool your postdocs-in a functional MRI that's masquerading as the cheap stuff. While people might lie, the latest re-

search suggests that brains don’t. To track changes in mental activity, Rangel measured changes in the blood flow in the subjects’ medial orbitofrontal cortex, a region of the brain believed to be involved in people’s experience of pleasure. The study, Rangel says, showed that “prices, by themselves, af-

fect activity in an area of the brain that is thought to encode the pleasure of an experience.” Most people believe that the more they pay for something, the better it must be, and this study shows that, in the case of wine, at least, they seem to like “expensive” stuff more, regardless of its actual attributes. Like oenophiles at the opening of the Pinot Noir season, the public seemed to lap up Rangel’s wine study, which made headlines and news reports around the world, and even sparked vigorous consumer debates over the Internet about wine pricing. Rangel says that following the report’s January release, he was deluged with phone calls from reporters, a phenomenon that he had never experienced before. His reaction to the outpouring of public interest is restrained: “I don’t have any-

thing interesting to say about this.” It’s not surprising that Rangel would be mum about the media onslaught, since he hasn’t generally in-

vestigated such intoxicating subjects. Rangel, who grew up in Madrid and Mexico City, came to Caltech in 1989 with an interest in physics. But during his sophomore year, he took a class with John Ledyard, Davis Professor of Economics and Social Sciences, who immediately inspired, and became an economics major. “I just fell in love with economics,” he says. “The fact that you could think analytically about real-world problems was exciting.” Rangel got his PhD in economics from Harvard in 1998 and then became an assistant professor of economics at Stanford. He focused on theoretical studies of public policy issues such as how to inspire people to take into

Continued on page 5 . . .
A Book for the Curious Brain

BY BARBARA ELLIS

You know how it is—the person you meet at a party or on the plane starts up a conversation, and inevitably the subject turns to "So, what do you do?" For some academics—mathematicians or theoretical chemists, perhaps—the answer to that innocent question can be a conversation stopper. But for others, it can lead to a barrage of questions. This has always been the case for Sam Wang '86, associate professor of molecular biology in Princeton's Neuroscience Institute, and not just on planes or at parties. Wang studies the brain, and taxi drivers, barbers, even scientists from other disciplines, ply him with questions once they find out his field. "Is it true that alcohol kills brain cells?" "Does Sudoku improve my memory?" "Can blind people hear better than sighted people?" Wang heard so many variations on this theme that he finally decided "it would be fun to write a popular book for nonscientists that would bust some popular myths and tell all those curious people some real facts—a kind of user's manual for the brain."

That user's manual has now been published as Welcome to Your Brain by Bloomsbury USA (the same publisher whose British counterpart brought out an unassuming little series about a child-wizard named Harry Potter) and is subtitled Why You Lose Your Car Keys But Never Forget How to Drive and Other Puzzles of Everyday Life. Early reviews have been encouraging. "If all scientists could write like this," enthused science writer Sandra Blakeslee, a frequent contributor to the New York Times, "professional science writers would be out of a job." Wang wrote the book with Sandra Aamodt, the editor of Nature Neuroscience, who had been thinking of writing a book along the same lines when a mutual acquaintance brought them together.

When the New York Times ran a "teaser" from the book last fall on how to keep aging brains healthy, it became the most e-mailed article of the newspaper for almost a month.

It's "a book about the brain for people who own one and are interested in how it works, and how to use it better," Wang says. It has "practical advice for people in their 40s who are feeling a little less smart than they were; a parent worried about raising a child; and a businesswoman who wants to use her cell phone better." With its soft cover and almost-square shape reminiscent of the For Dummies series, and amusingly quirky illustrations by Lisa Haney, the book has the look and feel of a graphic novel. It's precisely that user-friendly aura that makes it accessible and appealing to a broad audience, including "high-school students in Illinois, an art gallery owner in Los Angeles, or a taxi driver in Boston." It's written in a humorous, direct style with references to popular culture, personal stories, and puzzles, and although it's scientifically accurate (every chapter was checked by at least two colleagues in the field), there are no daunting scientific terms, tables, diagrams, or references to papers. Readers who want to know more are directed to a website.

It's hard not to be drawn into this book, whose shaded boxes in three categories—"Practical tip," "Myth," and "Did you know?"—break up the text and carry eye-catching titles such as "Men learn to be gay," "Go see it on the mountain: The neuroscience of visions," and "Warning signs of a stroke—and what to do." (We'll leave it to you to decide which heading is in which category.) The manual's six sections, each dealing with a different aspect of the brain, encourage readers to leaf and dip. Wang and Aamodt hope at least some of them will start by taking the quiz that opens the book, to test what they already know, rightly or wrongly, about the brain. (We've included a sampling of the questions on page 8.) Even teachers shouldn't be dismayed if they score less than 100 percent. "Surprisingly, even neuroscientists don't do so well in that quiz," Sam says. "The people who do best are physicians, because they learn the most useful information about the brain during their medical training."

Naturally, Wang hopes the book will be a critical and popular success. But he was motivated to write it because "I spend my time in the lab looking for fundamental facts on brain function, and had been wondering how an ivory tower person like myself could do something that's useful for people." He points out that over the last 20 years, new techniques have greatly increased scientific understanding of how the brain functions. "We used to look at brain tissue in the dish, and now we're imaging brain function in the intact animal." The general public, however, hasn't had much opportunity to keep up with these advances, because many of them are published in journals that only neuroscientists tend to read. The information needs to be tweaked into something that's relevant to people.

"When I read scientific papers," Sam says, "I'm always thinking in the back of my mind how I could make what I'm reading into something to interest a lay person. For example, mice cannot appreciate Diet Coke because the sugar receptors in their tongues can't bind to the sugar substitute aspartame. A neuroscientist may not think this is a particularly interesting fact, but perhaps a lay person would." Of course, he adds, "I use different criteria when designing laboratory experiments or thinking up projects for my lab team."

Continued on page 8...

Left, Sam Wang in his Princeton office. Above, a toy wind-up brain toys with the idea of self-contemplation.
Caltech broke ground for two new laboratories this winter, each of which will provide the Institute with state-of-the-art facilities to pursue work at the forefronts of science and technology.

On December 7, a groundbreaking ceremony was held for the Walter and Leonore Annenbergen Center for Information Science and Technology. The building, which will be located on the site of a former parking lot east of the Moore Laboratory, is slated to be completed in the summer of 2009.

The Annenbergen Center will house participants of the IST (Information Science and Technology) initiative, a program of interdisciplinary research and instruction that addresses the growth and impact of information as it relates to all science and engineering practices; researchers in this initiative come from many academic divisions.

Construction of the building was made possible by a $23 million gift from the Annenbergen Foundation. Walter H. Annenbergen’s widow, Leonore, the president and chairman of the foundation, was personally involved in the bequest, and in aesthetic aspects of the design process.

At the ceremony, her daughter, Wallis, vice president of the Foundation, said that as the scientists at IST are reinventing the very boundaries of science and technology, “we deserve a research home that is collaborative and inclusive and revolutionary as the work itself.” She noted that she is especially pleased to be helping along because “as a society, we must redouble our commitment to basic, undirected, scientific research.”

On February 13, Caltech officially broke ground for the Warren and Katharine Schlinger Laboratory for Chemistry and Chemical Engineering. The new facility, situated between Noyes and Beckman Behavioral Biology laboratories, will provide laboratories and classroom and conference space for Caltech’s chemists and chemical engineers, and is scheduled for completion in 18 months.

The Schlinger Lab was named in recognition of a $20 million campaign donation from Warren Schlinger ’44, PhD ’49, and his wife, Katharine, a Pasadena native, who met her husband at Caltech while working as a department secretary for chemical engineering.

Additional gifts have come from an array of supporters, including the Moore Foundation, the estate of former trustee Victor K. Atkins; trustee G. Patricia Beckman (daughter of Mabel and Arnold Beckman, PhD ’28); Barbara J. Dickinson (widow of Richard Dickinson ’52); The Ralph M. Parsons Foundation; the John Stauffer Charitable Trust; John W. Jones ’41; Helen and Will Webster ’49; Gregory P. Stone ’74; and others.

**Campus Update**

**GROUND BROKEN FOR GROUNDBREAKING RESEARCH**

NPR science correspondent and ABC News Special Correspondent. Robert Krulwich will be the speaker at Caltech’s 114th commencement on June 13. Krulwich, who has been called “the most inventive network reporter in television” by *TV Guide*, specializes in explaining the complexities of science, technology, and economics in a style that is clear, compelling, and entertaining.

He has explored the chemistry of global warming and the mysteries of RNA, created an Italian opera, *Ratso Rizzo*, to explain how the Federal Reserve regulates interest rates, and pioneered the use of new animation on ABC’s *Nightline* and *World News*, and on NPR’s Internet site to explore cellular biology and subprime lending.

Krulwich regularly appears on ABC’s *World News* and on NPR’s *Morning Edition* and *All Things Considered*. He cohosts NPR’s *Radio Lab*, a national radio series that highlights new developments in science for people who are curious but not usually drawn to science shows.

“I like talking about ideas, and I especially like creating images that will keep those ideas in peoples’ heads,” he says.

Krulwich first joined NPR in 1978 and was the station’s economics reporter until 1985, when he joined CBS News. Since 1994, Krulwich has been an ABC News correspondent, and he has collaborated on projects with the network’s leading new personalities, including Barbara Walters, the late ABC News anchor Peter Jennings, and longtime *Nightline* host Ted Koppel, with whom he cohosted the eight-part prime-time series “Brave New World,” which probed the “eight biggest questions facing humankind.”

Krulwich is also a regular correspondent on the PBS investigative series *Frontline*, where he won an Alfred I. du Pont-Columbia University Award for his coverage of campaign finance in the 1992 presidential campaign. He has also received a national Emmy Award for his investigation of privacy on the Internet, “High Stakes in Cyberspace,” and a George Polk Award for a show on the savings and loan scandal. His ABC special on Barbie, a cultural history of perhaps the world’s most celebrated doll, also won a national Emmy.

His other reporting awards include the Eleanor Neeon Extraordinary Communicator’s Award from the National Cancer Institute in 2000 and a Science Journalism Award from the American Association for the Advancement of Science in 2001 for a NOVA special on the human genome. Most recently, he shared a 2007 Communion Award for TV/Radio reporting from the National Academies Keck Futures Initiative. Krulwich and his co-winners were honored for “imaginative use of radio to make science accessible to broad audiences.”

Krulwich, who holds a BS from Oberlin College and a law degree from Columbia, lives in New York City with his wife, Tamar Lewis, a national reporter for the *New York Times*.

**Recognition**

For an up-to-date list of awards and honors bestowed recently upon Caltech faculty and staff, go to http://today.caltech.edu/index/awards/

**GOLDEN FUTURE**

*The Ralph M. Parsons Foundation* contributed $11 million to the Chemical Engineering Program of Technology, $5 million to the Moore Foundation, and $2 million to the Moore Center for Information Science. This gift, along with the names of generous donors, is featured in the plaque that will be placed on the front entrance to the Institute’s new building. The plaque reads:

> *The Ralph M. Parsons Foundation* contributed $11 million to the Chemical Engineering Program of Technology, $5 million to the Moore Foundation, and $2 million to the Moore Center for Information Science.

The Ralph M. Parsons Foundation is a private, not-for-profit philanthropic institution that seeks to support and protect the health and well-being of humanity and the environment. It is dedicated to the development of a world that is sustainable, healthy, and just.

The Parsons Foundation believes that education is a fundamental right and a tool for positive change. It supports organizations and programs that promote education, research, and innovation in fields such as science, technology, engineering, and mathematics. The foundation also supports organizations that work to improve the health and well-being of individuals and communities.

The Ralph M. Parsons Foundation has a long history of supporting Caltech, and its contributions to the Institute have helped to advance its mission of educating the next generation of leaders in science, technology, and engineering. The foundation has made significant contributions to a number of Caltech’s programs and initiatives, including the McBean Center for Science and Engineering Education, the Beckman Institute for Advanced Study, and the Moore Laboratory for Nanotechnology.

The Ralph M. Parsons Foundation’s support for Caltech is a testament to the foundation’s commitment to the community and to the importance of education and innovation in shaping the future.

*The Ralph M. Parsons Foundation* is proud to support Caltech and its mission to advance knowledge and understanding through education, research, and innovation. The foundation’s contributions to the Institute are a testament to its commitment to supporting education and innovation in the fields of science, technology, engineering, and mathematics.
CALTECH PROFESSOR TIRRELL AND FOUR ALUMNI NAMED TO NAE

David Tirrell, the McCullom-Corcoran Professor, professor of chemistry and chemical engineering, and chair of Caltech’s Division of Chemistry and Chemical Engineering is one of 65 new members to be elected to the National Academy of Engineering (NAE).

Tirrell was cited by the academy for his “pioneering contributions to bioengineered materials and synthesis of novel artificial proteins.” His research combines organic, biological, and materials chemistry to make new macromolecular systems with exquisite control of structure and function. NAE membership is among the highest professional distinctions accorded to an engineer. It honors those who have made important contributions to engineering theory and practice, and those who have demonstrated unusual accomplishments in the pioneering of new and developing fields of technology.

Tirrell’s research explores artificial proteins made by the expression of artificial genes in microbial cells. He uses biological cells to make proteins, just as nature does, but reprograms the cells to produce specific materials that are targeted toward important biomedical technologies. He is also investigating the creation of novel amino acids that are the building blocks for applications in biology, biotechnology, and medicine.

In addition to Tirrell, four Caltech alumni were named to the NAE: Michael Hurkapiller, PhD ’74, general partner with Alloy Ventures Inc.; Palo Alto (“for the invention and commercialization of DNA and protein sequences and DNA synthesizers that have revolutionized comparative genetics and the mapping of the human genome”); Alex Livianos ’70, PhD ’75, president, Northrop Grumman Space Technology (“for contributions to the development and insertion of advanced semiconductor technology for commercial and government space systems”); David Luenberger ’59, professor, department of management science and engineering, Stanford (“for contributions to control theory, optimization algorithms, and economic dynamics”); and Yanis C. Voros, PhD ’79, dean, Viterbi School of Engineering, USC (“for fundamental advances in fluid flow, transport, and reactions in porous media applied to the recovery of subsurface resources”).

Founded in 1964, the NAE is an independent, nonprofit institution that advises the federal government on issues of science and technology policy while conducting studies to articulate the societal implications of rapid technological change. The NAE also initiates programs designed to encourage international cooperation between engineering societies, to improve the public’s technological awareness and understanding, and to enhance the dialogue between scientists, engineers, and policy makers.

Chemistry professor David Tirrell is Caltech’s newest member of the National Academy of Engineering.

Technology ("for contributions to the development and insertion of advanced semiconductor technology for commercial and government space systems"), David Luenberger ’59, professor, department of management science and engineering, Stanford ("for contributions to control theory, optimization algorithms, and economic dynamics"); and Yanis C. Voros, PhD ’79, dean, Viterbi School of Engineering, USC ("for fundamental advances in fluid flow, transport, and reactions in porous media applied to the recovery of subsurface resources").

Wine . . . from page 2

I always was interested in understanding behavior and public policy in situations that weren’t standard,” Rangel says. “But the standard economic models did not apply to behaviors like addictions. I started to read about neuroscience. For one year, I just read and read. I blew my mind how much one could understand about the neuroscience of addiction in ways that were useful for social scientists.” Neuroscience research could be used, for example, to improve public policy regarding addiction.

Rangel’s interest in neuroscience coincided with the emergence of the field of neuroeconomics. About five years ago, social scientists began using brain imaging techniques like MRIs to obtain visual data of how people make decisions. These scans literally show which parts of the brain are active when people are making economic choices, and scientists believe that as they learn more about the brain, they will be able to develop a neural blueprint of behavior that will have numerous economic, political, social, and even medical applications.

With the opening in 2002 of Caltech’s Broad Center for the Biological Sciences and its sophisticated imaging facilities, the Institute became one of the leaders in neuroeconomics, and in 2006, Rangel departed Stanford for Caltech.

“Caltech has a shot over the next few decades to crack the problem of how the brain makes decisions,” Rangel says. “Why do some people have self-control and others don’t? Why can some people take addictive substances with no ill effects while others become trapped? These and other questions go to the core of who we are, and we now have tools to make significant steps. That’s too beautiful not to be done.”

Switching from theoretical to experimental economics has been “a huge change,” says the Caltech professor. Previously accustomed to sitting alone in his office with a pencil and pad, he now works with a team of graduate students, postdocs, and technicians, and collaborates on experiments with several Caltech biologists.

Rangel, who drinks at most one glass of wine a week, says that the wine study reflects his interest in how the brain distinguishes between attraction and aversion. “We spend more money on products that we believe are higher quality,” he says. “How much is driven by a product’s characteristics, and how much just by our beliefs that it is superior?”

In the wine study, the 20 volunteers sipped wine that they thought were five kinds of Cabernet Sauvignon, ranging in price from $5 to $90. But they were actually only treated to three different brands—the $5 wine presented in both its cheap incarnation and disguised as a $45 brand, along with a $35 brand and a $90 bottle, also presented as a $10 variety. The majority of volunteers preferred the cheap wine over the expensive wine when they thought it had a higher price, but were less enamored of the expensive wine when told it had a price tag of $10. Scans of their brains while they were sipping the wines they said tasted better showed higher activity in the medial orbitofrontal cortex, which is thought to register positive experiences.

“Strictly speaking, all we know is that this area of the brain is more active when subjects believe that wine they are drinking is an expensive brand,” Rangel says.

Although Rangel could conceivably parlay his research findings into a new career as a wine-industry consultant, he says he has particular interest in marketing. Thus far, only one company has contacted him about his wine study and then only to request a copy of his paper.

Not surprisingly, Rangel says that he has no particular interest in publishing. “I wouldn’t make anyone else do what I do. I wouldn’t put a price on my work,” he says. “We did a study about pain, and then only to request a copy of his paper. There are applications here for pain management,” Rangel says, “but what I really am after is understanding the basic science of how we make decisions.”

Rangel says that there are strict protocols for conducting experiments involving electric shock, adding, “I put myself through every experiment first. I wouldn’t make anyone else do what I wouldn’t do.”

Mike Rogers
Baker's Dozen with Anneila Sargent

"I often feel my life has been a series of fortunate accidents," says Anneila Sargent, Caltech's newly appointed vice president for student affairs. As a young girl with an aptitude for math and science, she says she was lucky to come of age at a time when her native country, Scotland, was busy creating new opportunities for young people in scientific and technical fields, and to have parents who encouraged her to excel. After earning her B.Sc. with honors in physics from the University of Edinburgh in 1963, she had the "good fortune" to come to America as a graduate student with her husband, Wal Sargent, who had been hired onto the astronomy faculty of UC San Diego, and to meet accomplished female scientists who encouraged her to persevere in her career. In 1966, Wal joined Caltech (today he is the Bowen Professor of Astronomy), and Anneila transferred her graduate studies to the Institute. She took a break to raise two daughters, then received her PhD in 1977 and joined Caltech's research faculty. More luck followed in the form of an opportunity to do pioneering research into the interstellar medium and star and planetary formation, which earned her an international reputation in the 1980s and 1990s, and saw her appointed associate director (1992–1996) and then director (1996–2007) of the Institute's Owens Valley Radio Observatory (OVRO), and in 2003 the founding director of CARMA (Combined Array for Research in Millimeter-wave Astronomy). She was named professor of astronomy in 1998 and the Rosen Professor in 2004.

Late last year, Sargent, who also served as president of the American Astronomical Society from 2000 to 2002, took on a new administrative challenge when she agreed to head up Caltech's student affairs office, whose diverse portfolio includes oversight of undergraduate and graduate studies, admissions, athletics, campus life, and a range of other offices related to student education and well-being. In this 13-question interview with Caltech News editor Heidi Attpattian, Sargent talks about her new job, her life in science, and a variety of other topics, including Shakespeare's unapt portrait of Macbeth, and how serving on committees reminds her of Mary Queen of Scots.

You graduated from the University of Edinburgh in 1963 with a physics degree, which was rare for a young woman at that time. What motivated you, and what was that experience like?

The fact is, it was kind of cute in those days to be a woman in science in Scotland. I came of age in the post-Sputnik era when Scotland, like the United States, was putting tremendous emphasis on educating scientists. No one really cared at the time what gender you were. Obviously there were relatively few women in science fields: maybe four women out of 24 students in both my high-school physics and chemistry classes. But I never felt that anything stopped me from going into science. It's also an interesting fact that people from more modest backgrounds, as I was, find they have a more level playing field in the sciences. I may well have been good at humanities, but not as good as the doctor's daughter. And in fact my father, who worked in the local shipyard, thought it was wonderful that I did science well.

There was also the influence of teachers. I went to the largest high school in Scotland, and a number of graduates later became prominent in one way or another, including Gordon Brown, Britain's current prime minister. What was unusual at the time I went were the number of female teachers. Teaching is a highly respected profession in Scotland, and traditionally the upper-level positions were filled by men, but then came the Second World War. The men went off to fight, and many of the women who took over their jobs stayed in them, unmarried, after the war ended. Many of them had in fact lost their fiancés in the war. And so I was taught by a large number of these effective, clever, lively, independent women. Eventually, nearly all of them achieved a position with the curious name of "lady supervisor," which was essentially the equivalent of being a headmaster. So these were definitely early role models for me.

What led you to study physics at Edinburgh?

I started as a math major, and then I realized I wasn't any good at it. I've talked to quite a few people who have had the same experience. You do well up to a certain point, and then one day your brain just says, "I can't go any farther, I can't go there." Once I discovered that I was not the brilliant mathematician I thought I was, physics beckoned. For a while I thought about a career in nuclear physics, but I also took astrophysics and discovered that the field came naturally to me. Then I went to the Royal Greenwich Observatory as a summer astronomy student, and that was a great deal of fun. I also met Wal there, and by then I had started to think about a PhD. We were planning to get married, and he said, "I'm going to teach in the States; why don't you plan to get a PhD there?" At one point, I also applied for a nuclear physics position in the British civil service that would have led to a PhD, but I didn't get it. Years later I met one of the men who had interviewed me for the job, and he told me, "I wanted to hire you, but the head of the lab said, 'No. If we hire her, she'll just get married and be of no use to us. Or, she won't get married and cause trouble in the lab.'" And that's how I didn't become a nuclear physicist.

But I didn't realize that this had been an issue at the time. In fact, I never felt it was an impediment to be a girl in science, until I started graduate work at UC San Diego, where Wal taught for two years before we came to Caltech. I was in a math class with two other women and the usual 20 or 25 males, and the professor just dumped on me, sneering, "What does the lady in our class think?" I had never encountered this attitude before. I was not intimidated by it, but I was certainly outraged.

I got quite an education in many ways at La Jolla. One of my teachers there was Maria Goeppert Mayer. She had won the Nobel Prize in Physics in 1963, and this was one of her first professorships! There was also Margaret Burbidge, an outstanding astronomer who couldn't be a professor of physics at UCSD because of nepotism
Tauri stars might be moving in accord with Kepler's perspective was so important here. He was a consummate Irishman, and he taught a revival of a certain appeal.

And that experience taught me a lot about life. Encountering sexism was nothing to assasini of Duncan. The historical facts suggest that Macbeth either killed Duncan or good king. The problem with his reputation was created by James wounded him very seriously in hand-to-hand single combat, and that Macbeth was surprised when I said I'd like to hike too! We love to travel-Edinburgh and Florence are two of our favorite cities, although the food is definitely better in Italy.

Are there Scottish traditions that you still observe?

Brussels sprouts! We always have them at Christmas. And despite my Catholic background, I think the influence of Scotland's Puritan ethic on my life has been very strong. My daughters certainly think so, and I've talked about it with friends who grew up in Scotland. The single piece of advice we all remember hearing from our mothers—and I guess my daughters heard it from me—is, whatever is bothering you, get over it and get on with it. This is wonderful advice, if you can follow it.

How do you like to spend your free time?

Wal and I like to go to the opera and to concerts. We also like to hike, particularly in the northwest of Scotland. Wal was already hiking there when he was young. In those days, women were not actually encouraged to go along, so he was really quite strong.

Ah, no, everyone in Scotland knows that's wrong. Macbeth actually was a very good king. The problem with his reputation was created by James VI of Scotland, who became James I of England while Shakespeare was writing his plays. James believed very strongly in the divine right of kings, and wanted to trace his own, according to the Bible, back to Duncan and Duncan's son, Malcolm. So Shakespeare, who of course as a court playwright had to please his patron, made Macbeth the very wicked assassin of Duncan. The historical facts suggest that Macbeth either killed Duncan or wounded him very seriously in hand-to-hand single combat, and that Macbeth himself was killed the same way by Duncan's son, Malcolm.

How about other historic figures or role models whom you admire?

Here's my Scottish side coming out again. There's Robert the Bruce, the great 12th-century king who put an end to the English occupation of Scotland. And, of course, possibly because of my religious background, Mary Stuart—Mary Queen of Scots. What a fascinating woman—way, way better than Elizabeth Tudor [her cousin, the queen of England, who had her executed in 1587]. A few years ago, I saw a revival of Maria Stuart, the 18th-century play by the German writer Schiller. It was an amazing portrayal of these two very different women, and I have to say I saw interesting parallels to people I have known on committees and how they handle things. There's Elizabeth, the savvy politician, never quite taking the blame and always passing the buck. Mary Stuart wasn't the greatest of managers, but she was never afraid to show her fallible human side. I've met people on committees who simply never can be wrong, and it's just plain not helpful.

In your career as an astronomer, is there one piece of research that you have found most rewarding?

I think it was the work that Steve Beckwith [then at Cornell, now vice president for research and graduate studies for the University of California system] and I collaborated on in the mid-1980s to '90s. This was when we found that the immense disks of gas and dust around T-Tauri stars might be moving in accord with Kepler's laws of planetary motion, suggesting that we were seeing the very early stages of solar-system formation around these stars. This work was so much fun, because Steve and I complemented each other very well, and because we were doing something that no one else was doing at the time. There were hardly any appropriate telescopes for these investigations in those days, and it took us a long time to build up our data.

I can remember to the day when we got our second set of results on the star HL Tau. Our first results had been okay, but when Steve and I proposed to make further observations, everybody told us that we probably wouldn't see anything useful. In actual fact, our second set of observations was better than our first, and while they were improved upon later, our work really provided the first indication that you could measure velocities in the clouds of dust and gas around these stars and actually observe what might be the very first phase of planetary-system formation. That was terribly exciting. And I think we did make a real difference to the field.

Having successfully combined a scientific career with raising a family, do you have advice for young women in science today who want to follow your example?

Don't think about it; just do it. Or as my mother would say, Get over it and get on with it. I really don't see that there's any other way. I'm not saying that women don't face different issues in science than men—they do, and I frequently argue that point when I serve on committees for hiring. Men on the fast track are often extremely assertive and willing to take big risks when they're young. From my limited observations, it seems to me that many women prefer to establish solid research credentials first, and then they become more willing to assert themselves and take those riskier steps. And it is certainly not easy, balancing a commitment to family with the demands of being a scientist. If I had my career to do over again, I think I might have had my children earlier, rather than dropping out of graduate school as I did after I got my Caltech master's degree in 1967. But my timing when I decided to return turned out to be very fortunate because I got in on the ground floor of this new millimeter-wave research into the interstellar medium, a field that hardly existed at the time I left. I was just very lucky in that regard. I often say my whole life has been a series of fortunate accidents, including this new job.

That's right. You told the California Tech that you never even applied for it.

I didn't! [Professor of Chemical Engineering] Julie Kornfeld, who was heading up the search committee, got in touch with me and said, "You've been at the Institute for such a long time and have probably seen a lot of changes, and we'd like to have you come talk to us about them." I said sure, and I went and I had a blast. They asked me about this and that, and I gave them my opinions, and then they thanked me and I left. I really hadn't a clue that this was in some sense an interview, and when Jean-Lou [Chameau] later called to offer me the job, I was shocked.

I did understand that the administration desired someone with a strong management background. I certainly do have that because of my directorship of OVRO and CARMA. But I've also been busy for the last 10 years teaching and doing research in astronomy, overseeing the building of telescopes, and serving on committees. So the student affairs area is very new to me. But in management, there are certain basic skills that apply across the board. And working with students seemed a great opportunity. It's rejuvenating!

I like to say I'm imbued with the self-righteous

Puritan ethic on my Scots side, and a very well-

boned sense of the ridiculous on my Irish side.
Wang grew up in Riverside, California, the sociable, outgoing son of Chinese-born parents who settled there in the 1960s. When he came to Caltech in 1982, he quickly immersed himself in student life. "I was the social cochair of Ruddock, the campus social chair, and the business manager for the little," he says. "Caltech has an exceptional playing field when it comes to being social—it's a very accessible place, 'friendly' being the operative word, and a lot of activities are available to the individual person if they want to take advantage of it. It's like a liberal-arts college, but at the same time, it's a great tech college as well. It's the only place like that that I'm aware of."

Wang majored in physics, but was drawn to neuroscience after taking Professor of Physics Jerry Pine's course on the biophysics of the nervous system in his sophomore year, and a neurobiology course taught by biologists David Van Essen (now at Washington University in St. Louis) and Mark Tanasuye (now at UC Berkeley) in his final year. He went on to graduate school in the neurosciences at Stanford, where he conducted research into calcium-signaling among nerve cells for his doctorate.

Although other physicists, among them Caltech's renowned practitioners Max Delbrück and Seymour Benzer, moved into biological research with great success, it's not an easy transition. Surrounded by fellow graduate students whose backgrounds in biology were far more extensive than his, Sam initially spent much of his time in the library, poring through a crash course in the field. One of the greatest challenges, he says, was replacing some of the intuitive approaches he had come to rely on in physics with different modes of thought. Another was the large mass of knowledge that had to be acquired. "The field was a zoo—literally," he says. Researchers have "accumulated a large body of information, but they're still trying to find out the organizing principles behind it."

Wang went on to postdoctoral research at Duke University in 1994, but after a year he decided to try something new. He applied for and was awarded a Congressional Science Fellowship by the American Association for the Advancement of Science. It gave him a year off his studies to work in Washington, first as a legislative assistant for Texas Democrat Lloyd Doggett in the House of Representatives, whom he advised on energy and environmental issues, then as a legislative fellow for Senator Ted Kennedy. "Getting to see how Congress functioned was a fantastic experience," he recalls. While working for Kennedy, he wrote speeches for the senator and worked on science and education policy. At the end of the year, he was invited to apply for a position at the Clinton White House to work on education policy, but says that his break from lab work helped him realize that his first love really was scientific research. He doesn't rule out a science policy position in his future, though.

After finishing his postdoc at Duke, Wang spent two years at Bell Labs in New Jersey, before joining Princeton's department of molecular biology as an assistant professor in 2000 (he was named associate professor in 2006). One of the things his research group investigates is the way in which brain circuits process and store information. The focus is mainly on the cerebellum, the large region at the back of the brain that integrates sensory information to guide movement and cognition. "Our current project, which is very exciting to me, is to understand how cerebellar circuits can encode—and decode—real-world events in a useful way to be processed by the rest of the brain," he says.

As a Caltech undergraduate, Wang thought about pursuing a double major in physics and literature (as his classmate Sanda Tsing Loh '83 actually did), and today he continues to emphasize to his students the importance of lively, lucid writing. "Verbal expression is an extremely important skill for any working scientist, and it's something many don't do well," he feels. His model for excellence in science writing is one of his own teachers, Richard Feynman. "In popular books about science, it's very hard to get things across clearly and still be faithful to the science. Feynman could do this." One of his fondest memories of Caltech is attending Feynman's special evening lecture course, "Physics X," which the irreverent Nobel laureate held weekly for undergraduates. "Feynman would walk into a room at a prearranged time and make himself available to answer any question anyone had, then riff off about it. He was remarkable in his clarity; we felt we understood everything he told us." Then Sam adds, "But later, we found we didn't." (This phenomenon, experienced by many, even has a name: the Feynman Effect.)

Wang's counterpart, Sandra Aamodt, shares his passion for precision and polish in writing. Together, they spent about three years (on and off) reading through hundreds of scientific papers, writing, and passing their individual contributions back and forth until both felt they had got it right. But progress was slow because Aamodt lives on the outskirts of Davis, California, and Wang in Princeton, so in April 2006 they obtained a writer's residency grant from the Rockefeller Foundation that allowed them to spend a very productive month together at the foundation's study center in Bloombury USA.

Quiz: How Well Do You Know Your Brain?

1. When are the last neurons born in your brain?
   a) Before birth
   b) The age of six
   c) Between the ages of 18 and 23
   d) In old age

2. Men and women have inborn differences in
   a) Spatial reasoning
   b) Strategies for navigation
   c) Ability to leave the toilet seat down for someone else
   d) Both a and b
   e) Both b and c

3. Which of the following is not likely to improve brain functioning in old age?
   a) Eating fish with omega-3 fatty acids
   b) Getting regular exercise
   c) Drinking one or two glasses of red wine per day
   d) Drinking a whole bottle of red wine per day

4. Which of the following activities is likely to improve performance in school?
   a) Listening to classical music while you sleep
   b) Listening to classical music while you study
   c) Learning to play a musical instrument as a child
   d) Taking frequent breaks from studying to play video games
   e) Both c and d

5. Which of the following strategies is the best one for overcoming jet lag?
   a) Taking melatonin the night after you arrive at your destination
   b) Avoiding daylight for several days
   c) Getting sunlight in the afternoon at your destination
   d) Sleeping with the lights on

6. Blind people are better than sighted people at which of the following?
   a) Understanding words
   b) Hearing sounds
   c) Remembering stories
   d) Training dogs

7. Which deception of neurological damage is the least realistic?
   a) Guy Pearce's character Leonard in Memento
   b) Drew Barrymore in 50 First Dates
   c) Dora the Fish in Finding Nemo
   d) John Nash in A Beautiful Mind

8. What fraction of your brain do you use?
   a) 10%
   b) 5% when you are awake
   c) 100%
   d) Varies according to intelligence

Answers are provided at the end of the article.
And that's true, and I am not the only faculty member who thinks like this. It really came home to me when I gave a talk at Fresh Camp a few years ago. I found it an especially moving experience because it was just after 9/11, and here I was with all these hopeful kids and realizing that their parents had just put them on airplanes in September to come here. I gave my little pep talk about astronomy, and afterward they asked so many enthusiastic questions! And I found myself thinking, “Why don't they ask questions like this in my class? Where does the enthusiasm go?”

Well, for one thing, they're all so tired all the time. They work so hard, and many of them routinely take too many courses. I really believe that if they spent more of their school year working with a professor in a lab or doing something more creative than just taking classes, it would be extremely beneficial. Part of being a scientist is that there are always opportunities to learn something completely different.

I had some of these unusual experiences as a young person. The summer before I started college, I worked at the Kirkcaldy branch of the British department store Marks & Spencer. I worked on the lingerie counter, which included what we called the “bloomers counter” with huge piles of cotton knickers. These large farmwives would come in from the countryside, pick up these vast cotton underthings, look at me, and say, “Well, lasse, can you bile them?” They wanted to boil them before wearing them to be sure they were clean. And they wanted to be sure they wouldn’t shrink or be maimed by this necessity for cleanliness. It was absolutely hilarious, but it was also an education for me.

So, are you saying...?

That selling undergraduates is inaviable preparation for life? No. I actually had a much more lasting life experience working one summer as a temporary teacher of math in a middle school in a truly rough working-class area—like teaching in the projects here. It was shocking to me to see how their circumstances already con-strained the futures of these kids. Education meant very little to a lot of them because already the doors were closed. I, a university student, was as foreign to them as if I had come from another country. In fact they asked me if I was “English.” It was certainly a lesson for me in what a privilege it is to be educated. I’ve never taken it for granted again. Life is full of learning opportunities if you are open to them.

I'd like to think we are preparing Caltech students to make the most of every opportunity as well as creating new possibilities for them. I'm looking forward to working with many others on campus to make that happen. I think it is great that our new vice provosts—Melaney and Steve Mayo—have offices just down the hall from mine and that there will be many opportunities for interaction and collaboration between us. I do feel that the Student Affairs office has grown a little isolated from the rest of Caltech over the past few years, and one of my main goals is to bring it back into the mainstream of campus life. The Institute is so small that there are always opportunities to learn something completely different.
The Sun Also Catalyzes

By Michael Rogers

Tucked away in a cluttered Caltech chemistry lab filled with expensive, sophisticated equipment sits an ordinary $200 desktop printer. No paper ever passes through this printer and it's always out of ink, but it may hold a key to solving the world's energy crisis.

A little more than 1,000 miles northeast of Pasadena, a similar office printer is ensconced in a lab on the Fort Collins campus of Colorado State University. Both labs are run by Caltech alumni who think that the energy from the sun offers the best alternative to fossil fuels, with more potential than any other renewable energy resource.

The scientists are Nate Lewis '77, MS '78, Argusyn Professor and professor of chemistry at Caltech, and Bruce Parkinson, PhD '78, professor of chemistry at Colorado State. Although the two were only casual acquaintances in their Institute days, Parkinson's best friend was fellow graduate student Kent Mann, PhD '77, who recruited Lewis for assistance on a couple of solar energy experiments and was instrumental in turning Lewis's focus from physics to solar photochemistry.

At Caltech, both Lewis and Parkinson got training in electrochemistry, a discipline that is useful in the development of solar cells. In electrochemistry, energy can be converted when an electrode—typically a metal or semiconductor such as silicon—comes in contact with a solution of chemicals dissolved in water. After graduation, Lewis and Parkinson went their separate ways. Lewis went on to graduate school at MIT, joined the Stanford faculty in 1981, and then returned to Caltech as a professor in 1988. Parkinson conducted research in government and industry labs for several years before going to Colorado State in 1991.

For about 30 years, both Lewis and Parkinson have been involved in basic research on photoelectrochemistry, or "wet" solar cell technology, investigating the electrical energy that is produced when light shines on a semiconductor in a solution, and its application to solar energy conversion. In the past few years they have found themselves converging on what Lewis likes to laconically call "a large climate problem." He's referring of course to the planetary changes caused by humans' near-insatiable appetite for energy. Within the next 20 years, both Lewis and Parkinson are convinced that solar energy offers the best hope for resolving civilization's excessive reliance on fossil fuels and for averting a looming environmental catastrophe. "In one hour, more energy shines on the earth than all the energy consumed by humans in one year," Lewis says. But there's a big problem. "There's plenty of sunlight, but you have to be able to capture, store, and distribute its energy to people when and where they want it. Just to make electricity, without the ability to store and transport it, doesn't solve the problem. We don't have the technology that can capture solar energy at low enough cost to make it economical at scale compared with fossil fuels."

Many experts believe that one key to efficiently harnessing solar energy is to find an economical way of using sunlight to break up water molecules into their constituent oxygen and hydrogen atoms, so that the energy can be recovered from hydrogen when needed. This was a view that began to take shape when Parkinson and Lewis were at Caltech. In 1975, two Japanese scientists showed that ultraviolet light illuminating titanium oxide electrodes splits water into oxygen and hydrogen. Titanium oxide is a metal oxide that is the primary ingredient in white paint, so the fact that such a common material could break up water was big news. Since that time, says Parkinson, "Efficient and inexpensive production of hydrogen from water and sunlight has been the holy grail of photoelectrochemistry."

"The CO₂ we produce over the next 40 years, and its associated effects, will last for a timescale comparable to modern human history. Within the next 20 years, we either solve this problem or the world will never be the same."

"The CO₂ we produce over the next 40 years, and its associated effects, will last for a timescale comparable to modern human history. Within the next 20 years, we either solve this problem or the world will never be the same."

Both Lewis and Parkinson are convinced that solar energy offers the best hope both for resolving civilization's excessive reliance on fossil fuels and for averting a looming environmental catastrophe. "In one hour, more energy shines on the earth than all the energy consumed by humans in one year," Lewis says. But there's a big problem. "There's plenty of sunlight, but you have to be able to capture, store, and distribute its energy to people when and where they want it. Just to make electricity, without the ability to store and transport it, doesn't solve the problem. We don't have the technology that can capture solar energy at low enough cost to make it economical at scale compared with fossil fuels."

Many experts believe that one key to efficiently harnessing solar energy is to find an economical way of using sunlight to break up water molecules into their constituent oxygen and hydrogen atoms, so that the energy can be recovered from hydrogen when needed. This was a view that began to take shape when Parkinson and Lewis were at Caltech. In 1975, two Japanese scientists showed that ultraviolet light illuminating titanium oxide electrodes splits water into oxygen and hydrogen. Titanium oxide is a metal oxide that is the primary ingredient in white paint, so the fact that such a common material could break up water was big news. Since that time, says Parkinson, "Efficient and inexpensive production of hydrogen from water and sunlight has been the holy grail of photoelectrochemistry."

Lewis recalls that the Japanese breakthrough "had an impact on all the Caltech chemists on the third floor of Noyes. It probably had some influence on my choosing to do a postdoc in semiconductor photoelectrochemistry." Lewis says that the Arab oil embargoes of the 1970s were also a factor. "There was an energy crisis at the time, and solar research was the thing to do," he says. During his senior year, he was part of a Caltech team led by Harry Gray, the Beckman Professor of Chemistry, and Kent Mann that discovered a metal complex with hydrogen-producing properties similar to titanium oxide. "The compounds used visible light, but could not complete the water-splitting cycle robustly," Lewis says. "TiO₂ is robust, but uses ultraviolet light."

"There's not much power in ultraviolet light," Parkinson says. "Only a few percent of the photons emitted by the sun in this portion of the spectrum get through the atmosphere. (It's for this same reason that ultraviolet astronomical observatories are all space-based, where they can operate above the earth's atmosphere.) Progress toward finding a viable successor to the first generation of metal oxides has been slow. Those that have been shown to work are "not efficient enough or don't last long enough," Lewis says.

For a metal oxide to work, it needs to meet several criteria, Lewis says. Ideally, it should be fairly abundant in nature, and able to absorb solar radiation across a wide portion of the electromagnetic spectrum so as to maximize the use of sunlight. It also...
has to be stable. Some compounds can split water across several wavelength ranges, says Lewis, but they essentially self-destruct in the process. (Sun-kissed silicon, for example, no sooner separates water into hydrogen and oxygen than it begins to corrode in the presence of the oxygen that’s released and breaks down ignorominously into sand.) Third, the electrons in the metal oxide have to be arranged in a suitable configuration for water to split into hydrogen and oxygen.

Parkinson says that while any viable candidate will most likely consist of several metals, there’s not enough theoretical knowledge to confidently determine which combinations of metals possess the requisite properties to perform efficient photoelectrolysis of water. So actual trial-and-error testing is needed to identify the best candidates.

For years, Lewis, Parkinson, and others have been studying metal oxides, using time-consuming methods that basically have involved analyzing one compound at a time. A couple of years ago, however, rapidly rising energy prices coupled with the looming environmental crisis made it clear that they had to find a way to speed up their investigations. With fuel consumption reaching unprecedented levels throughout the world, and signs of significant climate change appearing worldwide, even the most ardent cheerleaders for cheap oil and the most vocal global warming skeptics were now riding in the presence of the oxygen that’s released and breaks down ignominiously over time. A couple of years ago, however, rapidly rising energy prices coupled with the environmental crisis made it clear that they had to find a way to speed up their investigations. With fuel consumption reaching unprecedented levels throughout the world, and signs of significant climate change appearing worldwide, even the most ardent cheerleaders for cheap oil and the most vocal global warming skeptics were now riding in the presence of the oxygen that’s released and breaks down ignominiously over time.

Katz also had to create software to keep track of the photoelectrochemical results. “We needed to find a way to make hydrogen cheaply.”

Four years ago, Parkinson was attending a conference when he heard a research chemist talk about how he had used a standard inkjet printer to spew out different combinations of chemicals to test for catalytic activity. He realized that he could use the same procedure to screen metal oxides for their suitability as solar energy photocatalysts. Part of his idea was to empty ink cartridges and load them with different combinations of chemicals to create different metal oxide compounds.

Back in his Colorado lab, he and his graduate student Mike Woodhouse built a system using an inkjet printer in which they substituted dissolved metals for ink. They modified the printer to accept thin glass plates rather than paper, and programmed it to print out different combinations of the metals on the plates. Heating the printed plates in a furnace for two hours at 500°C converted the metal salts into metal oxides, after which the plates were submerged in a solution, while a laser, serving as a stand-in for the sun, irradiated the material. By checking the plates with an amplifier to measure whether any current was produced by each compound, they could determine whether water molecules were being split and energy was being stored.

“It was extremely simple and easy,” Parkinson says. In 2005, he and Woodhouse described the process in a paper published in the journal Chemistry of Materials.

When Lewis read about Parkinson’s procedure, he called him up and asked if he could get more information so he could develop his own system. “I interact with Bruce frequently,” Lewis says. “He is always very collegial and helpful in assisting people to advance the science in this area.” So, in the summer of 2006, he sent one of his graduate students, Jordan Katz, and an undergradmate, Todd Gingrich, to visit Parkinson and find out how his system worked.

“Bruce shared everything that he did with us and helped us with an initial setup method, which was great,” Lewis says. While still in the testing phase, ‘Bruce’s work helped legitimize screening as something one can do and actually get funded for, instead of just being a ‘fishing expedition,’ which it still partly is but hopefully can be done intelligently to find new materials.”

Once Katz and Gingrich came back from Colorado, they started building their own metal oxide analyzer, and had one up and running by the end of the summer of 2006. They spent much of the next year modifying some of Parkinson’s design features, including adding a method to analyze voltage, which makes it possible to obtain precise measurements of the electrons generated by the material. While it registers the presence of current when water is split, Parkinson’s technique is not designed to detect charges below this threshold.

“Knowing the voltage is important because that figure tells us just how close we are to the needed number,” Lewis says. “It takes 1.25 volts of potential to split water.” If we only get 1.2 volts, says Katz, “while that material could not split water as is, it would still be interesting and worth further investigation, because it would be awfully close to giving enough voltage” to split water and perhaps could be modified to work effectively.

Lewis’s system also makes it possible to test up to 250 separate compounds on each plate, whereas Parkinson’s system produces a continuous gradient pattern of different ratios of three or four metals at a time. “We want to mass-produce thousands of compounds as quickly as possible,” Katz says. “The printer is like pouring from the beaker, using microliter spritzes of ink. Printers are good at spraying liquid and mixing in proportions. In a few minutes, we can put 250 dots on a plate and test them. In an hour, we can do 1,000 just using a commercial $200 printer.”

In reconfiguring Parkinson’s system to evaluate dozens of compounds per plate, Katz says that one of the challenges was writing the software to instruct the printer to print the dissolved metals in different combinations and concentrations. He and Gingrich also had to create software to keep track of the photoelectrochemical results.

“It’s not a trivial process,” Katz says. “You have to fabricate the glass so that there are no interfering signals between metal oxides, you have to print the compounds on the glass, you have to bake it, and then screen it. Each process takes time.

Common sense dictates which candidates are chosen for analysis. “We first consider the abundant metals in the crust of the earth,” Katz says. “For any successful electrode to have an impact on a global scale, we need a colossal amount of the appropriate material. We don’t want to use a metal oxide that costs $5,000 a gram. We probably won’t use radioactive elements, either.” He sees promise in metal oxide candidates whose current utility is limited by how selectively they absorb light. “To solve the problem, you can take a compound that you know works and try to extend its light-absorbing region to absorb more sunlight” by gradually adjusting the ratios of the metals that compose it to see if you can optimize the electrical response. “Or you can try to make an unstable compound that only works up to a point more stable. Or you can try to find a new and completely different compound that just works.”

Says Katz, “There’s no reason why we can’t find a stable metal oxide that absorbs visible light that doesn’t degrade and that can produce energy. If the third compound that we test works, that’s great, but it could be the ten millionth compound. It’s unlikely we’ll find something quickly, but there’s only one way to find out.”

Katz, who recently left Caltech for a postdoctoral fellowship at UC Berkeley, figures that once the screening system is out of the test phase in a month or two, it will be able to analyze about 20,000 metal oxides a week. Parkinson says that he’s tested...
about 500 metal oxides, with no major breakthroughs so far. He says that he only recently read Katz's thesis describing the Lewis lab's screening system and so hasn't decided yet whether it is worth copying. But he is convinced that to have any chance of finding a metal oxide that works, he has to expand the project.

To that end, Parkinson hopes to enlist dozens of university labs around the country, using simple but effective testing kits operated by an army of undergraduates. "I want to use undergraduate students' hands and brains," he says. "The kits should be inexpensive and easy to use." With that in mind, he taught a class last year in which he had students build metal oxide screening kits out of Lego Mindstorms robotic kits, using a laser pointer. The prototype kits worked, but before he can ramp up production, he needs to test them further.

Parkinson recently received a grant from the Camille and Henry Dreyfus Foundation to send kits to nine undergraduate universities that have offered to recruit students to test them. He hopes to expand the project later this year by joining up with a National Science Foundation–funded Caltech initiative called the Chemical Bonding Center, in which investigators, including Lewis, are seeking ways to efficiently store solar energy in the form of chemical bonds. "The more people who do this, the better," Parkinson says. "There has to be a national commitment here. It's a difficult project, but the payoff is so big and so important."

Although metal oxide devices offer a promising route to capturing and utilizing solar energy on a global scale, other alternatives do exist, some of which have been already work. They just have the problem that the ones that work well are unstable and the ones that are stable don't work well. We know it can be done, we know it can be done, but we just don't yet know how we can do it under commercially feasible conditions." Cost is key, says Katz. "We're trying to beat out coal. No one is going to be interested in exploiting solar energy for 10 times the cost of burning coal, just because we have global warming."

Moore Foundation commits $200 Million to Thirty-Meter Telescope

Caltech and the University of California have received a $200 million commitment, extending over a nine-year period, from the Gordon and Betty Moore Foundation toward the further development and construction of the Thirty-Meter Telescope (TMT). Funding under this commitment will be shared equally between the two universities, with matching gifts from the two institutions expected to bring the total to $300 million. The completed TMT will be the largest telescope in the world.

The telescope design is being developed by a U.S.-Canadian team that includes Caltech, the University of California, and the Association of Canadian Universities for Research in Astronomy (ACURA), with completion of the design development expected by March 2009.

"The impressive scope of this project has now been matched by the extraordinary generosity of the Gordon and Betty Moore Foundation," said Caltech president Jean-Lou Chameau. "Caltech and the UC system are thrilled with the foundation's confidence in the project. We and our partners are eager to create this history-making instrument."

"Using the TMT, astronomers will be able to investigate the structure and dynamics of the universe and cosmic objects on unprecedented scales. They will locate and analyze the light from the stellar systems born shortly after the Big Bang, the event that gave birth to the universe; conduct detailed investigations of the physical processes governing the formation and evolution of galaxies like our own Milky Way; study the formation of planets around nearby stars; and make observations that test the fundamental laws of physics. However, as with every new astronomical instrument, unexpected discoveries made with the TMT are likely to be the most exciting."

"This is a tremendous investment by the Gordon and Betty Moore Foundation in a path-breaking scientific tool with great potential for unlocking new insights about the nature of the universe," said UC President Robert C. Dynes. "UC and Caltech are pleased that the foundation has recognized the tremendous research capacity of our institutions, and we look forward to the exciting findings that this telescope will deliver in the future."

The TMT will consist of a primary mirror with 492 individual 1.45-meter segments that together measure 30 meters in diameter, providing more than eight times the light-collimating area of the current largest telescope. All segments will be under precision computer control so that they will work together as a single mirror. This revolutionary technology was developed for the 10-meter mirrors in the two Keck telescopes in Hawaii.

In addition to being the largest optical-infrared telescope in the world, the TMT will also be at the forefront of technology in virtually every aspect of its design. Adaptive optics (AO) will allow the telescope to achieve a resolution superior to that of the Hubble Space Telescope.

The TMT AO system will use six laser beams to create six luminous spots in a layer of sodium atoms high in Earth's upper atmosphere. These bright artificial stars serve as references for measuring the turbulence in the atmosphere, allowing the AO system to compensate for blurring of starlight by Earth's fluctuating atmosphere. This technology was pioneered at the Lick Observatory 3-meter telescope and has been developed further at the Palomar 5-meter and Keck 10-meter telescopes.

TMT, whose project office is in Pasadena, is a collaboration between Caltech, UC, and ACURA, with significant work being done by industry and by university teams studying instrument designs. The Moore Foundation has already granted $75 million in support of a $79 million design-development phase that has been under way since April 2004. ACURA and the Association of Universities for Research in Astronomy also contributed to the design-development phase.

For more information on the project, see http://www.tmt.org.

Established in 2000, the Gordon and Betty Moore Foundation seeks to advance environmental conservation and cutting-edge scientific research around the world and to improve the quality of life in the San Francisco Bay Area. For more information, visit http://www.moore.org.

For a closer look at the TMT and what it will see, check out this issue's book-page poster.

Friends

there's only one.caltech

THE CAMPAIGN

Undergraduate students at Colorado State University examine one of the metal oxide analyzers that they built on a shoestring partly out of Legos.
Global Environmental Science Fellowship, please call 626/395-3919 or visit http://associates.caltech.edu.

opportunity to hear firsthand from faculty and students about the vital and essential supply problems at a global level. To support these efforts, the Caltech Associates have established the Associates Global Environmental Science Fellowship, partnering with faculty and students to address the most challenging global environmental science problems.

The endowment of the Associates Global Environmental Science Fellowship will provide in perpetuity a mechanism to support the training of graduate students in support has exceeded expectations, and the Associates currently have raised $657,000 for this exciting and much-needed fellowship. Environmental science is very much an interdisciplinary enterprise, and students supported by the fellowship will interact with faculty in a wide range of fields, including engineering and applied science, chemistry and chemical engineering, and geology and planetary science. The Associates look forward to hosting future events at which they will have the opportunity to hear firsthand from faculty and students about the vital and essential research supported by this fellowship. To learn more about the Associates and the Global Environmental Science Fellowship, please call 626/395-3919 or visit http://associates.caltech.edu.

This past October, 34 members of the Caltech Associates President's Circle joined John Brewer, the Broad Professor of Humanities and Social Sciences and professor of history and literature, on a trip to the Italian province of Tuscany. The group toured the exquisite medieval hill city of Siena and enjoyed a visit and luncheon at the nearby Villa La Foce, hosted by its owner, Benedetta Origo. Traveling through Italy's Chianti region, famed for its vineyards, participants also spent the day at the Castelli di Volpaia Winery, where Nicolo Mascheroni Scianti (center), son of the owners, taught a cooking class for the group. Pictured are Associates Marlene Konnar, Ginger Jenkins, Julie Farr, and Janet Holliday.

associates.caltech.edu.

opportunity to hear firsthand from faculty and students about the vital and essential supply problems at a global level. To support these efforts, the Caltech Associates have established the Associates Global Environmental Science Fellowship, partnering with faculty and students to address the most challenging global environmental science problems.

The endowment of the Associates Global Environmental Science Fellowship will provide in perpetuity a mechanism to support the training of graduate students in support has exceeded expectations, and the Associates currently have raised $657,000 for this exciting and much-needed fellowship. Environmental science is very much an interdisciplinary enterprise, and students supported by the fellowship will interact with faculty in a wide range of fields, including engineering and applied science, chemistry and chemical engineering, and geology and planetary science. The Associates look forward to hosting future events at which they will have the opportunity to hear firsthand from faculty and students about the vital and essential research supported by this fellowship. To learn more about the Associates and the Global Environmental Science Fellowship, please call 626/395-3919 or visit http://associates.caltech.edu.

This past October, 34 members of the Caltech Associates President's Circle joined John Brewer, the Broad Professor of Humanities and Social Sciences and professor of history and literature, on a trip to the Italian province of Tuscany. The group toured the exquisite medieval hill city of Siena and enjoyed a visit and luncheon at the nearby Villa La Foce, hosted by its owner, Benedetta Origo. Traveling through Italy's Chianti region, famed for its vineyards, participants also spent the day at the Castelli di Volpaia Winery, where Nicolo Mascheroni Scianti (center), son of the owners, taught a cooking class for the group. Pictured are Associates Marlene Konnar, Ginger Jenkins, Julie Farr, and Janet Holliday.

associates.caltech.edu.

opportunity to hear firsthand from faculty and students about the vital and essential supply problems at a global level. To support these efforts, the Caltech Associates have established the Associates Global Environmental Science Fellowship, partnering with faculty and students to address the most challenging global environmental science problems.

The endowment of the Associates Global Environmental Science Fellowship will provide in perpetuity a mechanism to support the training of graduate students in support has exceeded expectations, and the Associates currently have raised $657,000 for this exciting and much-needed fellowship. Environmental science is very much an interdisciplinary enterprise, and students supported by the fellowship will interact with faculty in a wide range of fields, including engineering and applied science, chemistry and chemical engineering, and geology and planetary science. The Associates look forward to hosting future events at which they will have the opportunity to hear firsthand from faculty and students about the vital and essential research supported by this fellowship. To learn more about the Associates and the Global Environmental Science Fellowship, please call 626/395-3919 or visit http://associates.caltech.edu.

This past October, 34 members of the Caltech Associates President's Circle joined John Brewer, the Broad Professor of Humanities and Social Sciences and professor of history and literature, on a trip to the Italian province of Tuscany. The group toured the exquisite medieval hill city of Siena and enjoyed a visit and luncheon at the nearby Villa La Foce, hosted by its owner, Benedetta Origo. Traveling through Italy's Chianti region, famed for its vineyards, participants also spent the day at the Castelli di Volpaia Winery, where Nicolo Mascheroni Scianti (center), son of the owners, taught a cooking class for the group. Pictured are Associates Marlene Konnar, Ginger Jenkins, Julie Farr, and Janet Holliday.

associates.caltech.edu.

opportunity to hear firsthand from faculty and students about the vital and essential supply problems at a global level. To support these efforts, the Caltech Associates have established the Associates Global Environmental Science Fellowship, partnering with faculty and students to address the most challenging global environmental science problems.

The endowment of the Associates Global Environmental Science Fellowship will provide in perpetuity a mechanism to support the training of graduate students in support has exceeded expectations, and the Associates currently have raised $657,000 for this exciting and much-needed fellowship. Environmental science is very much an interdisciplinary enterprise, and students supported by the fellowship will interact with faculty in a wide range of fields, including engineering and applied science, chemistry and chemical engineering, and geology and planetary science. The Associates look forward to hosting future events at which they will have the opportunity to hear firsthand from faculty and students about the vital and essential research supported by this fellowship. To learn more about the Associates and the Global Environmental Science Fellowship, please call 626/395-3919 or visit http://associates.caltech.edu.

This past October, 34 members of the Caltech Associates President's Circle joined John Brewer, the Broad Professor of Humanities and Social Sciences and professor of history and literature, on a trip to the Italian province of Tuscany. The group toured the exquisite medieval hill city of Siena and enjoyed a visit and luncheon at the nearby Villa La Foce, hosted by its owner, Benedetta Origo. Traveling through Italy's Chianti region, famed for its vineyards, participants also spent the day at the Castelli di Volpaia Winery, where Nicolo Mascheroni Scianti (center), son of the owners, taught a cooking class for the group. Pictured are Associates Marlene Konnar, Ginger Jenkins, Julie Farr, and Janet Holliday.

associates.caltech.edu.

opportunity to hear firsthand from faculty and students about the vital and essential supply problems at a global level. To support these efforts, the Caltech Associates have established the Associates Global Environmental Science Fellowship, partnering with faculty and students to address the most challenging global environmental science problems.

The endowment of the Associates Global Environmental Science Fellowship will provide in perpetuity a mechanism to support the training of graduate students in support has exceeded expectations, and the Associates currently have raised $657,000 for this exciting and much-needed fellowship. Environmental science is very much an interdisciplinary enterprise, and students supported by the fellowship will interact with faculty in a wide range of fields, including engineering and applied science, chemistry and chemical engineering, and geology and planetary science. The Associates look forward to hosting future events at which they will have the opportunity to hear firsthand from faculty and students about the vital and essential research supported by this fellowship. To learn more about the Associates and the Global Environmental Science Fellowship, please call 626/395-3919 or visit http://associates.caltech.edu.

This past October, 34 members of the Caltech Associates President's Circle joined John Brewer, the Broad Professor of Humanities and Social Sciences and professor of history and literature, on a trip to the Italian province of Tuscany. The group toured the exquisite medieval hill city of Siena and enjoyed a visit and luncheon at the nearby Villa La Foce, hosted by its owner, Benedetta Origo. Traveling through Italy's Chianti region, famed for its vineyards, participants also spent the day at the Castelli di Volpaia Winery, where Nicolo Mascheroni Scianti (center), son of the owners, taught a cooking class for the group. Pictured are Associates Marlene Konnar, Ginger Jenkins, Julie Farr, and Janet Holliday.

associates.caltech.edu.
of meeting alumni who are university professors involved in field studies or international collaborations, who work for multinational companies, and who are serving in embassies. Sharing the benefits of their Caltech education with their counterparts in other cultures is often the highlight of their careers.

To further the Alumni Association's mission of promoting Caltech and building the greater Caltech community, we have organized alumni gatherings in many locations outside the United States in recent years. Our most active group is in Hong Kong. We also have enthusiastic alumni in London. In locations with smaller alumni numbers, we are opportunistic. For instance, the Association hosted a dinner in Beijing during the 2006 COSPAR (Committee on Space Research) meeting, organized by Jinlin Zhu, PhD '86.

An Alumni Association trip can also be a great chance to renew acquaintances. The most elegant of the CAA's international events was a reception at the Icelandic President's House in the summer of 2006, hosted by Stein­grímur Hermannsson, MS '52, a recipient of Caltech's Distinguished Alumni Award and Iceland's prime minister during the Reykjavik Summit meeting of Ronald Reagan and Mikhail Gorbachev in 1986.

So, wherever you are on our home planet, you're not far from another alumnus who'd probably be happy to reminisce about long-ago physics problems and catch up on current interests and activities. "World-renowned Caltech" has connections around the world.

Alumni travelers walk toward the Iceland's President's House for a reception in the summer of 2006. The event at the 18th-century home was hosted by Stein­grímur Hermannsson, MS '52, Iceland's prime minister from 1983 to 1987 and 1988 to 1991.

extends to our alumni. While some overseas arrivals go on to pursue careers in the United States, many return to their native countries or move on to other nations. And many Americans relocate abroad for all or part of their lives.

Some alumni start early, as Watson Fellows, immediately after receiving their BS degrees. A recent Caltech News article profiled some of these Watsons ("Graduates Abroad," v. 41, no. 3, and online at http://pr.caltech.edu/periodicals/CaltechNews/articles/v41/graduatesabroad.html). Other Techers branch out into overseas assignments later in their careers. In my many journeys abroad, I've had the pleasure,
At commencement 2005, physicist David Politzer enjoys a joke told by fellow Alumnus Mary Sherman Morgan '49, produce a son who becomes a screenwriter. Enough rocket fuel resulted in the creation of the Redstone rocket to launch America's first satellite. The Army chooses the Caltech's first alumna commencement speaker.

Sandra Tsing Loh has hosted her eponymous 90-second science radio spot since 2004, as a contributor to The Atlantic Monthly and was a finalist for the National Magazine Award. Loh has written and performed several one-woman shows, composed and performed music for film, and authored four books.

He says quarks, she says quirks, let's call the whole thing Rocket Girl. 

Mary Sherman Morgan

Unrestricted Net Assets $8,635,402 7,480,669

Total Liabilities and Net Assets $8,711,915 7,516,415

STANCES OF ACTIVITIES AND CHANGES IN NET ASSETS

For more on Loh, go to http://pr.caltech.edu/periodicals/CaltechNews/articles/ and follow the links for this issue (Vol. 42, No.1).
1936
Simon Ramo, PhD, a Caltech Life Trustee as well as the R in TRW Inc., has joined the faculty of USC's Viterbi School of Engineering as a Presidential Chair Professor and director of electrical engineering. After receiving his doctorate at the age of 23, Ramo established 25 patents and was voted one of America's top electrical engineers before the age of 50. As a General Electric scientist, he pioneered research in microwave, the extremely high radio frequencies fundamental to radar and advanced communications, and he developed GE's electron microscope. A founding member of the National Academy of Engineering and a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society, he was chief scientist for the U.S. intercontinental ballistic missile program. He is in addition a recipient of the National Medal of Science and a fellow of various professional societies. His writings on technology and society have appeared in numerous books and periodicals, and his books,Cars for China and Century of Mismatch advocate the application of science to social programs.

1959
Hsue-Shen Tsien, PhD, widely considered the father of China's space program, has been named the 2007 Person of the Year in an Aviation Week & Space Technology cover story released January 7. He is being recognized for his contributions to aerospace science in both the United States and China. A co-founder of JPL, Tsien was deported against his will back to China during the "Red Scare" of the 1950s, and he eventually became administrator of the Chinese missile and space program. "China is now at the forefront of space exploration, with two key developments in 2007: a successful antiship missile strike and a manned spacecraft mission," points out Aviation Week & Space Technology editor in chief Anthony L. Velenci Jr. "Aviation Week's profile of Tsien discusses these aspects of China's space program in rich detail, and analyzes the far-ranging impact Tsien has had on the global aerospace industry—indeed, the world—at large." According to the publication's press release, "The Person of the Year Distinction, the third in Aviation Week's 91-year history, recognizes the impact individuals have on the broader aviation, aerospace and defense communities. Aviation Week staff editor selected Tsien from an international field of candidates. Prior recipients include France's Pierre de Fermi and NASA's Ira Magaziner in 2005 and Alan R. Mulally, CEO of Boeing Co., in 2006."

Despite his contributions, Tsien was forced by the Red Guard into a period of hard labor during the Cultural Revolution. Currently 96 and said to be in poor health, he is no longer active in the Chinese space program. He was the subject of Tribe of the Silk, a 1995 biography by U.S. author Iris Chang, as well as a reminiscence by Frank McBride, Caltech's Hayman Professor of Mechanical Engineering and Professor of jet propulsion. Emerson, published in Caltech News, volume 36, number 1, 2002, and accessible at http://pt.caltech.edu/potldoc/CaltechNewspapers/CaltechNews/10/1/1/newspaper.html. The actual Aviation Week article can be found at http://www.aviationweek.com/expand/story_channel.jsp?channel=sp\sc\scrid=80010488.xml (where his name has been romanized as Qian Xuesen).

1999
William Leslie Ko, MS, PhD '63, who studied for his doctorate with Paul J. Blunt, at that time a senior research fellow at Caltech, and they established the Blunt-Ko constitutive law for describing the mechanical behavior of hyperelastic compressive materials such as solid rocket fuel grains. Ko writes that classmate Wolfgang Knauss '38, MS '59, PhD '63, now Caltech's von Kármán Professor of Aeronautics and Applied Mechanics, Emeritus, has informed him that many scientists internationally are using the law as the basis for their research and have created a number of technical terms in honor of its originators. As well as Blunt-Ko constitutive law, terms include Blunt-Ko strain energy function, Blunt-Ko-function, Blunt-Ko hyperelastic bodies, Blunt-Ko material, Blunt-Ko rubber, and Blunt-Ko model, among others. Ko also reports that a Google search of Blunt-Ko revealed as many as 8,380 citations. After a career of successful research with private institutions and a number of technical publications covering a wide spectrum of solid mechanics—including, he notes, his "work on blast-waves/structure interactions," which "provided the basic knowledge in the design of missile silos to withstand nuclear blast waves"—he joined the NASA Dryden Flight Research Center. There he has conducted research in a wide variety of areas, including problems associated with high-speed aerospace vehicles such as the Space Shuttle and hypersonic wing structures. He has recently developed "Ko aging theories for operational life predictions of aerospace critical structural components using the 'half-cycle' theory." This work provides the ability to predict the operational life of critical aerospace structural components and can set the numerical limit for safe test flights at NASA Dryden. Ko also receives requests from scientists and engineers worldwide for his publications. In addition, Ko is an internationally known, award-winning watercolor artist whose paintings have been

Get credit for being part of the world's foremost scientific community with a CEFCU VISA card. Combining a choice of four stellar designs with solid, down-to-earth value, each card is a proud reflection of our membership. A CEFCU VISA offers:

- A low fixed 10.5% APR
- NO annual fee
- NO cash advance fee
- 25-day grace period

And our cards feature high credit limits and low minimum monthly payments.

You've earned this VISA card. Use it with pride. Choose it to save. Make it yours today! For more information, call us or visit a CEFCU office location.

CEFCU EMPLOYEES
Federal Credit Union
800.592.3328 • www.cefcu.org

Foothill Office: 538 Foothill Blvd. • La Canada Flintridge
JPL Office: 4800 Oak Grove Dr., Bldg. 218 • Pasadena
Campus Office: 515 S. Wilson Ave. • Pasadena

* All credit subject to approval and membership eligibility. Rates and terms subject to change without notice. CEFCU is an Equal Opportunity Lender.
published in American Artist and Southwest Art. His LJ Rend in Spring Time is part of the permanent collection of the Lyndon Baines Johnson Library, in Austin, Texas.

1962
Peter C. Ford, a professor in UC Santa Barbara's department of chemistry and biochemistry, has received the International Chemical Society's 2008 I-APS Award in Photochemistry "for his work on the photochemistry and photophysics of transition metal complexes and the bioinorganic chemistry of NO complexes." After receiving his PhD from Yale in 1966 and serving an NSF postdoctoral fellowship at Stanford, he joined UCSB's faculty in 1967. According to his website, "Our research is concerned with three long-term interests: catalysis, the photochemistry and photophysics of transition metal complexes, and the bioinorganic chemistry of nitric oxide complexes. The common theme is our interest in reaction mechanisms and in applications of quantitative spectroscopic techniques to investigate these systems." Ford is a fellow of the AAAS and has been a Dreyfus Foundation Teacher-Scientist and a Senor Fulbright Fellow. His awards include an Alexander von Humboldt Foundation Senior U.S. Scientist Award (1992) and the American Chemical Society's Michael T. Talman Medal (1993).

1972
Mark S. Weisbrod, PhD, chancellor of Washington University in St. Louis since 1995, has been named St. Louis's Citizen of the Year—a committee of past winners selected him for the award, which is sponsored by the St. Louis Post-Dispatch. During his tenure, the number of applications received by Washington University has more than doubled, allowing the school to become one of the most selective in the nation, and 165 new endowed professorships for faculty have been created. When Weisbrod first arrived, the university's endowment was $2 billion, and today it is $5.7 billion. Dozens of buildings have been constructed during his terms, including new residence halls, the law school, the biomedical-engineering building, and the Mildred Lane Kemper Art Museum. Buildings to come include a medical research building, a new student center, and an engineering campus. A chemist, Weisbrod holds 14 patents and has authored or coauthored over 300 articles. He is a fellow of the American Academy of Arts and Sciences and the American Association for the Advancement of Science and a member of the American Philosophical Society, and his numerous honors include a MacArthur Foundation Fellowship and Caltech's Distinguished Alumni Award. He delivered Caltech's commencement address in 1995. After receiving his PhD, Weisbrod joined MIT as an assistant professor of chemistry. Appointed associate professor in 1976 and professor in 1977, he held the Frederick G. Keyes Chair in Chemistry from 1981 until 1989, when he became the first holder of the Giso-Geiger Chair in Chemistry. He was head of the chemistry department from 1987 to 1990, the year he became provost, a position he held until moving to Washington University. Weisbrod's research interests include transition metal catalysis, photochemistry, surface chemistry, and molecular electronics. He has served on numerous editorial boards and advisory committees.

1988
Howard Stone, PhD, Vicky Joseph Professor of Engineering and Applied Mathematics and associate dean for academic programs in the Harvard School of Engineering and Applied Sciences, has won the first ever G. K. Batchelor Prize in Fluid Mechanics. Awarded under the auspices of the International Union of Theoretical and Applied Mechanics, this newly established prize is sponsored by Cambridge University Press and the Journal of Fluid Mechanics. The award of $25,000 will be presented at the 22nd International Congress of Theoretical and Applied Mechanics, to be held in Adelaide, Australia, August 24–30, 2008. Stone is being recognized "for the breadth and depth of his research over the ten-year period 1998–2007, and for his widely acknowledged leadership in fluid mechanics generally."

1994
David Perlman reports that he has started the PhD program in psychology at the University of Wisconsin–Madison, after more than 10 years of working as a computer consultant in Seattle. He is working in the lab of Dr. Richard Davidson, doing brain-imaging research on meditation with the cooperation of a number of Buddhist monks. As part of his work in that lab, he recently attended the Mind and Life meeting at the home of the Dalai Lama in Dharamsala, India. Perlman moved to Madison from Seattle in August 2006 and is still getting used to life away from the West Coast. Both he and his father, Michael, were residents of Ricketts House, and he is "cautiously optimistic that the recent renovations will benefit current resident Scouries."

2007
Paul J. Miller writes that he has moved to Redmond, Washington, and is working for Microsoft in the area of operating system security.
REMEMBERING WOLFGANG PANOFSKY

Dear Editor,

I was saddened to read in the Chicago Tribune an obituary of the untimely death of Wolfgang Panofsky, PhD '42, whose passing was also reported in the last Caltech News.

Most readers of Caltech News probably didn't know Wolfgang Panofsky, or how smart he was, and the following will be illuminating.

In 1942 Caltech awarded Wolfgang a PhD in physics. Wolfgang and his one-year-younger brother had been undergraduates majoring in physics at Princeton, where both took the same physics courses. During their years at Princeton, of all the students in these physics courses—and there were many—none were brilliant and achieved great success—Wolfgang was first in scholarship in course work, with the highest grades: 98 and higher out of a possible 100. Close behind came the younger brother, Hans, who was second to Wolfgang in these same courses, with grades in the 95 range. No student had grades that fell between the brothers.

In consequence, at Princeton, Wolfgang's younger brother was known as "The Dumb Panofsky."

Some years ago, I attended a seminar on particle physics by a Nobelist laureate professor of physics. During his lecture, the professor said some kind words about SLAC, the Stanford Linear Accelerator, and noted that Wolfgang Panofsky, a prominent antwar activist, was the director. At a reception after the seminar, expecting to share a smile with the professor, I asked him if he knew the anecdote about Wolfgang Panofsky and his younger brother.

"Oh, yes," the professor said. "I know that one. You mean the one about Wolfgang and his brother, when they were students at Princeton. When Wolfgang got grades is much better than his brother that he was called "The Smart Panofsky.""

Go figure.

Bernard Rasof, PhD '50

[Editor's note: Hans Panofsky went on to a distinguished career in meteorology at Penn State University, pioneering research in such areas as pollution control and the study of planetary atmospheres using space mission data. He died in 1988.]

KEEP US INFORMED THROUGH THE CALTECH NEWS ALUMNI NOTES!

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

Name

Degree(s) and year(s)

Address

Day phone

E-mail

NEWS

1944
Robert D. Boche, PhD '38, on September 24, 2007; William C. McFadden, on April 12, 2007.

1935

1946
Arthur L. Bishop, on December 24, 2007; William C. Cooper, MS '38, August 29, 2007.

1958
Edward N. Frisius, on November 13, 2007.

1999
Richard H. Bishop, MS '43, in July 1987; Albert P. Green, on June 12, 1994; William M. Green, on December 14, 2007; Winthrop G. Jones, MS, on March 27, 1988; Walter B. Powell, MS '40, on May 10, 1994.

1940
Alan T. Waterman, on January 9, 2008; James W. Whitley, on November 11, 2007.

1942
Robert E. Anderson, on November 13, 2007; George W. Lind Jr, MS, on October 11, 2007.

1943
Theodore G. Lawrence, ME, on November 8, 2007; Edwin S. Lee Jr., Eng., MS, on October 17, 2007.

1944
Richard B. Escue, PhD, on October 1, 2007; Lawrence U. Hudson, on November 12, 2006.

1945
Emil L. Sorenson, MS, on March 22, 2006; Merle G. Waugh, on August 27, 2007.

1946
Robert D. Bonner, MS, on June 28, 2007.

1947
Le Val Lund, on November 30, 2007; George W. Lyon, on September 16, 2007; Gordon McClure on August 14, 2007.

1948
Harold W. Baugh, on June 23, 2006; Lorne Campbell Dunsworth, MS '48, on January 10, 2008; Harry M. Ellis, PhD '31, on November 4, 2007; Paul W. Fullerton Jr., October 12, 2007; Keith W. Henderson, on October 15, 2007; Robert W. Poindexter, on May 20, 2006; Bruce B. Rennie, on July 4, 2007; Fred M. Wells, MS, on October 26, 2007.

1950
John M. Greene, on October 22, 2007; William F. Jones, MS, on May 30, 2006; William D. Warters, PhD '33, on October 23, 2007.

1952
Paul Dergarabedian, PhD, on November 17, 2007; James A. Rose, MS '53, on December 10, 2007.

1955
James M. Bell, MS, PhD '65, on July 1, 2007.

1956
Robert Metzenberg, PhD, on July 15, 2007.

Seymour Benzer, Caltech's Boswell Professor of Neuroscience, Emeritus, died in Pasadena on November 30 after suffering a stroke; he was 86. His long research career spanned solid-state physics, biophysics, molecular biology, and behavioral genetics, and he made significant contributions to each of these fields. After helping to lay the foundations of modern-day genetics with his research on gene mutation and regulation, he decided to investigate the genetic underpinnings of behavior, work that earned him the title of "the father of neurogenetics."
The only son of Polish Jews who emigrated to New York City in 1910, Benzer was interested in biology from an early age, but chose to major in physics at Brooklyn College because the school would not permit him to skip the first-year taxonmy courses that he considered to be boring. After earning his bachelor's degree in 1942, he moved to Purdue University for his PhD, working on a secret military project to develop reliable crystal receptors that could detect radio waves reflected back from moving aircraft. The receptor he developed was subsequently adapted by scientists at Bell Labs to become the first-tenant taxonmomy detector.

Benzer was interested in biology from an early age, but chose to major in physics at Brooklyn College because the school would not permit him to skip the first-year taxonomy courses that he considered to be boring. After earning his bachelor's degree in 1942, he moved to Purdue University for his PhD, working on a secret military project to develop reliable crystal receptors that could detect radio waves reflected back from moving aircraft. The receptor he developed was subsequently adapted by scientists at Bell Labs to become the first-tenant taxonmomy detector.

Benzer went on to examine tens of thousands of fly brains, virtually inventing the field that later became known as neurogenetics. His first experiments focused on the genes that condition flies to move toward bright light, and over the next two decades, he and graduate students made pioneering discoveries concerning the genetic bases of such drosophila traits as circadian rhythms, mating patterns, circumsision, and nervous disorders. He had accepted a tenured position at the Institute in 1967 and was appointed the Boswell Professor in 1975.

Many of Benzer's drosophila genes were later discovered to have analogs in higher organisms, a finding that led to the founding of the field of behavioral genetics. Benzer increasingly focused his own research on the genetic bases of neurodegeneration and aging in drosophila and he was the first to pursue this research after retiring as an emeritus professor in 1992. In the late 1990s, he discovered a gene that enabled drosophila to live longer and resist heat, starvation, and poison; and he dubbed these specimens "Methuselah flies."

"At the time of his death, his lab was (and still is) studying drosophila models of pain perception and odoriferous alarm response, and working on genetic analyses of appetite and obesity.

Benzer garnered many honors during his long and remarkable career, including election to the National Academy of Sciences, the Royal Society, and the American Academy of Arts and Sciences. He was awarded the National Medal of Science, the Wolf Prize in Medicine from Israel, the Crafoord Prize of the Royal Swedish Academy of Sciences, the International Prize for Biology from Japan, the Albert Lasker Award for Basic Medical Research, and, in 2006, the Albany Medical Center Prize, considered to be the "American Nobel Prize in physiology or medicine." He was also one of two few-time winners of the Gairdner International Award (in 1964 and 2004).

Benzer was the subject of the book Time, Love, Memory: A Great Biologist and His Quest for the Origins of Behavior, by Jonathan Weiner, which won the 1999 National Book Award for nonfiction, and of the 2006 book Reawakening the Gene: Seymour Benzer's Adventures in Phage Genetics, by Frederic Lawrence Holmes.

Benzer is survived by his wife, Carol Miller; his first wife, Dorothy, whom he married in 1942, predeceased him; by two daughters, Barbara Freidin and Martha Goldschmid; and a daughter, Melissa Benzer; stepson Renny and Douglas Feldman; and four grandchildren.

With his Scottish burr and erudite charm, Elliot was a charming and well-liked colleague and teacher, who received Caltech's ASCIT Teaching Award in 1977. His research interests encompassed a diverse range of subjects, including Scotland's Liberal Party, the city of London during the English Restoration, arms control, and national defense. He also served as a consultant to the Ford Foundation, the RAND Corporation, NASA, and the Foreign Area Fellowship program. He was the executive officer for Humanities and Social Sciences from 1967 to 1971, secretary to the faculty board from 1973 to 1985, and chaired the Institute's year-long 75th Anniversary celebrations in 1966.

Predeceased by his wife, Nancy, in 1991, and son John Clepham Elliot in 1995, Elliot is survived by his daughter, Nan Elliot Hale of Anchorage, Alaska, and Enid Elliot of Victoria, British Columbia, as well as by Enid's husband, Richard Kool, and their four children and two grandchildren.

Elliot's oral history, conducted in 1986 for the Caltech Archives Oral History Project, can be found online at http://oralhistories.library.caltech.edu.

DESIGNS ON THE COSMOS

Although the back-page poster may seem reminiscent of futuristic science fiction fantasies that were once featured in the funny pages of newspapers, Caltech's future Thirty-Meter Telescope (TMT) is quite real. The joint project to build what will be the largest and most powerful telescope in the world is currently in the design phase, expected to be completed in early 2009. Last December, the Gordon and Betty Moore Foundation committed $200 million over nine years for further development and construction of the TMT. (See article on page 12.) With a primary mirror consisting of 492 individual 1.45-meter segments that together measure 30 meters in diameter, the TMT will be able to locate and analyze the light from the first stellar systems born soon after the Big Bang, determine the physical processes governing the formation and evolution of galaxies like the Milky Way, and make observations that test the fundamental laws of physics. Even Flash Gordon would be dazzled.
HERE COMES THE TMT!

IF YOU BUILD IT, THEY WILL OBSERVE

WHAT IT WILL SEE

ABOVE, CLOCKWISE: JUPITER'S EUROPA; GAS AND DUST SURROUNDING A YOUNG STAR; INFRARED IMAGE OF CENTRAL MILKY WAY; EARLIEST GALAXIES; DARK MATTER STRUCTURE; ... AND MUCH MORE.