

Proto Credits: Pages 2, 4, 7, 10, 12, 14–15, 19, 20–21 (portraits): Mario de Lopez; 2 (background image): NASA/CAC/SAO/DE-Caitech/STScr; 4 (background image): Bin Yang, Gradinaru Lab; 7 (background image): Mclek/Shutterstock.com; 8: Seth Hansen; 9: Courtesy of the USC/ Caltech Collaboration Group of Mark Humayun (USC) and Yu-Chong Tai (Caltech); 10 (background image): Lance Hayashida/Caltech Marcomm; 12 (background image): Space Telescope Science Institute; 14–15 (background image): NASA; 16: Eric Ogden; 17: Matt Shaner; 19 (background image): Louisa Howard, Dartmouth College Electron Microscope Facility; 20–21: Kim Briers/Shutterstock.com When we looked back at 2013, it became clear that it had been a year—yet another year, actually—in which Caltech had extended its reach through the exceptional work of its scientists and engineers.

We saw this literally in the announcement that the Caltech-led Voyager spacecraft had reached interstellar space. We saw it more figuratively through the invention by a Caltech electrical engineering professor of a tiny, inexpensive silicon microchip that can create scans and images using high-frequency terahertz waves, and through the discovery by a Caltech earth sciences research duo of evidence pointing to the existence of an ancient river delta on Mars.

In this same year, we renamed a division (Biology became **Biology and Biological Engineering) and created a new** department (Medical Engineering) within the Division of Engineering and Applied Science. Together, they are a sign of our willingness to reimagine ourselves and focus on reaching beyond our own borders with our most promising insights and innovations, and using them to change lives.

We invite you to learn more about the ways in which Caltech is reaching farther, reaching deeper, and reaching beyond by exploring Reach, our 2013 Annual Report.

Edward Stolger Daville

Edward Stolper Interim President and Provost, Caltech

David K. Lee Chair, Caltech Board of Trustees



# Space Voyager

**Ed Stone** 

David Morrisroe Professor of Physics

Ed Stone has helmed the Voyager 1 mission since 1977, when it was launched on a four-year journey to Jupiter and Saturn. Thirty-six years later, the mission has more than surpassed its original intent, traveling farther than any humanmade object in history. And in 2013, Voyager 1 reported back that it had reached uncharted territory: interstellar space.

Stone beams when talking about the spacecraft's many accomplishments.

"Voyager 1 is a mission much like the first circumnavigation of the earth or the first footprints on the moon. It's been a long journey humanity's longest journey, in fact. It's the only thing like it—and will be the only thing like it—for many, many years, serving as earth's silent ambassador and continuing to alter our view of the solar system. What makes this mission so exciting is that we keep finding things that we didn't even know were there to be discovered. That's the reason you explore."



## Neuron Stimulator

### Viviana Gradinaru

Assistant Professor of Biology

As a student in Romania, Viviana Gradinaru focused on theoretical work because of few resources for pursuing experimental science. That changed when she enrolled at Caltech: "My undergraduate experience was an eye-opener to the beauty of biology and its potential. That's how I got interested in neuroscience."

Later, as a PhD candidate at Stanford, Gradinaru would play an instrumental role in the early development and applications of optogenetics, a research technique that today allows scientists to detect and control neuronal activity in brain processes. Says Gradinaru: "Now that I'm back at my alma mater, I'm interested in collaborating with other labs across campus and pairing with researchers in other divisions to find better therapies for mental disorders. There is the potential for a lot of synergy between what my research group is doing and the knowledge that's already in hand in many of the labs at Caltech."

## Kisk Assessor

### **Colin Camerer**

Robert Kirby Professor of Behavioral Economics

The kind of bubble market that led to the 2008 financial crisis and Great Recession was not, says Colin Camerer, entirely fueled by investors' confusion and reckless behavior. Instead, according to the research findings he and his team published in 2013, the people driving such economic anomalies actually think a lot about what is going on and what is likely to happen next before deciding to jump in.

Says Camerer, a 2013 MacArthur Fellow who began studying behavioral economics in graduate school: "I'm seeking to bring sensible human psychology and economics together to find out how emotion fits into economic theory and learn what's happening in people's brains when they're making these kinds of economic choices. With very little neuroscience done on this type of thing, I've quickly reached fairly uncharted territory. But that's nothing new. At Caltech, we're always trying to do the first experiment on something, to conduct tests that people haven't tried or couldn't get to work, to be ahead of the pack technologically. That's what helps make Caltech unique."

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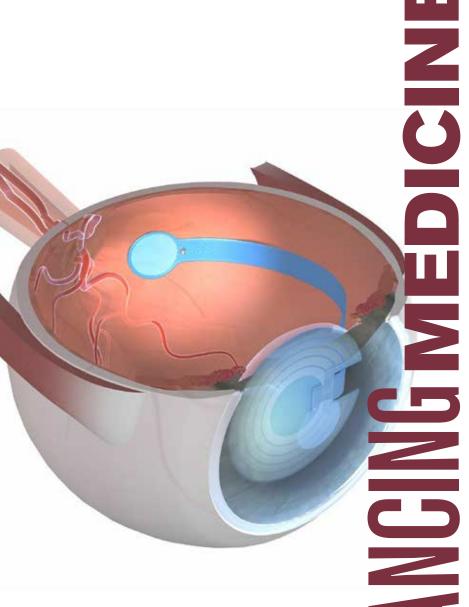




In 2013, for the first time in 43 years, Caltech established a new division, the Division of Biology and Biological Engineering (BBE), the first of its kind in the country. Stephen Mayo, William K. Bowes Jr. Leadership Chair of the division and Bren Professor of Biology and Chemistry, piloted BBE through these changes, creating a unit whose scientists and engineers will not only continue to address questions about the evolution, development, and function of living things, but also use those findings to devise and build innovative solutions to biological and medical problems.

Says Mayo: "Although other schools have biological engineering programs within their schools of engineering, none have a college or school in which biological engineering is integrated directly with biology so they can enhance each other. The potential synergy is powerful and important. Combining these disciplines into one division increases the potential and the pace for providing transformative solutions to some of the biggest problems in science, medicine, and health."

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Caltech helped secure its position as a leader in the field of translational, or "benchto-bedside," medicine in 2013 with the formation of the new Department of Medical Engineering (MedE) within the **Division of Engineering and** Applied Science (EAS). The interdisciplinary program was established "in response to the desire of many of our faculty and of local research hospitals and medical foundations to engage jointly in engineering-centric technology development efforts for medical applications," says Ares Rosakis, Theodore von Kármán Professor of Aeronautics and Mechanical Engineering and Booth Leadership Chair of EAS.

"MedE brings together faculty from diverse backgrounds who will reach out to medical schools and hospitals to engineer top-notch medical devices and provide solutions to the challenges that clinicians and medical researchers face every day. It will also offer graduate education to train a new generation of engineers to close the gap between engineering and medicine. This program truly has the potential to directly and positively impact human health and well-being."

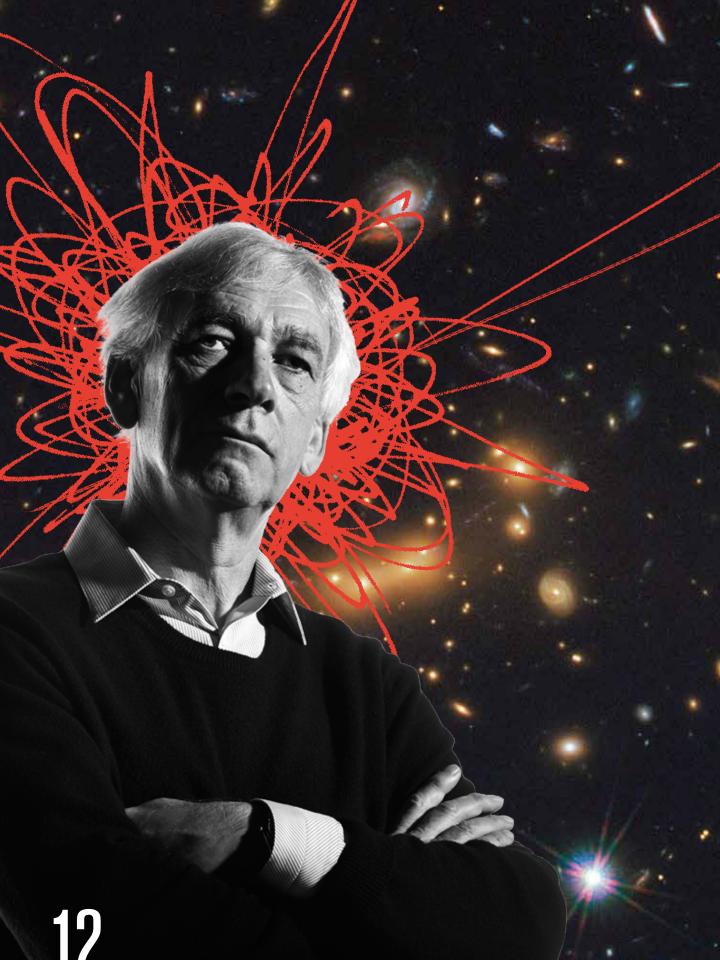


## Power Broker

### Ali Hajimiri

Thomas G. Myers Professor of Electrical Engineering

In 2013, Ali Hajimiri successfully harnessed the power available in a largely untapped region of the electromagnetic spectrum by creating tiny, inexpensive silicon microchips that can operate on the power of terahertz waveshigh-frequency electromagnetic waves that can create scans and images better than X-rays without the damaging effects of radiation. These waves also pick up on the chemical traces of drugs, weapons, and explosives. "A large range of the spectrum has been explored extensively, but there's always been this terahertz 'gap' primarily because there have been no cost-effective and sizeeffective methods of application. Our motivation for wanting to close this gap was to do something that everyone says is not possible. **Because Caltech encourages** high-risk, high-reward ventures and has always been on the forefront of challenging the status quo, we pushed. We expect that there will be a lot of commercial applications for the chip we've built. I'm even more excited about creative people using these chips in ways we never would have thought of. What I like about the potential of this thing is the unknown."



## Galaxy Explorer

### **Richard Ellis**

Steele Family Professor of Astronomy

A lifetime of scanning the skies has paid off in spades for Richard Ellis. Ellis and an international team secured coveted observing time with the Hubble Space Telescope, pushing Hubble to its technical limits to address questions about the universe's earliest galaxies, and probing deeper and more systematically than any researchers ever had before. In 2013, they published their observations, revealing seven of the most primitive and distant galaxies ever seen and providing the first insights into how those early systems formed.

"These galaxies formed more than 13 billion years ago and give us our first view of the last uncharted period of cosmic history. We're looking back to the birth of systems that eventually grow to ones like our Milky Way. Reaching these extreme limits has been a long personal journey for me involving larger telescopes, better detectors, and ultimately, this deep exposure with Hubble. Caltech provides the ideal scientific environment for such ambitious quests. Everyone is striving to do impressive things and you feel encouraged to seek answers to big questions."

## Planetary Partners

Woody Fischer

Assistant Professor of Geobiology

In 2013, Woody Fischer, Mike Lamb, and their colleagues teamed up to uncover evidence of an ancient delta on Mars where a river might once have emptied into a vast ocean.

"We are in different fields of earth science but recognized that we have quite a bit of overlap. Working together allows us to address problems that a lot of people miss," Fischer says.

Adds Lamb: "The idea of combining our skill sets was nurtured by our senior colleague, John Grotzinger. He pushed us to reach beyond our particular fields and make crossdisciplinary connections. But I also credit the collaborative and open environment Caltech has; it's that environment that leads us to fundamental questioning and innovative answers. Caltech puts trust and resources into us to pursue problems we are passionate about. If there are discoveries to be made, then we are encouraged to make them. It is the reason that the pace of discovery is so high here."

### **Mike Lamb** Assistant Professor of Geology

**The Division of Engineering** and Applied Science (EAS) will extend its legacy of leadership in engineering and technology research with the **Otis Booth Leadership Chair,** endowed by the Otis Booth Foundation. The foundation, established by Franklin Otis Booth Jr. (BS '44), created the endowment in order to give the division's chair the ability to invest in promising ideas that reach across discipline boundaries to create new solutions. This \$10 million gift, a permanent source of flexible financial resources, "will support potentially transformative research and educational efforts that could not go forward without early funds," says EAS division chair Ares Rosakis, the inaugural holder of the Booth Leadership Chair, and Theodore von Kármán **Professor of Aeronautics and** Mechanical Engineering.

Says Lynn Booth, president of the Otis Booth Foundation, a Caltech trustee, and a prominent Los Angeles philanthropist: "This gift will give Caltech greater financial flexibility to respond to special opportunities and unforeseen challenges. I am excited to see what inventions and ideas become realities as Dr. Rosakis and his successors at the helm of EAS use this endowment now and far into the future." A \$15 million gift from Lynda and Stewart Resnick will bring the vision of a sustainable planet within reach through the **Resnick Sustainability Institute** at Caltech. The Resnicks' support will help researchers who have new ideas for cleanenergy and sustainability science realize their work's potential while growing the **Resnick Sustainability Institute** endowment with one-to-one matching funds. "Support from the Resnicks has enabled us to pioneer technologies that derive fuels from sunlight, create chemical catalysts that convert waste materials to biofuels, and much more," says Harry Atwater, Howard Hughes Professor of **Applied Physics and Materials** Science and director of the Resnick Sustainability Institute.

Caltech is "uniquely qualified" to pioneer such advances, says Stewart Resnick, Caltech trustee and the chairman and co-owner of Roll Global. "The intimacy of its campus allows many diverse scientific disciplines to easily and regularly come together for a kind of innovative thinking that is hard to achieve elsewhere. We see funding Caltech's efforts as an investment in our future, not just as philanthropy."

## Catalyst Converter

### **Jonas Peters**

Bren Professor of Chemistry

For the past decade, Jonas Peters has been intensely focused on nitrogen fixation—the process of converting atmospheric nitrogen into ammonia. In 2013, that fixation on fixation paid off when he and his research team reported they'd developed the first molecular iron-based catalyst that promotes the conversion of nitrogen to ammonia—a reaction needed for the production of nitrogen fertilizer.

Peters hopes his group's research will promote a better understanding of how biological nitrogen fixation occurs, an understanding that may some day lead to environmentally friendly methods for ammonia production. "We need an enormous supply of fixed nitrogen to make the fertilizer that supplies the world with food. Understanding how biological nitrogen fixation occurs, and figuring out how to mimic this process synthetically in a lab with a molecular iron catalyst, was one of those problems that for years seemed intractable—which is why we were so attracted to it. Our recent discovery wasn't blind luck; it was a case where fundamental, rational, hypothesis-driven science got the job done through trial and error over a period of years. But our original goal in making this iron catalyst system was to help teach us the mechanism of nitrogen fixation. There are still so many rich questions to be answered. For us there's no goal that is more worthwhile than pursuing the answers to these questions."







# Utility Player

### Paige Logan

Caltech Senior

Senior Paige Logan, who has dreamed of being an oceanographer since she was 10 years old, will be one step closer to achieving that dream when she graduates in June 2014 with a double major in geophysics and in environmental science and engineering. In addition to attending classes, taking exams, and working through problem sets, Logan has played on three of Caltech's **NCAA Division III sports** teams; completed a Summer **Undergraduate Research** Fellowship, an internship, and a summer fellowship; served on the Executive Committee and as an Upperclassman Counselor for both Ruddock and Fleming Houses; cochaired the Student Athlete Advisory Committee; and chaired the Food Committee.

She says she knew Caltech was the school for her after her first trip to campus: "My dad kind of twisted my arm into visiting Caltech. And even though it was a rainy, gross, awful day, I totally loved it. It felt like somewhere I could fit in—and I was right. I've been so active because students actually have a voice here on campus. Caltech has a way of empowering its students to reach for more."



### Financial Summary

For the fiscal years ended on September 30, 2013 and 2012 (in thousands)

#### LETTER FROM THE VICE PRESIDENT FOR BUSINESS & FINANCE

Fiscal 2013 was a strong financial year for Caltech, one that resulted in an increase in net assets of 8.4%, to almost \$2.4 billion. We continue to manage operating costs and to benefit from strong philanthropic support. The Institute's endowment ended the year at \$1.96 billion, thanks to strong investment performance and new contributions to the endowment. In addition, the in funding to campus programs, which accounted for 16.8% of the campus operating budget. In these changeable times, we remain cautiously optimistic and are proud to be operating from a position of financial strength. Although the longterm outlook for research funding from federal agencies is uncertain, Caltech continues to receive a strong, steady flow of new research funding. We continue to invest in our infrastructure and have preserved a significant amount of 2011 taxable bond proceeds to ensure that we have the resources to continue to attract the best and brightest faculty and students. We remain committed to our core mission and are confident that our strategy and resources will allow Caltech to retain its prominent position in teaching and research.



Dean Currie Vice President for Business & Finance

|   |        | 2013      | 2012            |
|---|--------|-----------|-----------------|
| Operating Revenues (excluding JPL)            |        |           |                 |
| Tuition and fees, net                         | \$     | 35,216    | \$<br>34,130    |
| Endowment payout                              |        | 102,162   | 97,386          |
| Gifts and pledges                             |        | 46,174    | 54,393          |
| Grants and contracts                          |        | 342,279   | 357,368         |
| Other   |        | 80,476    | <br>60,428      |
| Operating revenues                            | \$     | 606,307   | \$<br>603,705   |
| Operating Expenses (excluding JPL)            |        |           | <br>            |
| Compensation and benefits                     | \$     | 349,643   | \$<br>338,697   |
| Supplies and services                         |        | 144,882   | 155,320         |
| Subcontracts                                  |        | 32,798    | 39,056          |
| Graduate fellowships                          |        | 17,720    | 17,807          |
| Depreciation, accretion,<br>& amortization    |        | 67,406    | 64,106          |
| Utilities                                     |        | 16,170    | 17,711          |
| Interest                                      |        | 16,400    | 13,039          |
| Operating expenses                            | \$     | 645,019   | \$<br>645,736   |
| Asset, Liability and Net Assets S             | Summar | У         | <br>            |
| Cash, advances, and deposits                  | \$     | 11,564    | \$<br>17,020    |
| Accounts receivable, net                      |        | 216,290   | 221,076         |
| Investments                                   |        | 2,392,563 | 2,245,694       |
| Other assets                                  |        | 180,012   | 181,917         |
| Deferred United States<br>government billings |        | 456,917   | 575,724         |
| Property, plant & equipment, net              |        | 874,288   | 873,768         |
| Total assets                                  | \$     | 4,131,634 | \$<br>4,115,199 |
| Accounts payable and accrued expenses         | \$     | 408,913   | \$<br>452,452   |
| Other liabilities                             |        | 118,155   | 109,833         |

Note: The figures that appear in the financial summary shown are derived from the financial statements for the years ended September 30, 2013 and 2012, that have been audited and have received an unmodified opinion The complete, audited fiancial statements for the Institute can be seen at www.businessandfinance.caltech.edu

\$

\$

Bonds and notes payable

Increase in net assets

benefit obligation

Total net assets

Accumulated postretirement

Total liabilities and net assets

726,970

515,032

2.362.564

4,131,634

182,125

709,571

662,904

2,180,439

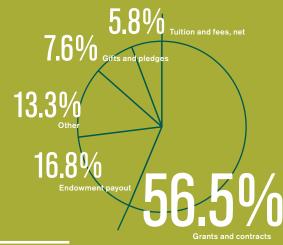
4,115,199

137,761

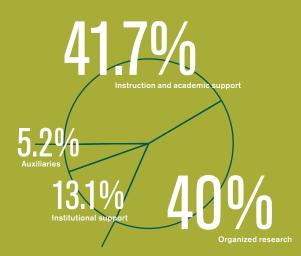
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| 2013 Operating Revenues (excluding JPL) |    |         |   |       |  |  |  |
|---|----|---------|---|-------|--|--|--|
| Grants and contracts                    | \$ | 342,279 |   | 56.5  |  |  |  |
| Endowment payout                        |    | 102,162 |   | 16.8  |  |  |  |
| Other                                   |    | 80,476  |   | 13.3  |  |  |  |
| Gifts and pledges                       |    | 46,174  |   | 7.6   |  |  |  |
| Tuition and fees, net                   |    | 35,216  |   | 5.8   |  |  |  |
| Operating revenues                      | \$ | 606,307 | % | 100.0 |  |  |  |



| 2013 Operating Expenses (excluding JPL) |    |         |   |       |  |  |  |
|---|----|---------|---|-------|--|--|--|
| Instruction and<br>academic support     | \$ | 268,719 |   | 41.7  |  |  |  |
| Organized research                      |    | 258,327 |   | 40.0  |  |  |  |
| Institutional support                   |    | 84,637  |   | 13.1  |  |  |  |
| Auxiliaries                             |    | 33,336  |   | 5.2   |  |  |  |
| Operating expenses                      | \$ | 645,019 | % | 100.0 |  |  |  |





#### NATIONAL AWARDS AND HONORS

INSTITUTE OF MEDICINE, Member:

Jacqueline K. Barton Arthur and Marian Hanisch Mem Professor and Professor of Chemist.

and Chair, Division of Chemistry and Chemical Engineering

NATIONAL ACADEMY OF ENGINEERING, Member: Richard M. Murray

Thomas E. and Doris Everhart Professor of Control and Dynamical Systems and Bioengineering

Michael Ortiz Frank and Ora Lee Marble Professor of Aeronautics and Mechanical Engineering

NATIONAL ACADEMY OF INVENTORS, Fellow: Morteza Gharib Hans W. Liepmann Professor of Aeronautics and Bioimpoired

of Aeronautics and Bioinspired Engineering, and Vice Provost

NATIONAL ACADEMY OF SCIENCES, Member: Michael E. Brown

Richard and Barbara Rosenberg Professor and Professor of Planetary Astronomy

Kenneth A. Farley W. M. Keck Foundation Professor of Geochemistry, and Chair, Division of Geological and Planetary Sciences

John H. Seinfeld Louis E. Nobl Professor and Professor of Chemical Engineering

NATIONAL INSTITUTES OF HEALTH, 2013 NIH Director's New Innovator Award: Viviana Gradinaru

Assistant Professor of Biology

FOUNDATION, NATIONAL SCIENCE BOARD, Member: Stephen L. Mayo

Bren Professor of Biology and Chemistry, and William K. Bowes Jr. Leadership Chair, Division of Biology and Biological Engineering

#### INTERNATIONAL AWARDS AND HONORS

FRENCH REPUBLIC, Chevalier de l'Ordre des Palmes Académiques:

Michael L. Roukes Robert M. Abbey Professor of Physics, Applied Physics, and Bioengineering

GERMAN PHYSICAL SOCIETY AND THE OPTICAL SOCIETY OF AMERICA, Herbert Walther Award:

**H. Jeff Kimble** William L. Valentine Professor and Professor of Physics

#### AWARDS AND HONORS FROM PROFESSIONAL SOCIETIES

AMERICAN ASTRONOMICAL SOCIETY, 2012 Annie Jump Cannon Award in Astronomy: Heather A. Knutson Assistant Professor of Planetary Science

AMERICAN CHEMICAL SOCIETY, 2013 Award in Pure Chemistry: Theodor Agapie

*Assistant Professor of Chemistr* 2013 Arthur C. Cope

Scholar Award: Sarah E. Reisman Assistant Professor of Chemistri

AMERICAN CHEMICAL SOCIETY, SOUTHERN CALIFORNIA SECTION, 2012 Richard C. Tolman Medal: John E. Bercaw Centennial Professor of Chemistry

AMERICAN INSTITUTE OF CHEMISTS, 2013 AIC Gold Medal:

John D. Roberts Institute Professor of Chemistry, Emeritus

AMERICAN MATHEMATICAL SOCIETY, Fellow: Tom M. Apostol

Professor of Mathematics, Emeritus Michael Aschbacher Shaler Arthur Hanisch Professor of Mathematics, Emeritus

Yizhao Thomas Hou Charles Lee Powell Professor of Applied and Computational Mathematics

Alexander Kechris Professor of Mathematics

Wilhelmus Luxemburg Professor of Mathematics, Emerit

Hirosi Ooguri Fred Kavli Professor of Theoretical Physics and Mathematics, and Deputy Chair, Division of Physics, Mathematics and Astronomy

**Dinakar Ramakrishnan** Taussky-Todd-Lonergan Professor of Mathematics, and Executive Officer for Mathematics

**Barry M. Simon** International Business Machines Professor of Mathematics and Theoretical Physics

MINERALS, METALS & MATERIALS SOCIETY, 2013 Early Career Faculty Fellow: Julia R. Greer Professor of Materials Science and Mechanics SOCIETY OF ENGINEERING SCIENCE, Young Investigator Medal: Julia R. Greer

Julia R. Greer Professor of Materials Science and Mechanics

SOCIETY FOR EXPERIMENTAL MECHANICS, 2013 P. S. Theocaris Award: Ares J. Rosakis

Theodore von Karman Professor of Aeronautics and Mechanical Engineering, and Otis Booth Leadership Chair, Division of Engineering and Applied Science

SOCIETY FOR INDUSTRIAL AND APPLIED MATHEMATICS, Fellow:

**Oscar P. Bruno** Professor of Applied and Computational Mathematics

#### AWARDS AND HONORS FROM FOUNDATIONS AND ORGANIZATIONS

CAMILLE AND HENRY DREYFUS FOUNDATION, 2013 Camille Dreyfus Teacher-Scholar Award: Thomas F. Miller

Professor of Chemistry

JOHN D. AND CATHERINE T. MACARTHUR FOUNDATION, Fellow:

**Sarkis Mazmanian** *Professor of Biology* 

**Colin F. Camerer** Robert Kirby Professor of Behavioral Economics

**NATIONAL GEOGRAPHIC SOCIETY,** 2013 Emerging Explorer Award:

Bethany L. Ehlmann Assistant Professor of Planetary Science and Jet Propulsion Laboratory Research Scientist

POPULAR MECHANICS, Breakthrough Award: Julia R. Greer Professor of Materials Science and Mechanics

RESEARCH CORPORATION FOR SCIENCE ADVANCEMENT,

**Theodor Agapie** Assistant Professor of Chemistry

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George Van Osdol Professor of Electrical Engineering

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Barbara and Stanley R. Rawn, Jr., Professor of Materials Science and Applied Physics

Fiona A. Harrison Benjamin M. Rosen Professor of Physics and Astronomy

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Anthony C. Readhead Robinson Professor of Astronom

Ares J. Rosakis Otis Booth Leadership Chair, Division of Engineering and Applied Science

Anneila I. Sargent Ira S. Bowen Professor of Astronomy

Peter Schroeder Shaler Arthur Hanisch Professor of Computer Science and Applied and Computational Mathematics

Yu-Chong Tai

Anna L. Rosen Professor of Electrical Engineering and Mechanical Engineering

RICHARD P. FEYNMAN PRIZE FOR EXCELLENCE IN TEACHING, Recipient: John A. Johnson Assistant Professor of Planetary

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