

# Caltech 336

T F S S M T W T F S S M T W

The campus community biweekly

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Upper Paleolithic paintings depict Ice Age horses and a rhinoceros in Chauvet Cave, France.

## Leakey Lectures return to Caltech

After an 18-year hiatus from Caltech, the Leakey Speaker Series on Human Origins returns to the campus that served as its first home. Beginning this month, the series will bring researchers of the highest rank whose work delves into the oldest prehistoric rock art yet discovered, the evolutionary importance of a long human childhood, and the presence (or curious absence) of violence among our fellow primates.

In "The Chauvet Cave Now: The Oldest Rock Art Site in the World," prehistorian Jean Clottes will share Ice Age images of mammoths, deer, bears—in all, 425 animal images drawn on the walls of a cave in southern France. Discovered by spelunkers in 1994, the extensive Chauvet Cave's galleries house images that have been radiocarbon dated to 30,400 B.C. This makes them more than 2,000 years older than the bulls found at the famed Lascaux cave.

Clottes, who is a rock-art specialist, says the level of sophistication required to produce the Chauvet drawings brings into doubt the current thinking that art evolution develops in a linear fashion, from crude to complex. This lecture will be presented on Wednesday, February 12.

Compared to the chimpanzees, our closest relatives, we humans take an unusually long time to reach maturity. Our life spans are also quite long, longer than that of any other primate. One theory posits that hunting promoted nuclear families, which in turn promoted a longer period of dependency in children. However, recent research suggests that our long lifespans permit a prolonged childhood. In the lecture "Grandmothers and Human Evolution," Kristen Hawkes, an anthropologist and evolutionary ecologist, will discuss this hypothesis in addition to the intriguing possibility that our lifespans are a legacy inherited from ancestral grandmothers. This lecture will take place on Wednesday, March 19.

While studying chimpanzees and bonobos, Richard Wrangham, a prima-

see *Leakey*, page 6

## Shake it, baby— at one gigahertz

Nanoscience has achieved a milestone in their burgeoning field by creating a device that vibrates a billion times per second, or at one gigahertz (1 GHz). This feat further increases the likelihood that tiny mechanical devices working at the quantum level can someday supplement electronic devices for new products.

Reporting in the January 30 issue of *Nature*, Caltech professor of physics, applied physics, and bioengineering Michael Roukes; graduate student in physics Xue-Ming (Henry) Huang; and engineering professors Chris Zorman and Mehran Mehregany of Case Western Reserve University demonstrate that the tiny mechanism operates at microwave frequencies. A prototype, the device is not developed enough to be integrated into a commercial application. Nevertheless, it demonstrates progress in the quest to turn nanotechnology into a reality—that is, to make useful devices whose dimensions are less than a millionth of a meter.

This latest effort in the field of NEMS, or nanoelectromechanical systems, is part of a larger emerging effort to produce mechanical devices for sensitive force detection and high-frequency signal processing. According to Roukes, the technology could also have implications for enhancing biological imaging and, ultimately, for observing individual molecules with improved magnetic resonance spectroscopy, as well as for a new form of mass spectrometry that may permit single molecules to be "fingerprinted" by their mass.

see *Gigahertz*, page 6

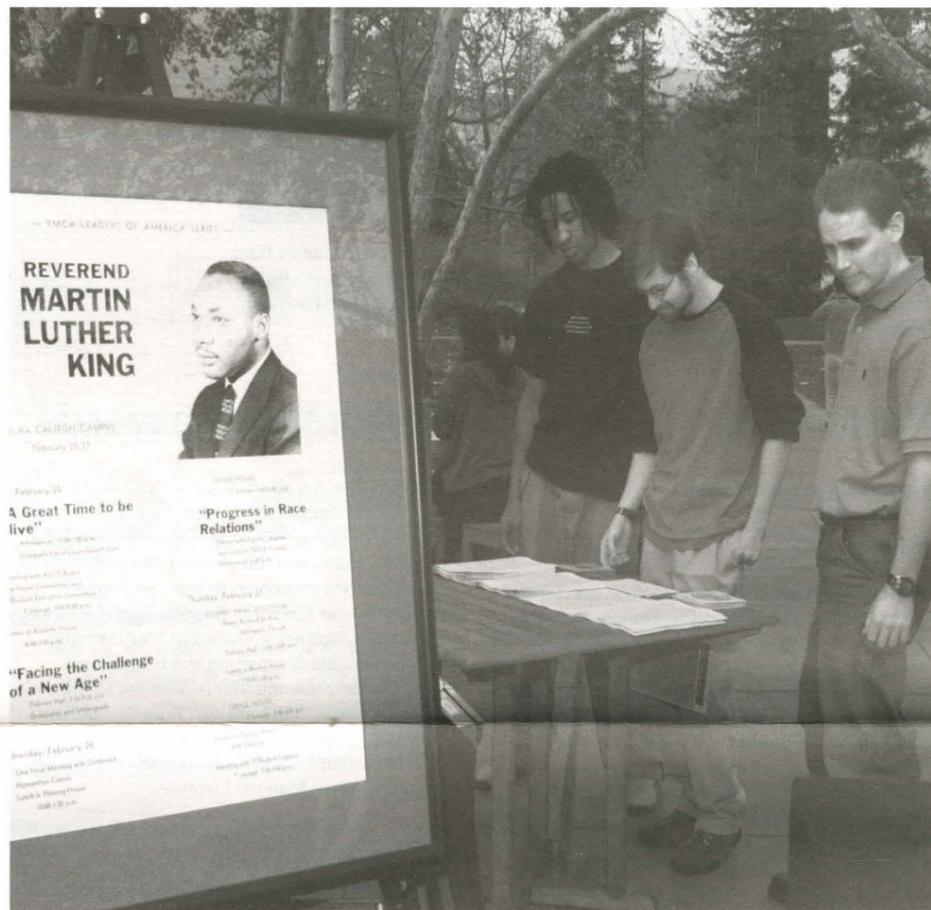
## Caltech helps students get to college

This decade, according to a recent report from the Advisory Committee on Student Financial Assistance, 4.4 million qualified low- and moderate-income high school graduates will not attend a four-year college, and 2 million will not attend college at all. Caltech is partnering with area academic institutions and government leaders in a statewide initiative to help overcome this hurdle and get more California high school students into college.

Caltech's director of financial aid, David Levy, has helped spearhead the College Goal Sunday kickoff and its local "Free Cash for College" workshops, aimed at helping eligible low-income, underrepresented students and their

see *Financial aid*, page 6

## Tribute to a hero



A display on the life of Martin Luther King, Jr., was one of several events honoring the slain civil rights leader last month. From left are Eugene L. D. Mahmoud, Mike Russo, and Kevin Bundy of Peaceful Justice at Caltech. The week's events were also cosponsored by the Women's Center, the Caltech Y, International Student Programs, Minority Student Education, Human Resources, the Counseling Center, the Health Center, the Writing Center, and the President's Office.

## Eyewitness to a tragedy

At approximately 5:45 Saturday morning, Caltech astronomer Tony Beasley was outside his home in Bishop, northern California. He, his wife, Anne, and his mother-in-law, none of whom had ever seen a spacecraft landing, were watching for the space shuttle *Columbia's* reentry into Earth's atmosphere. The sky was clear and still dark.

Beasley, project manager for the Combined Array for Research in Millimeter-wave Astronomy at the Owens Valley Radio Observatory (OVRO), was unaware that what he was about to see would gain major significance as the world learned of the tragic loss of the seven crew members and the shuttle. A few hours later, he summarized his observations in an e-mail message.

"We began watching about five minutes early to make sure we saw it," Beasley wrote. "The landing track was to the north of Bishop, several tens of miles . . . The orbiter was sighted immediately when it cleared the Sierra Nevada mountains to the west of Bishop . . . sometime shortly after 05:50 PST . . ."

"Initial view was a single very bright object, tracking west to east rapidly. There was a pinkish hue to the trail it was

leaving, and the trail was long-lived—by the time the orbiter had passed from view to the east the trail visibly spanned the entire path west to east. It faded to a typical looking contrail (i.e., cloudlike) within a minute or two.

"The orbiter appeared as a single bright object. I could resolve the actual orbiter, but the hot coma around it appeared to be at least slightly resolved (by coma I mean the visible region of heated gas at the head of the trail). During the track from west to east, on at least three separate occasions, there was a brief brightening (pulsing) of the coma (lasting 0.2–0.5 seconds or so . . .).

"I have tried to recall the events from memory about two hours later.

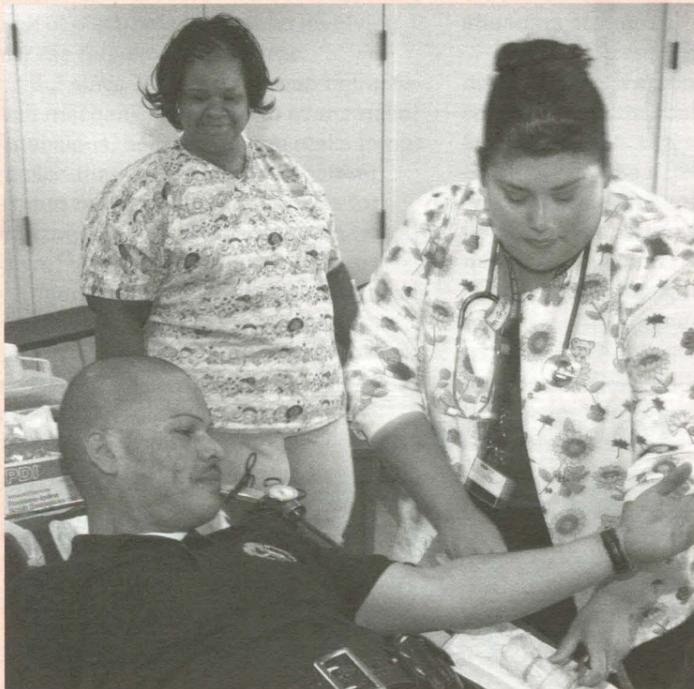
"First event: Seen shortly after orbiter came into view ( . . . maybe 10–15 seconds after first sighting). Brief pulse [fraction of a second]. Possibly saw secondary material in trail immediately after.

"At [the] time I thought it must have lost a tile (I was aware the shuttles routinely did when they landed, no idea what that would look like . . .).

"Second event: About 10–20 seconds later. By this time orbiter was roughly

see *Columbia*, page 6

# NewsBriefs



Sharon Gryalava (right) and Tracee Elder of the City of Hope get ready to take blood from Juan Balcazar, staff member in Security. Caltech's first-ever bone-marrow donor drive added 33 new potential donors to the National Marrow Donor Program database and netted 41 units of blood.

## Personals

### Welcome to Caltech

#### January

**Barbara Avouac**, human resources specialist, Human Resources; **Courtney Brown**, division/department assistant, mathematics; **Andrey Demyanenko**, optical/MR engineer, biology; **Shaun Healy**, remote sensing/GIS specialist, geological and planetary sciences; **Martha Henderson**, MRI facility assistant, biology; **Shafiqul Khan**, revenue and receivables clerk, Athenaeum; **Samuel Ki**, research assistant I, biology; **Abraham Kuo**, network engineer, Information Technology Services; **Steven Kwoh**, research aide A, biology; **Corinne Ladous**, laboratory technician, mechanical engineering; **Cecil Patrick**, cook, Owens Valley Radio Observatory; **Rosalyn Sayaman**, research technician, bioengineering; **Rebecca Smith**, assistant to the director of principal and major gifts, Development and Alumni Relations; **Kang-Shi Wang**, research assistant, chemistry; **Bevin Ashley Zauderer**, research assistant, Owens Valley Radio Observatory.

**James Heath** joined Caltech as Elizabeth W. Gilloon Professor and professor of chemistry. Internationally recognized for his work on quantum dot-based artificial solids and molecular computers, he is expected to contribute significantly to the Institute's materials-chemistry program, particularly in the areas of nanotechnology and molecular electronics. He received his BSc from Baylor University in 1984, and his MA and PhD from Rice University, both in 1988.

**Nadia Lapusta** joined the Institute as an assistant professor of mechanical engineering. Noted for her work on the modeling of spontaneous fracture in slowly loaded systems involving extreme ranges of spatial and temporal scales, she has applied this work to seismology but is interested in applying similar techniques to a variety of problems. She received her diploma from Kiev State University in 1994, and her MS and PhD from Harvard in 1996 and 2001, respectively.

#### Deaths

**Laura Hearne Marcus**, wife of Noyes Professor of Chemistry and Nobel Laureate Rudy Marcus, died on January 16; she was 80. She came to Pasadena with her husband in 1978 and for many years played an active role in the life of the Caltech community, both as a member of the Caltech Women's Club and as a writer and reporter for several Institute publications. Her writings about Caltech historical figures and campus personalities were noted for their descriptive flair and warm, wry style. The youngest child in a family of eight brothers and sisters, she is survived by five siblings; her sons, Alan, Kenneth, and Raymond; two grandchildren; and her husband of 53 years.

## Honors and awards

**Yanshun Liu**, a postdoctoral scholar in biochemistry and molecular biophysics, has been selected to receive a Damon Runyon postdoctoral fellowship, one of 20 awarded after a review by the scientific advisory committee of the Damon Runyon Cancer Research Foundation. The three-year fellowships are awarded to "outstanding young scientists conducting theoretical and experimental research that is relevant to the study of cancer." Liu's Damon Runyon sponsor was Douglas Rees, professor of and executive officer for chemistry at Caltech, and investigator, Howard Hughes Medical Institute.

### Techer selected for First Team

**Lisa Wang**, a Caltech junior in physics, has been named to the First Team of *USA Today's* All-USA College Academic Team. Chosen for their "outstanding" qualities, team members are selected by a panel of judges who look for "students who not only excel in their studies, but also apply their intellectual and leadership skills outside the classroom." Wang's selection will be announced in *USA Today* on Thursday, February 13.

### TACIT alum wins Academy technical award

Caltech alum Chris Springfield (MS 1993, PhD 1998) received an Academy of Motion Picture Arts and Sciences Technical Achievement Award, together with colleagues Eric Daniels, George Katanics, and Tasso Lappas, for developing the Deep Canvas rendering software. Deep Canvas "captures the original brush strokes of the traditional background artist to render elements in three dimensions for animated films," according to an Academy press release. In an e-mail to Theater Arts at Caltech, Springfield wrote, "I thought you guys would like to know since my mission to get into the movies really got started on the TACIT stages."



## Message from the president

David Baltimore

A belated but hearty Happy New Year to everyone at Caltech.

As we start 2003, where are we? Although the uncertainty of an invasion of Iraq hangs over us, Caltech continues on its path of education and research. The economic picture remains gloomy but the funding of research looks relatively healthy. In spite of the economy, our \$1.4 billion campaign continues to accrue gifts and pledges at a reasonable pace.

This fall brought us two new vice presidents who have taken hold very effectively. The major challenge for Gary Dicovitsky in Development and Alumni Relations is, of course, making the campaign a success. It is a daunting task to arrive at an institution just as it starts a campaign, but Gary has taken a cool, thoughtful, and systematic approach to both his self-education about Caltech and his assumption of the helm of Development. Meanwhile, Margo Marshak has come as Caltech's first full-time and nonfaculty vice president for student affairs. She has had to learn the workings of the complex student culture that has evolved at Caltech over decades. That culture is particularly valuable because it nurtures students through the rigorous educational program set by the faculty. With her support and guidance, the educational experience at Caltech promises to become even richer. It is a testament to the greatness of this institution that it could attract two such capable people.

The capital campaign was initiated by the remarkable gift of Gordon and Betty Moore and we are beginning to see the benefits of the gift. The Moore Foundation has provided the funds for giving Caltech two critical new capabilities, magnetic resonance imaging and cryo-electron microscopy, and other major grants from the foundation are expected during the coming year. Also, as I promised earlier, the first direct gift from the Moores has been used to create an endowment fund for the enrichment of student life. We are also grateful for the generosity of the MacArthur Foundation, which, in recognition of the contributions of a Caltech senior trustee, the Honorable Shirley Hufstедler, provided the first \$900,000 of our new \$3 million fund for the enrichment of Caltech student life.

In this New Year, I also have been very concerned about a particular challenge for Caltech: maintaining its unique style. We continue to grow without increasing the number of faculty or undergraduates (although we had an unexpectedly large yield of students this year, which we plan to balance by future moderation of the class size). The world of science and engineering offers an increasing wealth of opportunity both in questions and in funds to study them. The government has recognized this by doubling the NIH budget to \$27 billion during the past five years and beginning a similar doubling of the NSF budget this year. With all of this opportunity coupled to a faculty that hungers to grapple with challenging questions, where is the appropriate limit on the size of the institution? At this moment, we have had no collective consideration of this issue, no limits have been deliberately established, and no effective

mechanisms are in place to control growth. The faculty is considering a committee to examine this crucial issue and the Board of Trustees is also concerned. The future of Caltech is at stake here.

While I think about whether we are outgrowing our culture, I am also acutely aware that science is changing its complexion. Small science—a faculty member working with a limited number of graduate students and others—has been the style of most laboratories historically and is likely to dominate science for years to come. But big science—laboratories with many tens or even hundreds of people often coupled to large machines—is playing a more important role today. Physicists and astronomers have grappled with the challenges of big science for decades, but now other fields are developing this appetite. I doubt if Caltech wants to miss the unique opportunities afforded by facilities on a larger scale. At the same time, we certainly don't want to see them dominate the campus. Perhaps we wish to think about establishing a locale devoted to housing such enterprises. The St. Luke property offers us this opportunity.

With the economy increasingly driven by technological advance and with technology so tightly coupled to national security, Caltech is poised to play an ever more important role in the world. Our challenge is to maintain the environment that differentiates us from other research universities while not passing up the opportunity to play on a larger stage.

## A journey "On the Road to Glory"

Over the centuries, the music and literature of Africans in America have embodied the power and dignity of the human spirit, expressing hope and strength in the quest for freedom. From the horrors of enslavement, through the Civil War, the civil rights movement, and continuing even today, the sung and spoken word has been a galvanizing force in the struggle against seemingly impossible odds.

Through traditional African music and spirituals, poems, prose, and anthems, the Princely Players will take their audience "On the Road to Glory"—the historical journey from slavery to liberation—on Saturday, February 8, at 8 p.m. in Beckman Auditorium. The ensemble of four women and four men gives an evocative and stirring presentation that includes works from the earliest sources of notated and oral African-American music; classic hymns and anthems such as "Swing Low, Sweet Chariot," "Old Time Religion," and "We Shall Overcome"; and contemporary music and writings from Nina Simone, Duke Ellington, Quincy Jones, Langston Hughes, Gwendolyn Brooks, and Richard Wright.

Featured on TNN and the BBC, the Princely Players have also been heard on National Public Radio's "Wade in the Water" series and on the Time-Life Civil War recordings. The group has collaborated with Ladysmith Black Mambazo and the Nashville Symphony, and its members have recorded with musicians Randy Travis, Danny O'Keefe, and Kathy Mattea.

Tickets are available through Caltech Public Events, and special offers are available for Caltech/JPL community members. Call 1 (888) 2-CALTECH or (626) 395-4652, e-mail [events@caltech.edu](mailto:events@caltech.edu), or visit [www.events.caltech.edu](http://www.events.caltech.edu). Individuals with a disability can call 395-4688 (voice) or 395-3700 (TDD).

# February 10–16, 2003

M T W T F S S

## Monday, February 10

### Geological and Planetary Sciences Seminar

155 Arms, Robert Sharp Lecture Hall, 4 p.m.—“Hydrocarbon Hazes on Early Earth and Titan: Experimental Constraints on Photochemical Formation Rates and Optical Properties,” Kristie A. Boering, assistant professor, department of earth and planetary science, UC Berkeley. Information: [www.gps.caltech.edu](http://www.gps.caltech.edu).

### Inorganic-Electrochemistry Seminar

147 Noyes, Sturdivant Lecture Hall, 4 p.m.—“Chimeric Metalloprotein Nucleases: The HTH as a Scaffold for De Novo Design,” Sonya J. Franklin, assistant professor of chemistry, University of Iowa.

### James Michelin Seminar Series

25 Baxter, 4 p.m.—“A Sculpture at Caltech: *Moore's Stone Volute* and the Genealogy of Its Form.” Artist Lloyd Hamrol, creator of the 1995 Caltech sculpture, will speak about the sources of his inspiration and will also address the topic of creating art for public spaces. Refreshments.

### Applied and Computational Mathematics Colloquium

101 Guggenheim Lab, Lees-Kubota Lecture Hall, 4:15 p.m.—“Differential Complexes in Numerical Analysis,” Douglas Arnold, professor of mathematics and director, Institute of Mathematics and Its Applications, University of Minnesota, Twin Cities. Refreshments, 3:45 p.m. Information: [www.acm.caltech.edu/colloq.shtml](http://www.acm.caltech.edu/colloq.shtml).

## Tuesday, February 11

### LIGO Seminar

351 West Bridge, LIGO Science Conference Room, 11 a.m.—“Seismic Attenuation System (SAS) Prototype Test,” Akiteru Takamori, LIGO Project, Caltech.

### Institute for Quantum Information Seminar

74 Jorgensen, 3 p.m.—Topic to be announced. Jonathan Oppenheim, Lady Davis Fellow, Racah Institute of Physics, Hebrew University, Israel.

### Thesis Seminar

206 Thomas, 3 p.m.—“Thermoacoustic Instabilities in the Rijke Tube: Experiments and Modeling,” Konstantin Matveev, graduate student in mechanical engineering, Caltech.

### General Biology Seminar

119 Kerckhoff, 4 p.m.—“From Long-Range Gradients to Local Cell Shape Changes: How *Drosophila* Embryos Control Their Morphogenesis,” Eric Wieschaus, Squibb Professor in Molecular Biology, Princeton University, and investigator, Howard Hughes Medical Institute.

## Wednesday, February 12

### Mathematical Physics Seminar

351 Sloan, noon—“Reinforced Random Walks,” Silke Rolles, department of mathematics, UCLA. Information: [www.math.caltech.edu/events/mathphys.html](http://www.math.caltech.edu/events/mathphys.html).

### Astronomy Colloquium (Fifth Annual Greenstein Lecture)

155 Arms, Robert Sharp Lecture Hall, 4 p.m.—“Cosmological Parameters,” Wendy Freedman, Carnegie Observatories. Information: [www.astro.caltech.edu/~gma/colloquia.html](http://www.astro.caltech.edu/~gma/colloquia.html).

### Environmental Science and Engineering Seminar

142 Keck, 4 p.m.—“Flapping Forces of Freely Flying Fruit Flies,” Michael Dickinson, professor of bioengineering, Caltech. Refreshments, Keck Labs lobby, 3:40 p.m.

### Information Sciences Seminar Series

74 Jorgensen, 4 p.m.—“A Location-Dependent Recommender System for the Web,” Professor Battiti Roberto, Università di Trento, Italy. Information: <http://netlab.caltech.edu/seminar/winter03.htm>.

### Wiersma Lecture

24 Beckman Labs, 4 p.m.—“Ultrastructure of LTP,” Professor Kristen Harris, Institute of Molecular Medicine and Genetics, Medical College of Georgia.

### Leakey Speaker Series on Human Origins

Beckman Auditorium, 8 p.m.—“The Chauvet Cave Now: The Oldest Rock Art Site in the World,” Dr. Jean Clottes, Conservateur General du Patrimoine, retired, and former scientific adviser for prehistoric art to the French Ministry of Culture. Fee: \$10; \$24 for the series of three lectures. Tickets and information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

## Thursday, February 13

### LIGO Seminar

351 West Bridge, LIGO Science Conference Room, 11 a.m.—“Mirror Surface Losses and Their Thermal Noise Effects at Low Temperature,” Kazuhiro Yamamoto, Institute of Cosmic Ray Research, Kashiwa, Japan.

### Caltech Library System Presents: Web of Science for Science and Engineering

Sherman Fairchild Library, multimedia conference room, 2 p.m.—Learn tips and tricks for searching Web of Science databases more effectively. Registration: <http://library.caltech.edu/learning/form.htm>. Open to Caltech community members only.

### Geoclub Seminar

151 Arms, Buwalda Room, 4 p.m.—“Antarctic Glacial History: The Long and the Short of It,” Professor John Stone, department of earth and space sciences, University of Washington.

### Physics Research Conference

201 E. Bridge, 4 p.m.—“The Evolution of Heavy Elements Since the Big Bang,” G. J. Wasserburg, MacArthur Professor of Geology and Geophysics, Emeritus, Caltech. Refreshments, 114 E. Bridge, 3:45 p.m. Information: [www.pma.caltech.edu/~physcoll/PhysColl.html](http://www.pma.caltech.edu/~physcoll/PhysColl.html).

### Social and Information Sciences Laboratory Seminar Series

25 Baxter, 4 p.m.—“When CS Meets GT: The Agent's Perspective,” Moshe Tennenholtz, associate professor, industrial engineering and management department, Technion, Israel. Refreshments.

## Friday, February 14

### Theoretical Astrophysics and Relativity Seminar

114 E. Bridge, 2 p.m.—“Black Hole Flight Simulation,” Professor Andrew Hamilton, department of astrophysical and planetary sciences, University of Colorado at Boulder.

### Fluid Mechanics Seminar

101 Guggenheim Lab, Lees-Kubota Lecture Hall, 3 p.m.—Topic to be announced. Professor Costas Pozrikidis, department of mechanical and aerospace engineering, UC San Diego. Information: [www.galcit.caltech.edu/Seminars/Fluids/CurrentFluids/index.html](http://www.galcit.caltech.edu/Seminars/Fluids/CurrentFluids/index.html).

### Inorganic-Organometallics Seminar

151 Crellin, 4 p.m.—“Luminescent Metal Complexes as Probes for Base Pair Mismatches in DNA,” Eva Rueba, post-doctoral scholar in chemistry, Caltech.

# February 17–23, 2003

M T W T F S S

## Monday, February 17

### Presidents' Day holiday

#### 22nd Annual Western States Mathematical Physics Meeting

151 Sloan, 9 a.m. to 5 p.m.—Continues on February 18. For information on speakers and topics, see [www.math.caltech.edu/events/wsmmp03.html](http://www.math.caltech.edu/events/wsmmp03.html). Fee: \$10; graduate students free.

## Tuesday, February 18

#### 22nd Annual Western States Mathematical Physics Meeting

151 Sloan, 9 a.m. to 5 p.m.—Continuation of February 17 meeting. For information on speakers and topics, see [www.math.caltech.edu/events/wsmmp03.html](http://www.math.caltech.edu/events/wsmmp03.html). Fee: \$10; graduate students free.

#### Caltech Library System Presents: Life Sciences Information Resources

Sherman Fairchild Library, multimedia conference room, noon—Learn how to make the most of biology and chemistry information tools and services provided by the Caltech Library System. Registration: <http://library.caltech.edu/learning/form.htm>.

#### General Biology Seminar

119 Kerckhoff, 4 p.m.—“RNAi and Development in *C. elegans*,” Craig Mello, associate professor of molecular medicine, University of Massachusetts Medical School, and investigator, Howard Hughes Medical Institute.

#### Social and Information Sciences Laboratory Seminar Series

25 Baxter, 4 p.m.—“Preference Elicitation in Proxied Multiattribute Auctions,” David C. Parkes, assistant professor of computer science, Harvard University. Refreshments.

## Wednesday, February 19

#### Thesis Seminar

153 Noyes, Sturdivant Lecture Hall, 2 p.m.—“Spatial, Temporal, and Chemical Aspects of Vapor Detection Using Conductive Composite Chemically Sensitive Resistors,” Shawn M. Brigrin, graduate student in chemistry, Caltech.

#### Astronomy Colloquium

155 Arms, Robert Sharp Lecture Hall, 4 p.m.—Topic to be announced. Professor Chris Sneden, department of astronomy, University of Texas. Information: [www.astro.caltech.edu/~gma/colloquia.html](http://www.astro.caltech.edu/~gma/colloquia.html).

#### Environmental Science and Engineering Seminar

142 Keck, 4 p.m.—Topic to be announced, Professor Philippe Tortell, botany department, University of British Columbia.

#### Information Sciences Seminar Series

74 Jorgensen, 4 p.m.—Topic to be announced. Marc Riedel, graduate student in electrical engineering, Caltech. Information: <http://netlab.caltech.edu/seminar/winter03.htm>.

#### Molecular Mechanisms of Disease Seminar

24 Beckman Labs, 4 p.m.—“Molecular Imaging of Biological Processes: From Mouse to Man,” Professor Mike Phelps, department of molecular and medical pharmacology, Division of Nuclear Medicine, UCLA.

#### Rhetoric, Knowledge, and Information Seminar Series

237 Baxter, 4 p.m.—“Information and History,” Philip T. Hoffman, professor of history and social science, Caltech. Refreshments.

#### Earnest C. Watson Lecture

Beckman Auditorium, 8 p.m.—“Clean Water: The Oil of the 21st Century,” Janet Hering, professor of environmental science and engineering, and executive officer for Keck Laboratories, Caltech. Admission is free. Information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

## Thursday, February 20

#### General Biology Seminar

119 Kerckhoff, 4 p.m.—Topic to be announced. Dr. Patrick Page-McCaw, department of physiology, UC San Francisco.

#### Geoclub Seminar

151 Arms, Buwalda Room, 4 p.m.—“Tectonic Geomorphology, Chronology, and Rates of Active Tectonics of the Santa Barbara Fold Belt,” Edward Keller, professor of geology, UC Santa Barbara.

#### Physics Research Conference

201 E. Bridge, 4 p.m.—“MAPping the Universe,” Edward L. (Ned) Wright, professor of physics and astronomy, UCLA. Refreshments, 114 E. Bridge, 3:45 p.m. Information: [www.pma.caltech.edu/~physcoll/PhysColl.html](http://www.pma.caltech.edu/~physcoll/PhysColl.html).

#### Social and Information Sciences Laboratory Seminar Series

25 Baxter, 4 p.m.—“Diversity: The Interplay of Difference in Complex Adaptive Systems,” Professor Scott E. Page, Center for the Study of Complex Systems, University of Michigan. Refreshments.

#### Von Karman Lecture Series

JPL, von Karman Auditorium, 7 p.m.—“New Weather and Climate Tools for the 21st Century,” Dr. Moustafa Chahine, senior research scientist and science team leader, Aqua Spacecraft Sounding System, JPL. Admission is free. Information: [www.jpl.nasa.gov/lecture](http://www.jpl.nasa.gov/lecture).

## Friday, February 21

#### Condensed Matter Physics Seminar

107 Downs Lab, noon—Topic to be announced. Professor Dung-Hai Lee, physics department, UC Berkeley. Information: [www.its.caltech.edu/~jpelab/CMP\\_Seminar\\_Dates.html](http://www.its.caltech.edu/~jpelab/CMP_Seminar_Dates.html).

#### Fluid Mechanics Seminar

101 Guggenheim Lab, Lees-Kubota Lecture Hall, 3 p.m.—“Instability of a Junction Vortex,” James Allen, visiting research scientist, University of Poitiers, France. Information: [www.galcit.caltech.edu/Seminars/Fluids/CurrentFluids/index.html](http://www.galcit.caltech.edu/Seminars/Fluids/CurrentFluids/index.html).

#### Inorganic-Organometallics Seminar

151 Crellin, 4 p.m.—“Dynamic and Steady-State Studies of Dye-Sensitized Titanium Dioxide Photoelectrochemical Cells,” Elizabeth Mayo, graduate student in chemistry, Caltech.

#### Science, Ethics, and Public Policy Seminar

25 Baxter, 4 p.m.—“Archimedes' 'Eureka,’” Asger Aaboe, emeritus professor of mathematics, history of science, and Near Eastern languages and literatures, Yale University. Refreshments. Information: [www.hss.caltech.edu/ses/index.html](http://www.hss.caltech.edu/ses/index.html).

#### Von Karman Lecture Series

Pasadena City College, 1570 E. Colorado, the Vosloh Forum (south of Colorado on Bonnie), 7 p.m.—“New Weather and Climate Tools for the 21st Century,” Dr. Moustafa Chahine, senior research scientist and science team leader, Aqua Spacecraft Sounding System, JPL. Admission is free. Information: [www.jpl.nasa.gov/lecture](http://www.jpl.nasa.gov/lecture).

## The precious commodity of water

A basic necessity of life for all living things, water is something we often take for granted. However, ensuring a sufficient supply to meet the world's needs is becoming more and more difficult. Janet Hering, professor of environmental science and engineering and executive officer for Keck Laboratories, sums up the situation in the February 19 Watson lecture, “Clean Water: The Oil of the 21st Century.”

Lack of access to safe drinking water is a major cause of illness and death, especially in children, in many developing countries. In the arid southwestern United States, water resources are coming under increasing pressure as a result of population growth, the competing needs of cities, farms, and sensitive ecosystems, and the anticipated changes in rain- and snowfall patterns that may accompany global changes in climate. Both the quantity and quality of available water are critical concerns in managing water resources. In her lecture, Hering will examine the factors affecting water quality, technologies for improving it, and possible strategies to meet future water supply needs.

The free public lecture begins at 8 p.m. in Beckman Auditorium. No tickets are required; seats will be available on a first-come, first-served basis, starting at 7:30. For more information, contact Public Events at 1 (888) 2-CALTECH, (626) 395-4652, or [events@caltech.edu](mailto:events@caltech.edu), or visit [www.events.caltech.edu](http://www.events.caltech.edu). Individuals with a disability can call 395-4688 (voice) or 395-3700 (TDD).

# CampusEvents

## Monday, February 10

### Baby Furniture and Household Equipment Pool

234 S. Catalina, 10 a.m. to 1 p.m.—Loans of kitchen and household necessities and baby furniture are made to members of the Caltech community. Information: 584-9773.

### Men's Golf

vs. Claremont-Mudd-Scripps, Brookside Golf Course, 1 p.m.

## Tuesday, February 11

### Photoshop Class

New Media Classroom, 363 S. Hill Avenue, 10 a.m. to noon—Learn the important functions of Photoshop, such as selection, layers, image enhancement, and correct file formats. The emphasis is on research images, but the information is useful to anyone working with images. This two-day class will continue on Thursday. Registration: carolynp@caltech.edu. Information: <http://muri.caltech.edu/nmc/index.htm>.

### Preschool Playgroup

Tournament Park, 10 a.m. to noon—Song and storytime, crafts and free play for toddlers and preschoolers (from walking to age 4). Information: 792-7808 or [julia@astro.caltech.edu](mailto:julia@astro.caltech.edu).

### Reel Women Series: *Because This is About Love*

Second floor common space, Center for Student Services, noon—*Because This is About Love: A Portrait of Gay and Lesbian Marriage* profiles five lesbian and gay couples from multicultural backgrounds, whose members have made a lifelong commitment to each other by going through a marriage ceremony. They tell their own stories of how they met, why they decided to marry, and how their family and friends responded. Pizza and drinks provided.

### Greenstein Memorial Service

Dabney Lounge, 3:30 p.m.—The memorial service for the late Jesse L. Greenstein will be followed by a reception. Professor Greenstein founded Caltech's astronomy department in 1948. He was the colleague, mentor, and friend of several generations of astronomers and physicists who made Caltech their scientific home, and many others who passed through as students and postdocs.

### Caltech Tai Chi Club

Winnett Lounge, 7 p.m.—Meets Tuesdays and Fridays weekly. Sessions are free. Information: [www.its.caltech.edu/~taichi](http://www.its.caltech.edu/~taichi).

### Amnesty International Letter Writing

Athenaeum Rathskeller, 7:30 p.m.—An informal meeting at which we write letters on human rights abuses around the world. All are welcome. Refreshments. Information: (818) 354-4461 or [lkamp@lively.jpl.nasa.gov](mailto:lkamp@lively.jpl.nasa.gov).

### Frank Capra Film Festival: *Meet John Doe*

Beckman Auditorium, 7:30 p.m.—This work by Caltech alumnus Frank Capra (BS 1918) tells the story of a hobo who agrees to impersonate a nonexistent character in a newspaper story who threatened suicide to protest an unjust political and social system. A panel discussion will follow the film. Admission is free. Information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

### Women's Basketball

at University of La Verne, 7:30 p.m.

## Wednesday, February 12

### Baby Furniture and Household Equipment Pool

234 S. Catalina, 10 a.m. to 1 p.m.—Loans of kitchen and household necessities and baby furniture are made to members of the Caltech community. Information: 584-9773.

### Wednesdays in the Park

Tournament Park, 10 a.m. to noon—Conversation and coffee for parents and caregivers, and playtime for children. Information: 355-3874 or [lcklavins@hotmail.com](mailto:lcklavins@hotmail.com).

### Men's Basketball

at University of Redlands, 7:30 p.m.

## Thursday, February 13

### Photoshop Class

New Media Classroom, 363 S. Hill Avenue, 10 a.m. to noon—A continuation of Tuesday's class. Information: <http://muri.caltech.edu/nmc/index.htm>.

## Friday, February 14

### Caltech Tai Chi Club

Winnett Lounge, 7 p.m.—Meets Tuesdays and Fridays weekly. Sessions are free. Information: [www.its.caltech.edu/~taichi](http://www.its.caltech.edu/~taichi).

### Women's Basketball

vs. Claremont-Mudd-Scripps, 7:30 p.m.

## Saturday, February 15

### Men's Tennis

vs. Pomona-Pitzer, 9:30 a.m.

### Women's Tennis

at Pomona-Pitzer, 9:30 a.m.

### Baseball

vs. Cal State Monterey Bay, noon.

### Track and Field

MIT Coed Invitational, at MIT, noon.

### Beginning/Intermediate Ballet Class

Braun Gym, multipurpose room, 1 p.m.—A free class taught by experienced members of the Caltech Dance Troupe. All experience levels are invited. The first hour will be beginning/intermediate exercise at the barre, while the last half hour will be an intermediate floor exercise. No special clothing or shoes are required.

### Swimming and Diving

at Mills College, 1 p.m.

### Men's Basketball

vs. Cal Lutheran University, 7:30 p.m.

## Sunday, February 16

### Amnesty International Book Discussion Group

Vroman's Bookstore, 695 E. Colorado Boulevard, 2nd floor, 6:30 p.m.—This month's book is *Our Lady of the Assassins*, by Fernando Vallejo. All are welcome, even if you haven't read the book. Registered members of the group can buy the book at a discount from Vroman's.

## Monday, February 17

### Presidents' Day holiday

### Credit Union Closure

All branches of the Caltech Employees Federal Credit Union will be closed in observance of Presidents' Day.

## Tuesday, February 18

### Premiere Video Editing Class

New Media Classroom, 363 S. Hill Avenue, 10 a.m. to noon—Learn about digitizing video for use on your computer, including basic editing techniques, adding titles, and using effects and transitions. Output your final project to tape or to file. This two-day class will continue on Thursday. Registration: carolynp@caltech.edu. Information: <http://muri.caltech.edu/nmc/index.htm>.

### Preschool Playgroup

Tournament Park, 10 a.m. to noon—Song and storytime, crafts and free play for toddlers and preschoolers (from walking to age 4). Information: 792-7808 or [julia@astro.caltech.edu](mailto:julia@astro.caltech.edu).

### Caltech Tai Chi Club

Winnett Lounge, 7 p.m.—Meets Tuesdays and Fridays weekly. Sessions are free. Information: [www.its.caltech.edu/~taichi](http://www.its.caltech.edu/~taichi).

### Women's Basketball

vs. University of Redlands, 7:30 p.m.

### Intermediate Jazz Dance Class

Braun Gym, multipurpose room, 9:30 p.m.—Intermediate jazz dance, taught by a professional instructor. No special clothing or shoes are required. Open to all who have a valid gym membership.

## Wednesday, February 19

### Baby Furniture and Household Equipment Pool

234 S. Catalina, 10 a.m. to 1 p.m.—Loans of kitchen and household necessities and baby furniture are made to members of the Caltech community. Information: 584-9773.

### Wednesdays in the Park

Tournament Park, 10 a.m. to noon—Conversation and coffee for parents and caregivers, and playtime for children. Information: 355-3874 or [lcklavins@hotmail.com](mailto:lcklavins@hotmail.com).

### Laboratory Safety for Continuing Researchers

118 Keith Spalding Building, 3 p.m.—This refresher course, for researchers continuing their work in laboratories, will review issues including laboratory organization, emergencies, injuries, fire, earthquake, chemical and radioactive material incidents, general laboratory safety, chemical storage, transporting chemicals, preparation for experiments, electrical safety, mechanical safety, and Safety Office services. Registration: 395-6727 or e-mail [safety.training@caltech.edu](mailto:safety.training@caltech.edu).

### Men's Basketball

vs. Whittier College, 7:30 p.m.

## Thursday, February 20

### Premiere Video Editing

New Media Classroom, 363 S. Hill Avenue, 10 a.m. to noon—A continuation of Tuesday's class. Information: <http://muri.caltech.edu/nmc/index.htm>.

### Swimming and Diving

SCIAC Championship, at Cerritos, 10 a.m., through Saturday, February 22.

### Women's Wellness Series: Yoga off the Mat

Steele House (carriage house), noon—This workshop will give you an understanding of yoga as a holistic practice, demonstrating proper breathing, posture, and attitude, which can be used at any time to stay inspired and stress free. Lunch is provided. Space is limited. Registration: (626) 395-3221. Open only to members of the Caltech community.

## Friday, February 21

### Men's Tennis

vs. University of La Verne, 2 p.m.

### Women's Tennis

at University of La Verne, 2 p.m.

### Baseball

at Cal Lutheran University, 2:30 p.m.

### Caltech Tai Chi Club

Winnett Lounge, 7 p.m.—Meets Tuesdays and Fridays weekly. Sessions are free. Information: [www.its.caltech.edu/~taichi](http://www.its.caltech.edu/~taichi).

### Women's Basketball

at Whittier College, 7:30 p.m.

### Robin and Linda Williams and Their Fine Group

Dabney Lounge, 8 p.m.—Robin and Linda Williams, well known for their long association with Garrison Keillor's *A Prairie Home Companion*, combine the traditions of bluegrass, country, and folk with their own unique style. Their Fine Group includes Jim Watson on bass and Jimmy Gaudreau on mandolin. Tickets and information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit the Folk Music Society at [www.its.caltech.edu/~folkmusi](http://www.its.caltech.edu/~folkmusi).

### Opening Night of *Twelfth Night*

Ramo Auditorium, 8 p.m.—Theater Arts at Caltech presents *Twelfth Night, or What You Will*, by William Shakespeare. Tickets and information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

## Saturday, February 22

### Track and Field

Rossi Relays, at Claremont-Mudd-Scripps, 9 a.m.

### Men's Tennis

vs. Occidental College, 9:30 a.m.

### Women's Tennis

at Occidental College, 9:30 a.m.

### Baseball

doubleheader vs. Cal Lutheran University, 11:30 a.m.

### Beginning/Intermediate Ballet Class

Braun Gym, multipurpose room, 1 p.m.—A free class taught by experienced members of the Caltech Dance Troupe. All experience levels are invited. The first hour will be beginning/intermediate exercise at the barre, while the last half hour will be an intermediate floor exercise. No special clothing or shoes are required.

### MatheMagic!

Beckman Auditorium, 2 p.m.—Master magician Bradley Fields stimulates creative thinking and inspires children's curiosity by revealing the secrets behind startling magic tricks, allowing the beauty and language of math to be understood and appreciated. Suggested for ages five and older. Tickets and information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

### Men's Basketball

at Pomona-Pitzer, 7:30 p.m.

### Twelfth Night

Ramo Auditorium, 8 p.m.—Theater Arts at Caltech presents *Twelfth Night, or What You Will*, by William Shakespeare. Tickets and information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

## Sunday, February 23

### Skeptics Society Lecture

Baxter Lecture Hall, 2 p.m.—"Freedom Evolves: Free Will, Determinism, and Evolution," Daniel C. Dennett, University Professor and director of the Center for Cognitive Studies, Tufts University. Donation is \$8 for nonmembers, \$5 for members and non-Caltech students. Free to the Caltech/JPL community. Tickets and information: 794-3119 or [skepticmag@aol.com](mailto:skepticmag@aol.com). Visit the Skeptics Society at [www.skeptic.com](http://www.skeptic.com).

### Twelfth Night

Ramo Auditorium, 2 p.m.—Theater Arts at Caltech presents *Twelfth Night, or What You Will*, by William Shakespeare. Tickets and information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

### Coleman Chamber Concert

Beckman Auditorium, 3:30 p.m.—The Amelia Piano Trio performs works by Beethoven, Silverman, and Brahms. Tickets and information: 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability: 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

## Date corrections for basketball, Princely Players

The last issue of the 336 Calendar listed the incorrect date for the 7:30 p.m. men's basketball game against Claremont-Mudd-Scripps, and for the 8 p.m. appearance of the Princely Players in Beckman Auditorium. The correct date for both events is Saturday, February 8. We apologize for the inconvenience.

**Gigahertz**, from page 1

"When we think of microelectronics today, we think about moving charges around on chips," says Roukes. "We can do this at high rates of speed, but in this electronic age our mindset has been somewhat tyrannized in that we typically think of electronic devices as involving only the movement of charge.

"But since 1992, we've been trying to push mechanical devices to ever-smaller dimensions, because as you make things smaller, there's less inertia in getting them to move. So the time scales for inducing mechanical response go way down."

Though some home computers these days have speeds of one gigahertz or more, the quest to construct a mechanical device that can operate at such speeds has required multiple breakthroughs in manufacturing technology. In the case of the Roukes group, using silicon carbide epilayers to precisely control layer thickness and a balanced high-frequency technique for sensing motion have been crucial to success. Both advances were pioneered in the Roukes lab.

Grown on silicon wafers, the films used in the work are prepared in such a way as to produce two nearly identical beams, each 1.1 microns long, 120 nanometers wide, and 75 nanometers thick. When driven by a microwave-frequency electric current while exposed to a strong magnetic field, the beams mechanically vibrate at slightly more than one gigahertz.

Future work will include improving the nanodevices to better link their mechanical function to real-world applications, Roukes says. The issue of communicating information, or measurements, from the nanoworld to the scale of the everyday world we live in is not trivial. As devices become smaller, it becomes increasingly difficult to recognize the very small displacements that occur at much shorter time scales.

Such progress in NEMS might eventually lead to improvements in magnetic resonance imaging, to the extent of being able to image individual macromolecules; to novel forms of mass spectrometry that can sense individual biomolecules in fluids; or to quantum computing, through solid-state manifestations of the quantum bit.

**Financial aid**, from page 1

parents in filling out the necessary forms to receive Cal Grants, scholarships, work-study employment, and loans. By helping families navigate the complicated financial-aid process, the free statewide workshops will enhance students' chances of attending college.

One of the campaign's goals is to dispel the myth among many low-income families that college is not an affordable option. Under the historic Cal Grant Guarantee signed into law in 2000, any California student who meets grade point average, income, and asset requirements is eligible to receive money for college tuition, fees, books, and living expenses. All students need to do is fill out the Free Application for Federal Student Aid (FAFSA) and Cal Grant GPA Verification forms and submit them by the March 3 deadline.

"I wanted to be sure that eligible California students were aware of the availability of financial aid, and specifically the Cal Grants, to help them realize their dreams of a postsecondary education," said Levy.

He was instrumental in coordinating the College Goal Sunday campaign and workshops, assembling more than 600 colleagues from the California Association of Student Financial Aid Administrators to participate. Together with Catherine Thomas, associate dean for admission and financial aid at USC, Levy designed the workshop financial-aid presentation and trained volunteers in its implementation.

The Lumina Foundation for Education and the James Irvine Foundation are major sponsors of the California College Goal Sunday. Caltech is among the members of the steering committee convened by the governor's secretary for education.

"Free Cash for College" workshops will be held throughout February at numerous Southern California high schools and colleges. For more information or locations, visit [ww.californiacolleges.edu/collegegoalsunday](http://ww.californiacolleges.edu/collegegoalsunday); call toll free (866) 476-8787; or e-mail Dan Bernal, statewide coordinator, at [d.bernal@mindspring.com](mailto:d.bernal@mindspring.com).

**Columbia**, from page 1

north of viewing location . . . . Coma pulsed [again a fraction of a second], brighter than first event (although atmospheric attenuation at the lower elevation for event 1 makes direct comparison unreliable). There was clearly a new trail formed after this event, directly behind the orbiter (i.e. the second trail was parallel to and contained within the main trail). My impression was that it was more than one piece, i.e., that there was a main piece and a few smaller bits (2-3?). They fell behind quickly, taking a few seconds to fall [approximately] 1-2 degrees behind and then fade from sight, with some suggestion that they were falling just before vanishing.

"Again—seemed consistent with the tile hypothesis, so I didn't focus on it.

"Third event: Brightest of the events, about 15 seconds after #2. Substantially brighter than others . . . Very clear view of object detaching, forming separate trail. Looked like orbiter dropped a flare or something. Bright secondary object quickly fell out of main orbiter trail, generated its own trail for a few degrees . . . It took some time to fade from sight (5 seconds?)

"At the time I did wonder whether something that major would be a tile. My wife asked me what the things coming off were. I replied I thought they were tiles.

"I have some recollection that there may have been other dimmer events between the first and second events listed above.

"Total time to pass from rise . . . to out of sight ( . . . beyond orographic clouds over the White Mountains) was not timed, but I'd estimate it at 40 seconds minimum, probably over a minute all together. We waited 3-5 minutes longer to hear the sonic boom, and did not hear it unambiguously. Based on what I'm hearing from the news services, roughly 2 minutes later the orbiter broke up over Texas."

Beasley did not learn of the space shuttle's loss until he drove to OVRO, about 10 miles south, to speak with two photographers. He ended his message, "On behalf of the staff of the Caltech Owens Valley Observatory I'd like to offer our condolences to the family and friends of the shuttle astronauts and to NASA at this terrible tragedy."

When asked that day about Beasley's sighting, shuttle program manager Ron Dittmore said it might just be the normal buildup of hot plasma during a space shuttle reentry. On Sunday, however, Dittmore said that after closer examination of Mission Control data, NASA now believes that Beasley did in fact see pieces of the spacecraft falling off and that his observations will be important in the ongoing investigation.

**Leakey**, from page 1

tologist and biological anthropologist, noticed that the bonobos are tranquil while the chimpanzees are capable of humanlike aggression. The fact that these two apes are our closest relatives makes the comparison that much more intriguing. Wrangham will explore the mystery of why we are temperamentally like chimpanzees in some ways, and like bonobos in others. This lecture will be presented on Wednesday, May 28.

Begun in the early 1970s, the Leakey Lectures attracted many of the rising stars of archaeology and anthropology such as Louis Leakey, Mary Leakey, Donald C. Johanson, Jane Goodall, and Dian Fossey. All three lectures in the Leakey Speaker Series on Human Origins are open to the public. Tickets are \$10 per lecture, \$24 for the series. For tickets and information, contact Public Events at (626) 395-4652, 1 (888) 2CALTECH, or [events@caltech.edu](mailto:events@caltech.edu). Individuals with a disability, call (626) 395-4688 (voice) or 395-3700 (TDD). Visit Public Events at [www.events.caltech.edu](http://www.events.caltech.edu).

Each lecture will be presented at 8 p.m. in Beckman Auditorium.

**News extras...**

Resident Los Angeles Opera singers Jessica Rivera and Luis Contreras performed favorite selections, accompanied by Daniel Faltus, at a recent noon concert in Dabney Lounge. The visit was sponsored by Student Affairs, the Performing and Creative Arts Department, MOSH, and the Caltech Opera Club.

# Caltech 336

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