

- Bon appétit, Techers
- Amplifying a 75-year radio career
- Cruising campus on a couch; and more

Turning up the Heat

In November 2023, NASA's Juno spacecraft was a month away from its closest encounter yet with the surface of Jupiter's moon Io. Coming within roughly 930 miles of the most volcanic world in our solar system, the orbital pass would allow Juno's instruments to generate a firehose of data about variations between Io's volcanoes.

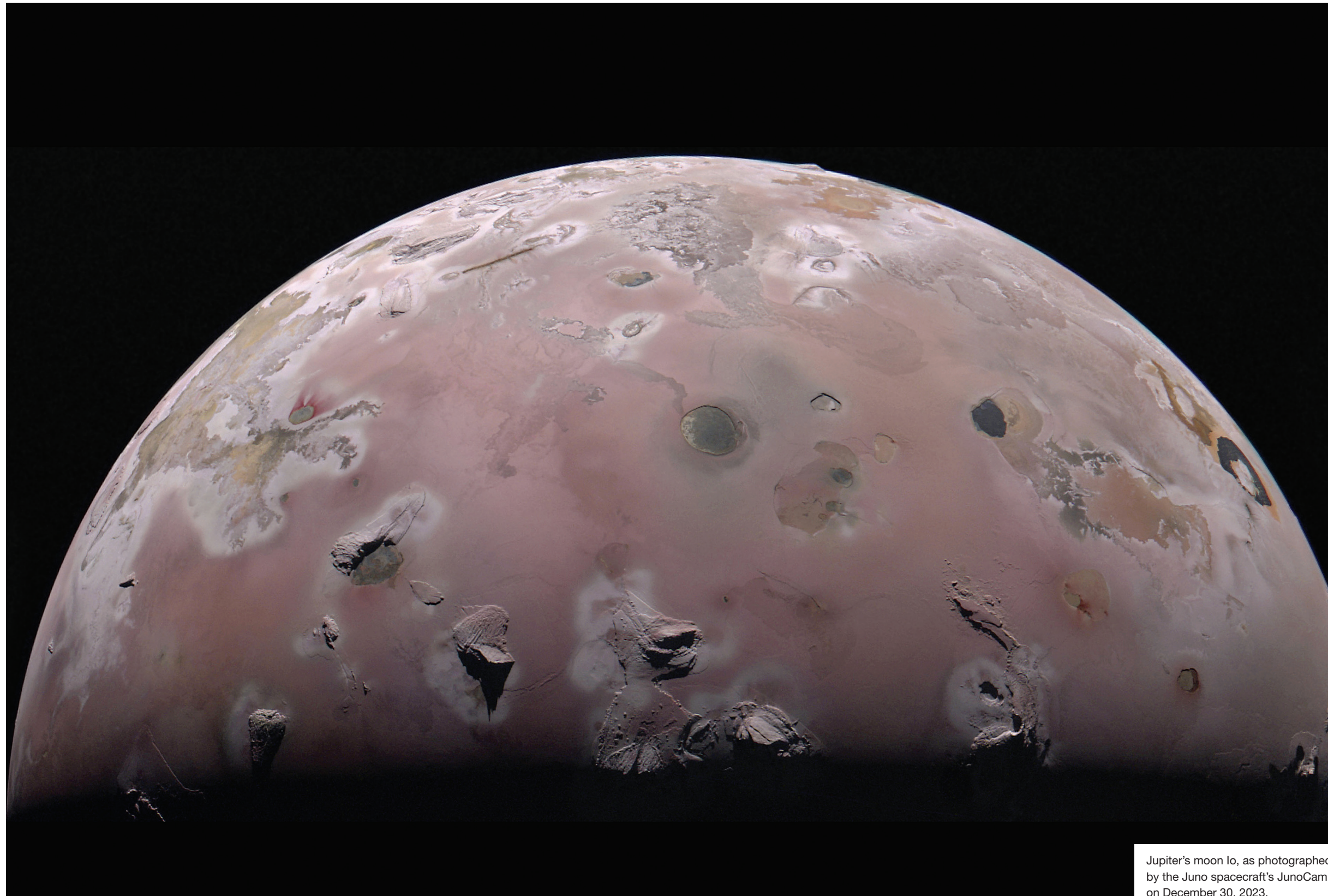
There was only one problem: Juno's camera, known as JunoCam, had stopped working. By the spacecraft's 55th orbit on November 22, 2023, nearly all of JunoCam's visible-light color images had been corrupted by Io's radiation. The problem, the team knew, would only get worse as the spacecraft flew deeper and deeper into the heart of Jupiter's radiation fields.

"Our images were full of streaks and noise," says JunoCam instrument lead Michael Ravine of Malin Space Science Systems. The Juno mission is managed by JPL, which Caltech operates for NASA. "We tried different schemes for processing the images to improve the quality, but nothing worked. With the Io close encounter bearing down on us in a few weeks, it was Hail Mary time."

The JunoCam images began to show hints of radiation damage during orbit 47. The team then tried heating the camera as part of a process called annealing, in which a material is heated for a specified period and then slowly cooled. The idea is that heating can reduce defects in the material. New images initially turned out crisper, but the damage soon returned. "The only thing left we hadn't tried was to crank JunoCam's heater all the way up and see if more extreme annealing would save us," Ravine says.

Test images showed little improvement the first week. Then, with the close approach of Io only days away, the images began to improve dramatically. By the time of the crucial pass on December 30, 2023, the images were almost as good as the day the camera launched. They captured detailed views of Io's north

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Jupiter's moon Io, as photographed by the Juno spacecraft's JunoCam on December 30, 2023.

Turning up the Heat

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polar region that revealed mountain blocks covered in sulfur dioxide frosts rising sharply from the plains and previously uncharted volcanos with extensive flow fields of lava.

Since the experiments with JunoCam, the Juno team has applied variations of the annealing technique to several Juno instruments and subsystems.

“Juno is teaching us how to create and maintain spacecraft tolerant to radiation, providing insights that will benefit satellites in orbit around Earth,” says Scott Bolton, Juno’s principal investigator from the Southwest Research Institute. “I expect the lessons learned from Juno will be applicable to both defense and commercial satellites as well as other NASA missions.”

Learn more



Couch on the Move

Making your way to class just got a lot more comfortable. The Caltech Robotics Club has crafted a robo-couch that sits on two wheels connected to an electric motor, plus two other unmotorized wheels that share the couch’s weight. A rechargeable battery supplies power to the sofa, which can hit 10 mph. “Our goal is to make the couch even more unique,” says club member Donny Lu (far left), an undergrad. “We want this to take you from your dorm to your class autonomously.”

Read more



Four Questions for :
Caltech radio astronomer
Sandy Weinreb

Sandy Weinreb has spent most of his career perfecting the design of radio astronomy receivers, small critical components of radio telescopes that amplify and digitize feeble radio waves from the cosmos. Weinreb joined Caltech in 1999 and is currently an emeritus research associate in astronomy at the Institute. He spearheaded development of uncooled low-noise amplifiers that will debut on Caltech’s Deep Synoptic Array (DSA-2000) radio telescope, an array of thousands of dishes to be built in the Nevada desert over the next couple years. The amplifiers are groundbreaking because they do not require cooling with expensive cryogenic refrigerators. “Personally, I think Sandy has a legacy of instrumentation development in radio astronomy that is second to none,” says Gregg Hallinan, a Caltech professor of astronomy, DSA-2000’s principal investigator, and director of the Institute’s Owens Valley Radio Observatory, where a team has been building prototype radio dishes for the DSA. Here, we speak with Weinreb, now 88, about his background and work.

1. What drew you to radio astronomy?

By age 12, I was fixing radios and TVs in repair shops (at right) to help my parents pay the rent. I became interested in radio



astronomy while looking for a summer job at MIT as an undergrad. I looked through the Boston phone book and ended up finding a company run by Harold (Doc) Ewen, who discovered the interstellar hydrogen line at Harvard in 1951. This was a big deal in radio astronomy. This hydrogen emission line allows astronomers to study galaxies across the universe. When I visited Ewen’s company, I remember that he was sitting on a platform, like a Buddha, with people around the outside who were building receiver components. Somebody explained I was from MIT and looking for a job. Doc said, “Let’s give him a buck and get him going.” Ten years later, I worked at the National Radio Astronomy Observatory (NRAO) in West Virginia as head of the electronics division.

2. Why are amplifiers so important in radio astronomy receivers?

Low-noise amplifiers determine the sensitivity of the observations. We want to detect faint radio waves from the universe, but our amplifiers can produce their own background noise, like a hiss. We developed ways to minimize that noise by cooling the device.

3. What prompted you to start working on uncooled low-noise amplifiers?

I knew that future radio astronomy observatories would utilize arrays of small antennas that could be combined to provide images of the radio sky. However, each antenna would require an expensive cryogenic cooler that would dominate the cost and limit the number of antennas, which would then limit the number of pixels in the image. Gregg Hallinan told me about the DSA and that he and his team intended to image a large area of sky. To be affordable, this required large numbers of uncooled low-noise amplifiers.

4. How did you figure out how to make them?

I started by looking at superior transistors with much lower noise being developed using indium phosphide semiconductors by groups in the US, Sweden, and Switzerland. I also knew that the usual solder method for printed circuit packaging increased the noise, so I turned to wire bonding of a bare transistor chip. This requires much skill to handle the millimeter-sized chip. The low-noise amplifier design was further improved by Caltech research engineer Kiran Shila [PhD ’25] as part of their PhD thesis using machine learning techniques.

Tables for Techers: A Record Year



Sandra Tsing Loh (BS '83) feeds her brother, Eugene Loh (BS '80), a cricket during a Tables for Techers dinner in July at her home in Pasadena.

This July, more than 800 Caltech alumni, students, postdocs, and faculty gathered throughout the country and worldwide to share stories and meaningful conversation as part of the annual Tables for Techers event.

In homes, on farms, and in restaurants, more than 150 hosts and cohosts created spaces that welcomed guests to enjoy a meal and Caltech camaraderie. Tables included participants of all ages, house affiliations, majors, and career paths. "It was great fun," says Sandra Tsing Loh (BS '83), who hosted an "eco-themed" table in Pasadena. "We especially appreciated the mix between the older generation and the younger generation. There was a great geographic mix too—from Hunan, China, to Grenoble, France. On top of that, four out of 17 guests walked here—so eco-friendly!"

Aspiring Astronaut

Geologist Lauren Edgar (PhD '13) has been selected by NASA to join the 2025 astronaut candidate class. Edgar has worked with the U.S. Geological Survey studying Earth, the Moon, and Mars through remote sensing and field techniques to support human and robotic exploration of the solar system. She has more than 17 years of mission operations experience supporting the JPL-managed Mars Science Laboratory and Mars Exploration Rovers. Most recently, she served as NASA's deputy principal investigator for the Artemis III Geology Team, helping to define the lunar science goals and geology activities NASA astronauts will conduct while on the Moon.



A Quantum Quarter Century

"Having IQIM at Caltech has been really helpful for recruiting students, postdocs, and also faculty involved in quantum science on campus. Twenty-five years ago, people who worked on quantum gravity and people who worked on quantum computing and quantum information did not interact. That has changed a lot. Our activity has also become highly interdisciplinary and now cuts across physics, applied physics, computer science, electrical engineering, chemistry, and materials science. That's one of the things I've found most exciting."



—John Preskill
Caltech's Richard P. Feynman Professor of Theoretical Physics and director of the Institute for Quantum Information and Matter, on IQIM's 25th anniversary

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Remembering David Baltimore
“Looking at the many chapters of David’s scientific life beginning as an undergraduate at Swarthmore, through times at MIT, the Salk, Rockefeller, and ultimately at Caltech, the through-line aspiration was the rigorous pursuit of what is new, true, and fundamental, in his own work and in the work of others. Mostly he succeeded, and when he did not, he always learned.”

Barbara Wold (PhD ’78),
Caltech’s Bren Professor of Molecular Biology and Merkin Institute Professor, on
Nobel Laureate David Baltimore, Caltech President Emeritus and the Judge Shirley
Hufstедler Professor of Biology, who passed away on September 6, 2025.

See also “In Memoriam,” page 39

On Its 10th Birthday, LIGO Verifies a Stephen Hawking Theorem

Ten years after the National Science Foundation Laser Interferometer Gravitational-wave Observatory’s landmark detection of gravitational waves, the observatory’s improved detectors are routinely observing roughly one black hole merger every three days. In 2025, the twin LIGO detectors “heard” the signal of one such powerful collision with unprecedented clarity. The data enabled scientists to distinguish multiple subtle tones ringing out like cosmic bells across the universe (imagined at right as intertwining musical threads spiraling toward the center). By analyzing the frequencies of gravitational waves emitted by the merger, the team from LIGO and its international partners (Virgo in Italy and KAGRA in Japan), in a study led by Katerina Chatziioannou, assistant professor of physics and a William H. Hurt Scholar at Caltech, provided the best observational evidence captured to date for what is known as the black hole area theorem. This idea, put forth by Stephen Hawking in 1971, says the total surface areas of black holes cannot decrease.

Read more



Curtis Lee (second-year undergraduate)

#SoCaltech is an occasional series celebrating the diverse individuals who give Caltech its spirit of excellence, ambition, and ingenuity. Know someone we should profile? Send nominations to magazine@caltech.edu.



Lee, who grew up in Hong Kong and went to high school in England, began cooking at age 11. At 15, Lee trained with Michelin-starred chef Maxime Gilbert in Hong Kong, and he was a stagiaire at several top restaurants in London, including Muse by Tom Aikens and The Fat Duck. In total, he has trained under chefs who hold a combined 42 Michelin stars. At Caltech, Lee is a teaching assistant in SA 16 Cooking Basics. He plans to double major in chemical engineering and business, economics, and management.

“Last year, I wanted to start playing with fermentation. So, I made a list of things I wanted to make and thought, ‘What’s the best way to make them?’ I was reading around online and found that I needed to have good control of temperature and humidity, so I decided to make my very own fermentation chamber using a speed rack, PID [proportional–integral–derivative] controller, and small heater. I started to make soy sauce, kombucha, sauerkraut, kimchi, and hot sauce! I’m not much of a baker, but I’ve been working on sourdough and pastries recently. The fermentation chamber really comes in handy to keep my starter happy or to proof my croissants.

I love learning about different cuisines from around the world. Even if you don’t know anything more about a place, if you’re able to talk to someone about a very niche dish from their homeland, they get so surprised. Then they tell you things you don’t know, and you learn even more. Many of my housemates in Avery are Indian, and I met some of their parents when I was in the kitchen cooking Indian food. So, I talked to them about it. I like to use the proper names for everything, and they got so excited. I just love that.”

In the Community

Untangling Entanglement, and More

A group of students from four Los Angeles-area universities, including Caltech, came together last summer with the shared goal of building non-scientists' understanding of quantum science and its applicability and use throughout society.

"The public has been led to believe that quantum science is this really funky, almost magical, mystical thing that exists," says Madison Howard, a physics graduate student at Caltech. "We wanted to help demystify quantum science by hosting events where people could learn about what it actually means for something to be quantum in a meaningful and accurate way."

Inspired by the International Year of Quantum Science and Technology, a worldwide initiative to increase public awareness of quantum science and its applications, the team of students from Caltech, USC, UCLA, and Chapman University developed a 10-week series called Summer of Quantum in LA. At Caltech, Howard worked with fellow graduate students Huma Jafree, Taylor Knapp, and Thomas Zacharias to create engaging programming that explained quantum concepts such as superposition and entanglement to people of all ages and expertise levels.

June events included "Quantum for Everyone," a public talk in which 80 guests experienced hands-on demonstrations led by Frank Rice, lecturer in physics and manager of Caltech's sophomore physics lab, and attended short, accessible talks about the frontiers of quantum research from graduate students Piero Chiappina and Hannah Manetsch, and postdoc

"We wanted to help demystify quantum science by hosting events where people could learn about what it actually means ..."

—Physics graduate student Madison Howard

helped host a quantum-themed board game night at Odyssey Games in Pasadena.

In July, the team welcomed more than 150 children and adults to campus for "Quantum for Kids," which featured demonstrations and interactive activities for young learners led by students from Caltech, USC, and Chapman. Events at local bars also brought together those studying quantum science with curious members of the community in a casual atmosphere.

"We wanted to have good outreach and awareness about what it means

to be on the cutting edge of quantum research and really build a community around it, both with people who are involved and people who are interested," Howard says. "Organizing so many different types of events gave us the opportunity to meet people where they're at but also to tailor the content toward different backgrounds and interests."

Meanwhile, Howard and Zacharias said the planning process not only helped them grow their quantum network across universities but also strengthened their connections on campus.

"We had a really positive response and saw that so many people, from students to professors to the administration, want to support events where we are trying to bridge the gap between scientists and nonscientists," says Zacharias, who estimates that at least 50 members of the Caltech community helped make Summer of Quantum a success.

He adds that it is crucial for students to develop communication skills so they can discuss their research in an accessible manner. "We are doing things that can hopefully help society in different ways, such as impacting health by creating better medical therapies or by improving computational power," Zacharias says. "All of us are trying to push quantum science and technology further so it can be useful for everyday people."

—Katie Neith



Lisa Drummond. Forty participants also visited Caltech labs that perform pioneering work in quantum science, including the Nonlinear Photonics Laboratory led by Alireza Marandi, professor of electrical engineering and applied physics. Additionally, Howard

Origins The Caltech Associates Turns 100

On March 9, 1926, retired railroad magnate and art collector Henry E. Huntington invited 100 of Southern California's most influential men and women to his home in San Marino. Although he had hosted many gatherings of the area's social and business leaders, this one would prove to be historically significant for a nearby institution—and the world.

Not long before, the Caltech Board of Trustees had recognized the need to raise flexible funds to aid and advance the recently renamed California Institute of Technology's welfare by forming a new organization: the Associates of the California Institute of Technology. When 100 donors had each agreed to contribute \$1,000 per year for 10 years to the Institute, Huntington held the Associates' first formal meeting at his home.

In the years following the group's founding, the Associates has continued to grow its membership base and cemented its importance in connecting individuals with the Institute and its pioneering researchers. Associates members have provided unrestricted support to propel some of the world's most promising discoveries, grow Caltech's physical footprint, and expand its societal reach.

In 1926, when the Associates started, the Institute's campus comprised just five buildings, and the Institute only offered courses in engineering, chemistry, and physics. Associates William G. Kerckhoff and his wife, Louisa Eshman Kerckhoff, funded a biology laboratory, which began construction in 1928.

The Division of Humanities, now the Division of Humanities and Social Sciences, was formed in 1926 and endowed by eight Associates. The division was then housed in a building funded in 1927 by Joseph B. Dabney and his wife, Louise E. Dabney. In the late 1920s, construction began on the Palomar Observatory, a dream of Caltech Trustee and Associate George Ellery Hale, who secured funds from the Rockefeller Foundation to build the facility's 200-inch telescope near San Diego.

Today's housing system, a staple of undergraduate life at Caltech, had its start in the 1930s, when Associates members, believing small residences were best for students, donated funds to build the South Houses. Architect Gordon Kaufmann designed the South Houses,

as well as the Athenaeum (photo below), Caltech's faculty and social club, which opened in 1930 thanks to a gift from Trustee Allen Balch and his wife, Janet Jacks, who were Associates members.

Today, the Associates' membership has grown to more than 1,000 households. Over the past century, Associates have given more than \$73 million in unrestricted annual membership gifts and more than \$2.5 billion to the Institute to support facilities, research, faculty, and students.

As the Associates moves into its second century, the group is honoring its past by creating the Associates 100 Legacy Circle. The Legacy Circle will comprise 100 individuals or households, each making an unrestricted commitment of \$150,000 over the next 10 years, an echo of the Associates' original and influential contributions.

—Omar Shamout

