

- A White House medal ceremony
- Swifties shake up SoCal
- Einstein's legacy lives on in Pasadena; and more

Beauty in Chaos

Aeronautics graduate student Tanner Harms studies turbulence. While many people might associate the word with a bumpy airplane ride, Harms says that is not exactly right. "That's the effects of turbulence more than turbulence itself," he explains. "Turbulence is actually the chaotic and unpredictable movement of fluids."

Harms demonstrated this phenomenon in his lab with some water and dye. "Every time I put a drop of dye in the water, it's not going to be the same. I do the best I can to replicate each drop, but no matter what I do, it's going to look different. Like a snowflake."

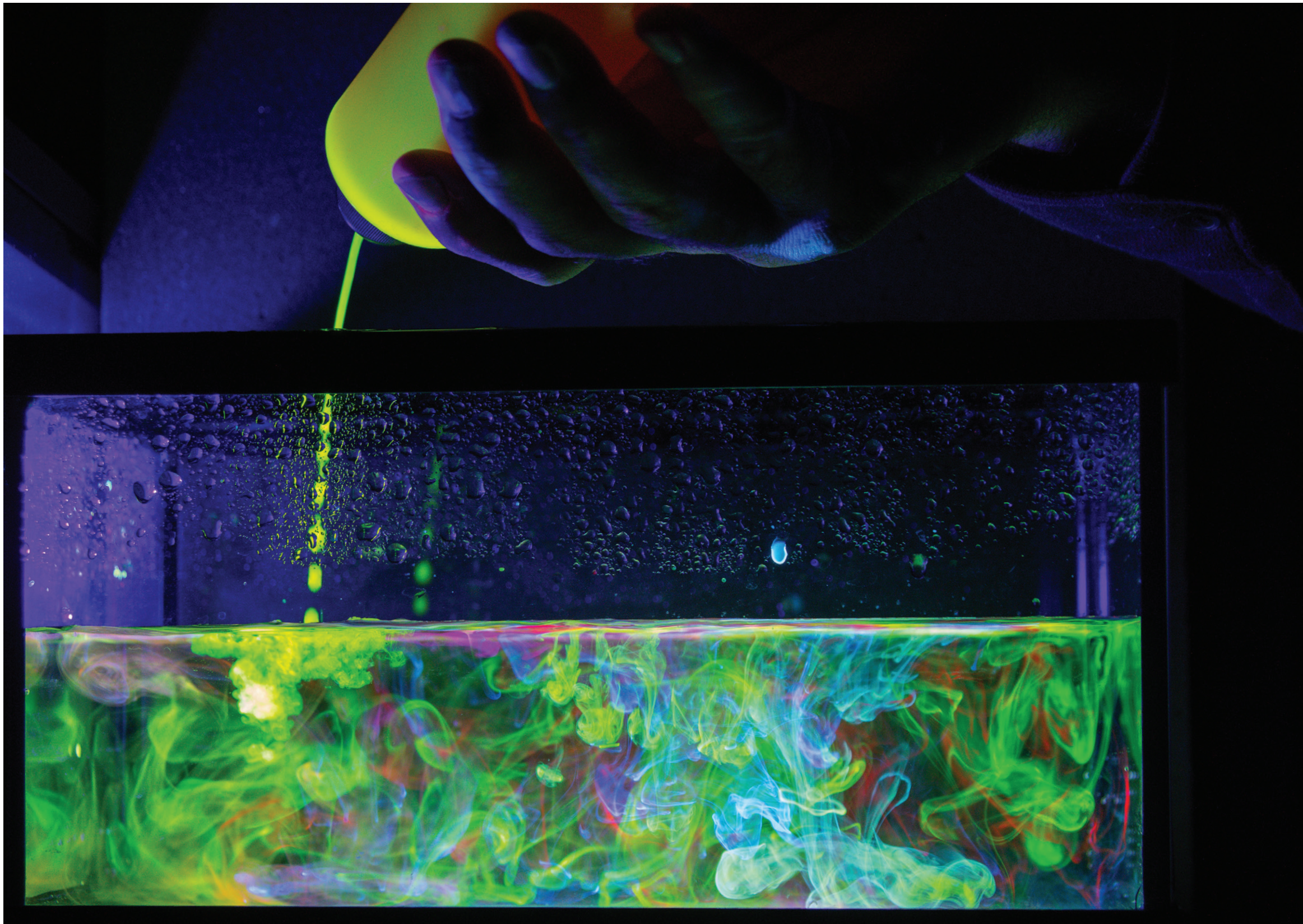
Among many other real-world applications, studying turbulence can help researchers figure out the best way to contain oil in the ocean following a spill and to better understand how garbage accumulates in the Great Pacific Garbage Patch, a floating pile of plastic that is twice the size of Texas.

Without turbulence, Harms adds, there would be no life on Earth—something to think about the next time you hear the familiar "ding" on an airplane warning you to buckle up. "Because mixing is largely driven by turbulence, a world with no turbulence might have pockets of dense oxygen and dense nitrogen, but they wouldn't mix together," he says. "It would be very difficult for there to be anything that could sustain life as we know it."

One of the things Harms says he loves most about his work is its inherent beauty. He notes that he learned to appreciate the aesthetic qualities of science from his mother.

"My mom was an art teacher and a graphic designer," he says. "Growing up, I really developed an appreciation for the artistic and creative side of science. Understanding the world—there's something beautiful in that. I mean, who would think turbulence is beautiful? But then you look at something like the surface of Jupiter, and it's just stunning. You see the swirling, and the Great Red Spot, and it evokes a sense of awe."

Watch Harms's Science Journeys lecture, "Chaos, Turbulence, and the Beauty of Uncertainty in Complex Systems"



'Shake' It Off

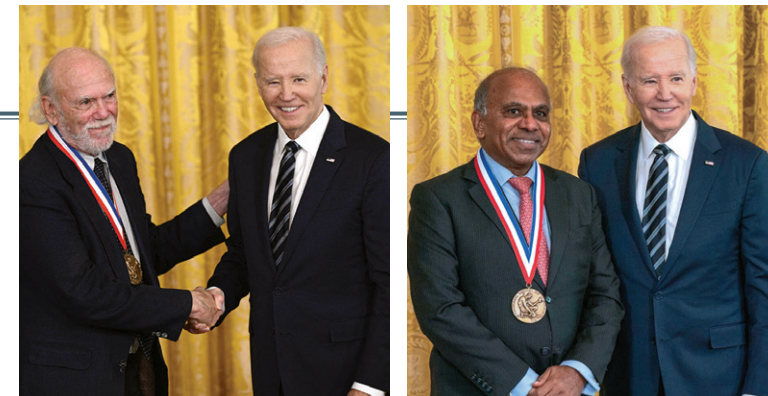
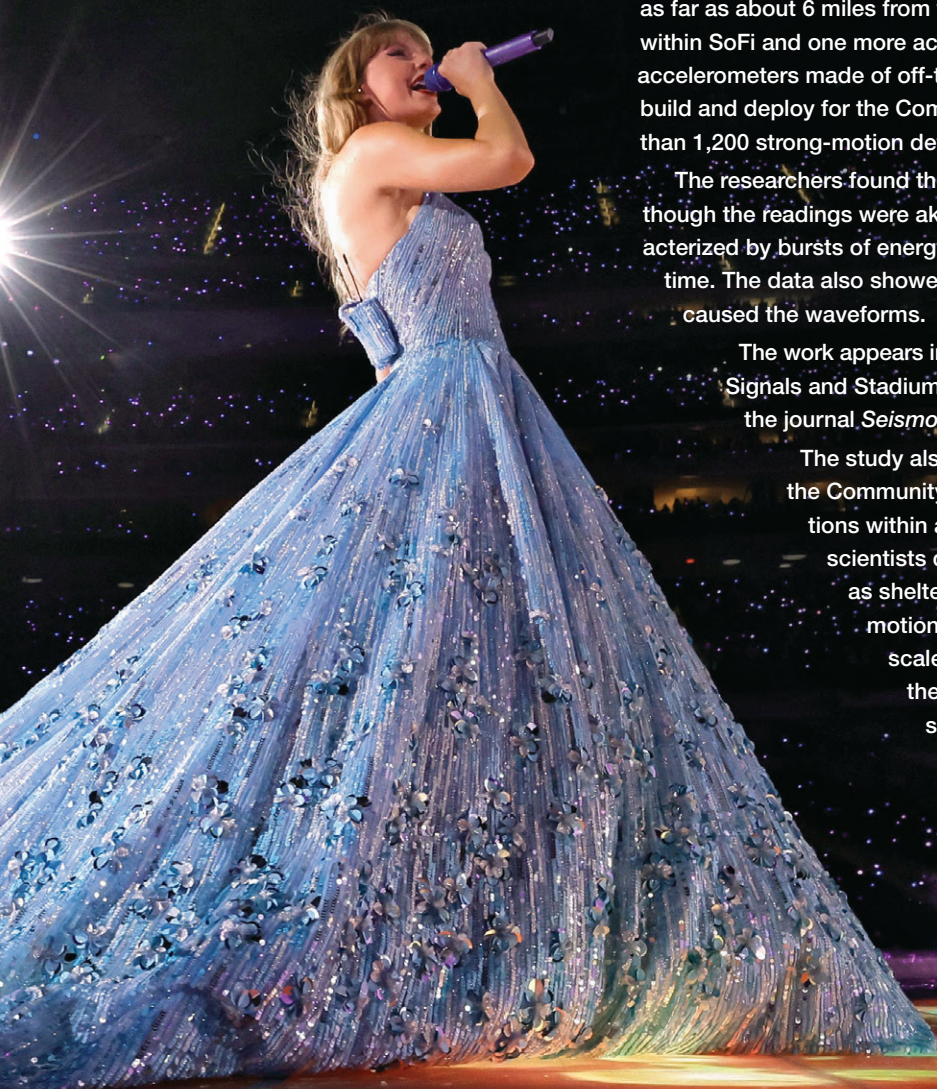
It turns out Taylor Swift concerts are truly seismic events. Following reports of Swift fans generating tremors during a concert in Washington state, the California Office of Emergency Services reached out to seismic network operators in California to see if interesting data could be collected during Swift's concerts at Inglewood's SoFi Stadium in August 2023. Monica Kohler (PhD '95), research professor of mechanical and civil engineering at Caltech, and her colleagues at the Institute's Seismological Laboratory and UCLA responded.

The team tapped into an existing regional network of seismic sensors reaching as far as about 6 miles from the stadium. They also temporarily installed 10 sensors within SoFi and one more across the street. The stadium sensors were inexpensive accelerometers made of off-the-shelf parts, like the kind that researchers regularly build and deploy for the Community Seismic Network, a distributed network of more than 1,200 strong-motion detectors in California.

The researchers found the stadium and its surroundings shook during the show, though the readings were akin not to an earthquake but to a harmonic tremor, characterized by bursts of energy at specific frequency intervals over longer periods of time. The data also showed that the concertgoers' dancing, rather than the music, caused the waveforms.

The work appears in a paper titled "Shake to the Beat: Exploring the Seismic Signals and Stadium Response of Concerts and Music Fans," published in the journal *Seismological Research Letters* in March 2024.

The study also showed that the inexpensive accelerometers used by the Community Seismic Network could be used to measure small vibrations within a stadium and relay those measurements in real time to scientists during emergencies when those facilities might be used as shelters. "It would be really important to be able to monitor the motions of these structures before, during, and after a large-scale event like an earthquake to determine whether the structure is still safe, reliable, and sound," Kohler says.



National Medal of Science Winners

President Biden awarded the 2023 National Medal of Science to Barry Barish, Caltech's Ronald and Maxine Linde Professor of Physics, Emeritus; and Subra Suresh, a Moore Scholar and former visiting professor.

Barish, who shared the 2017 Nobel Prize in Physics, was honored "for exemplary service to science, including groundbreaking research on subatomic particles. ... He has broadened our understanding of the universe and our nation's sense of wonder and discovery."

Suresh, professor at large at Brown University, was director of the National Science Foundation from 2010 to 2013 and has served as president of Singapore's Nanyang Technological University and as president of Carnegie Mellon University. He was honored "for pioneering research across engineering, physical sciences, and life sciences. A transformative educator, he has advanced the study of material science and its application to other disciplines."

"Einstein was not a big lover of history, but I think he would have appreciated that this work is being done now, and it's being done here, where so many scientists are actually continuing avenues and questions that he asked 100 years ago."

— Diana K. Buchwald, director and general editor of The Einstein Papers Project and Caltech's Robert M. Abbey Professor of History, on her group's work to delve into the famed physicist's correspondence, notebooks, diaries, lectures, calculations, speeches, and interviews.



Watch Buchwald's Watson Lecture, "Einstein in Pasadena: Between Two Worlds"

"In a very pleasantly unsurprising way, the dynamic with this crew is pretty much exactly as I had expected. Four people living in a small space will have its challenges, of course, but this crew got pretty tight very quickly."

— Ross Brockwell (MS '01), on life inside Mars Dune Alpha, a 1,700-square-foot 3D-printed habitat at Houston's Johnson Space Center, the site of a yearlong NASA mission to simulate the psychological and physical demands of living on Mars.

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“Many of the core questions we struggle with today are present in these much earlier periods of history but reveal themselves in different ways—some familiar, some radically distinct.”

—Jennifer Jahner, professor of English, dean of undergraduate studies, and a 2023–24 Fletcher Jones Foundation Distinguished Fellow at The Huntington Library, Art Museum, and Botanical Gardens, who is using the library’s manuscript collection to explore how astrology and applied sciences in the Middle Ages helped people navigate uncertainty.

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Three Questions for : Reza Sadri

Reza Sadri, the director of the new AI Bootcamp in the Division of Engineering and Applied Science, joined Caltech in 2023, bringing with him 30 years of experience in software development, including as head of machine learning infrastructure at Instacart. He hopes to bridge the gap between academia and AI technology through a series of eight to 10 workshops a year aimed at Caltech graduate students, postdocs, and researchers. Here, Sadri provides some more details about that effort.

1. What is the AI Bootcamp?

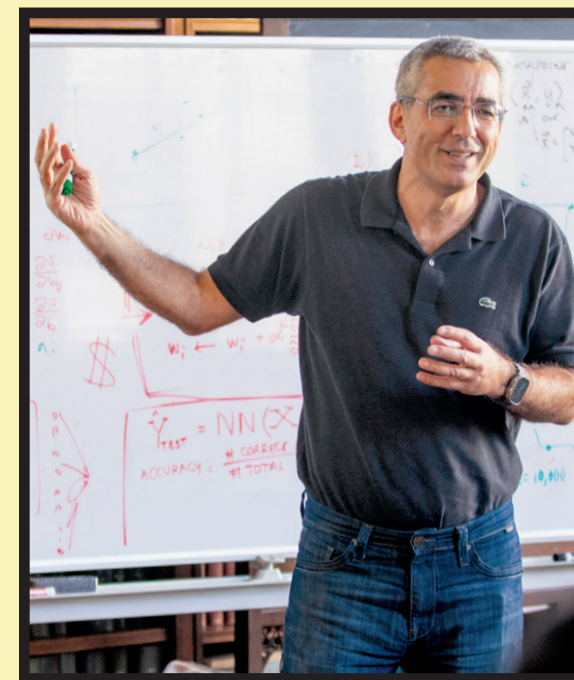
The main goal of the bootcamp is to help participants understand when and how to effectively use AI within their research as well as to identify its appropriate contexts and limitations. Forty years ago, there were a lot of physicists and chemists who could benefit from using a computer, but they didn’t know how. AI is at the stage that the computer was 40 years ago. We must bring scientists on board to be able to use AI effectively.

2. What are some ways AI is used ineffectively in industrial and research settings?

First, sometimes, you don’t need AI. There are some applications where you can get by using simple mathematical models or statistics. The second mistake is sometimes people use a complicated model when a simple model will work just as well. The third is mishandling data. Effective use of data requires clean, relevant, and non-leaky datasets—data leakage is when information from outside the training dataset is inadvertently included in the model, leading to unrealistic performance. Misusing data like this leads to wasted efforts such as publishing papers based on incorrect data assumptions.

3. What is the long-term vision for the bootcamp?

In the past decade, AI has expanded significantly into various branches and applications, and some AI applications are well suited to specific fields or problems. We will offer specialized bootcamps for these applications, such as reinforcement learning, graph neural networks, and large-scale data processing. The broader application of AI across diverse scientific disciplines inherently enriches AI and machine learning. Scientific research often tackles unconventional problems that are not mainstream, presenting unique challenges. Addressing these issues with AI and machine learning necessitates innovative approaches, pushing the boundaries of the field in unexpected directions.



“I remember from my own time at Caltech, there was a class called E 10. It was engineering presentations and public speaking. I had never spoken in public before. It was terrifying for me, but it was very valuable. This experience of taking an idea of yours, clarifying it down so it’s simple and understandable, and communicating it to someone else—that’s a valuable skill independent of whether you ever plan to start a business.”



— Bill Gross (BS ’81), an entrepreneur, start-up evangelist, and Caltech trustee, on teaching his new class: E/SEC 102, Science and Technology Entrepreneurship.

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KNI Celebrates 20th Anniversary

Just how small is a nanometer? Whatever you are thinking, think smaller. *Nano*, Greek for “dwarf,” signifies one billionth of a meter (or 10^{-9} meters). A single sheet of ordinary paper is 10,000 times thicker than a nanometer, as is the diameter of a single strand of human hair.

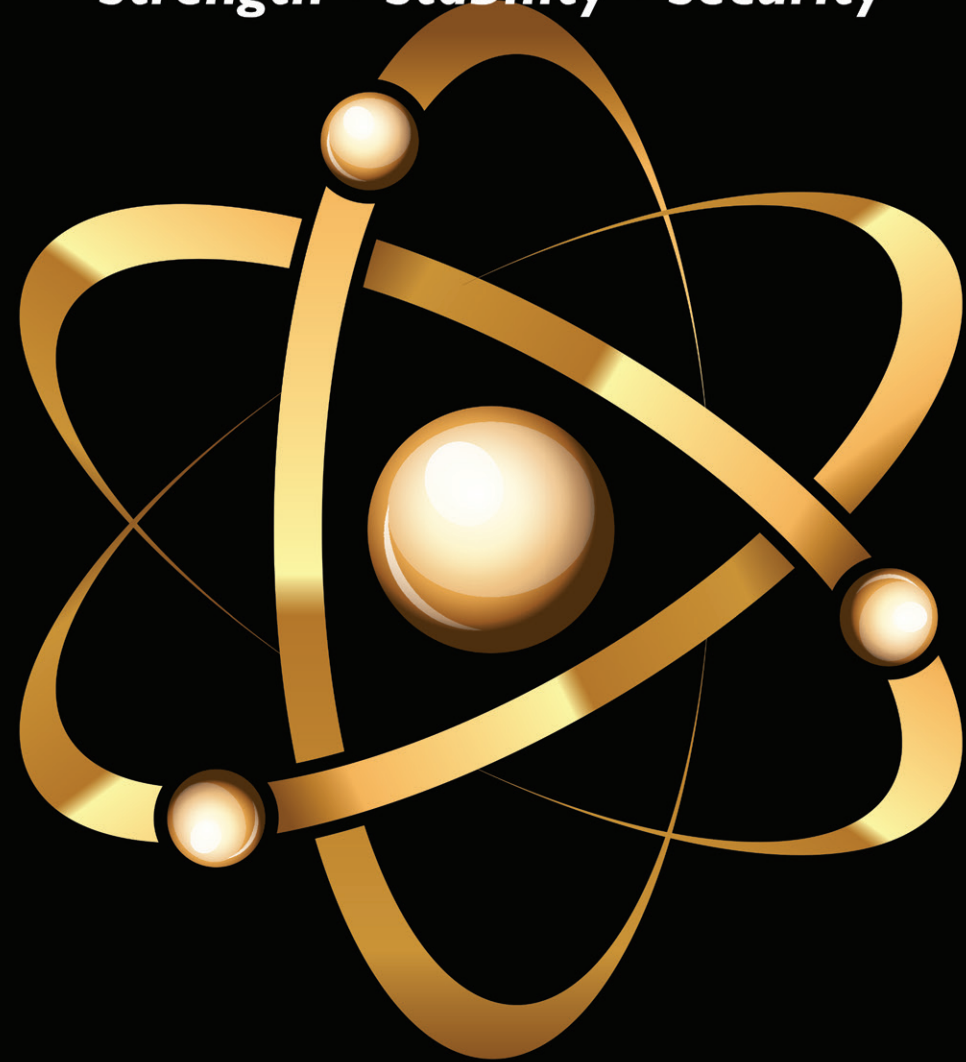
With the advent of sophisticated microscopy instruments, objects only several nanometers in size can be measured by researchers such as those at Caltech’s Kavli Nanoscience Institute (KNI), which celebrated its 20th anniversary March 7–8, 2024, with a symposium and a fireside chat between Caltech President Thomas F. Rosenbaum and chemist George M. Whitesides (PhD ’64), the 2022 Kavli Prize laureate and the Woodford L. and Ann A. Flowers University Research Professor at Harvard University.

“It is exhilarating to think about everything that is possible at the nano-scale and how many more challenges remain,” says Julia R. Greer, the Fletcher Jones Foundation Director of the KNI and Ruben F. and Donna Mettler Professor of Materials Science, Mechanics and Medical Engineering. “We are getting really close to fabricating, manipulating, and imaging samples at the atomic level, which propels new discoveries just about every day.”



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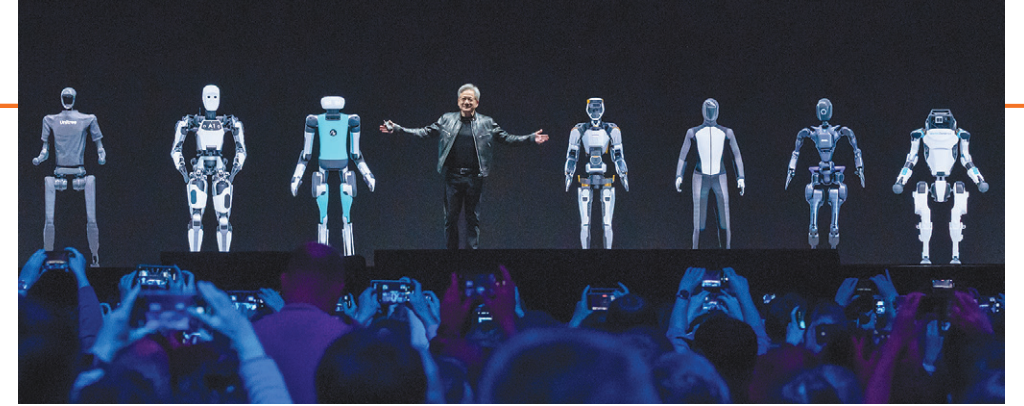
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NVIDIA CEO to Deliver 130th Commencement Keynote



Jensen (Jen-Hsun) Huang, founder and CEO of technology company NVIDIA, will deliver the keynote address at Caltech's 130th Commencement ceremony on June 14, 2024.

Named the world's best CEO by *Fortune*, *The Economist*, and *Brand Finance*, Huang led NVIDIA to become a pioneer in accelerated computing and the fourth-most valuable company in the world.

Huang co-founded NVIDIA in 1993 with Chris Malachowsky and Curtis Priem to take advantage of the growing demand for 3D graphics and visualization technology that accompanied the rapidly expanding PC and gaming industries. Huang's sights are now set on combining NVIDIA's computer graphics research with its generative AI research to create the "Omniverse," a platform capable of simulating the real world to create "digital twins" that could be used to safely train robots and self-driving cars, among other applications.

"As NVIDIA's CEO, Jensen Huang has led a revolution in computation and artificial intelligence," said Caltech President Thomas F. Rosenbaum. "His personal story underlies these accomplishments and provides a touchpoint for our students as they embark on the next stages of their careers."

The Commencement ceremony will be streamed live here



Laura Luebbert (fifth-year graduate student)

#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.

Laura Luebbert, a biology PhD student, recently won a prestigious award from the German Federal Ministry for Education and Research and the German Aerospace Center for her work on *gget*, an open-source software tool for analyzing RNA sequencing data, which has received roughly 100,000 downloads. Luebbert received her bachelor's and master's degrees from Leiden University in the Netherlands.

"I was a wet lab biologist who would spend an hour on her computer per week. Leiden did not teach advanced math or programming as part of its biology curriculum at the time, so I was thrown into the deep end regarding these skills when I arrived at Caltech.

However, I was determined to learn and spent a significant amount of time on YouTube, Codecademy, and Stack Overflow teaching myself to code in Bash, Python, and C++. I started writing code to analyze all my wet lab data—and then the data from other lab members. There was a massive gap between computer scientists with the coding skills to handle and analyze

large complex datasets and biologists with a deep understanding of the intricate biology underlying the experiment required for its interpretation. So, I started writing more general software to make complex analyses more accessible for novice programmers. I fell in love with this work so much that I completely switched research fields three years into my PhD."



In the Community

PST ART: Art & Science Collide

While objectivity may rule the day in science, it takes a sense of imagination, wonder, and creativity to see beyond the limits of our current knowledge. In September 2024, Caltech will take part in the landmark arts event, PST ART: *Art & Science Collide*, presented by Getty.

PST ART will span dozens of institutions across Southern California with exhibitions featuring more than 800 artists. Caltech entities on campus and at JPL received grants from the Getty Foundation for three separate projects that will explore the event's theme in unique ways.

Opening Doors

CaltechLive will present *Opening Doors*, a series of dance, music, and theater performances, including *HUANG YI & KUKA*, a dance show featuring Taiwanese choreographer Huang Yi, and Kuka, an industrial robot programmed by Huang; *Turing Tests, Apples, and Queens: Collective Storytelling Through Fairy Tales and Artificial Intelligence*, a performance by Invertigo Dance Theatre exploring the life and work of mathematician Alan Turing; *HomeCare*, a concert by Los Angeles-based choral ensemble Tonality about climate change; and *Tesla: A Radio Play for the Stage* about Nikola Tesla, Thomas Edison, and the monetization of scientific research.

"For centuries, the performing arts have played a pivotal role in the public's understanding of scientific, political, and social issues," says Michael Alexander, Caltech's campus arts and culture liaison. "We have engaged four incredible performing ensembles to demonstrate the truth in that statement."



Following each performance, a moderated discussion will engage the artists, Caltech scientists, and audience members in conversation around the topics explored.

Crossing Over: Art and Science at Caltech, 1920-2020

Presented by Caltech Library, *Crossing Over* will feature rare books, scientific instruments, molecular models, historical paintings, drawings, photographs, and films on display across four campus exhibits, as well as installations featuring contemporary art by artists Lita Albuquerque, Lia Halloran, Shana Mabari, Hillary Mushkin, and Helen Pashgian. The project will be accompanied by a visual catalog with 13 original essays about science history and visual culture at Caltech available online and in print.

"*Crossing Over* began in the Caltech Archives, with Caltech's collections of our own history and the history of the science and engineering done here," says Peter Collopy, university archivist

Clockwise from far left: Images from *Crossing Over*, *HomeCare*, *Blended Worlds*, and *HUANG YI & KUKA*.

and head of archives and special collections. "How, we asked, can Caltech's history help us understand how art and science contribute to each other, both now and over the last 100 years?"

Blended Worlds: Experiments in Interplanetary Imagination

JPL, which Caltech manages for NASA, in collaboration with the City of Glendale, will present *Blended Worlds* at the Brand Library and Art Center in Glendale. This exhibit explores the landscape of human relationships with nature and questions how empathy and connectedness can reveal new worlds and inspire innovative ways to nurture them. Twelve artists—including sculptor Larry Bell and performance artist Moon Ribas—will invite us to rethink our growing disconnection from nature and foster a renewed sense of wonder with our planet and the cosmos. *Blended Worlds* will also include a new stage production called *Earth Data: The Musical* directed by Caltech Theater Arts director Brian Brophy, which will be performed in Ramo Auditorium between October 31–November 3, 2024.

"By emphasizing belonging and connectedness, this exhibition hopes to prompt more responsible stewardship of Earth—and the universe—by rethinking traditional scientific methodologies and emphasizing creative ways of knowing," says Lois Rosson, an exhibit consultant and the Octavia E. Butler Fellow at The Huntington Library, Art Museum, and Botanical Gardens in Pasadena.

—Julia Ehlert

Learn more about the upcoming exhibits and performances



Origins

Propulsion, Aeronautics, and Rocket Systems Engineering at Caltech (PARSEC)

Nearly 90 years ago, a group of Caltech graduate students and amateur rocket enthusiasts known as the "Suicide Squad" began testing rocket engines under the mentorship of aeronautics pioneer Theodore von Kármán. Their achievements eventually led to the founding of the Jet Propulsion Laboratory (JPL), which Caltech manages for NASA.

The Suicide Squad's adventurous legacy lives on in PARSEC (Propulsion, Aeronautics, and Rocket Systems Engineering at Caltech), a team of students reigniting student rocketry at the Institute, who now have the added boost of a multimillion-dollar gift to help them reach the stars.

Aerospace graduate student Jack Caldwell (BS '22) and his former roommate Lewis Jones (BS '20) launched this rocketry revival in 2017, when they conceived of PARSEC as undergraduates. "Lewis and I were talking, and he mentioned another university's rocket team," Caldwell says. "I remember asking, 'Why isn't there a team here?'"

The two, joined by fellow Blacker House members Alexandra Stutt (BS '21), Richard Hamel (BS '20), and Benjamin Cassese (BS '20), co-founded PARSEC with the goal of building a liquid-propellant rocket and competing in a collegiate rocketry challenge. The COVID-19 pandemic, however, scrapped their plans. Upon graduating, the founding members went on to attend graduate school or work for aerospace companies, with Caldwell continuing as a graduate student at the Graduate Aerospace Laboratories at Caltech (GALCIT).

Recently, PARSEC has grown thanks to an influx of members (mentored by Caldwell) who share



An architectural rendering of the new PARSEC facility.

a fresh aspiration: to compete in the international Lander Challenge, which sees collegiate rocketry teams attempt to build a self-landing rocket that can fly up to 50 meters, hover for 10 seconds, and land in a designated spot. "Our goal is to set people up to go into industry with a lot of relevant knowledge," says undergrad Max Oberg, PARSEC's president.

But building a self-lander requires physical space and resources, which is why aerospace enthusiast Foster Stanback decided to step in and help PARSEC get its rocket off the ground—literally. An investor and philanthropist, Stanback has gifted \$7.4 million to the Institute to fund the construction of a new facility for high-speed flight dynamics. "Caltech students are some of the smartest in the world," Stanback says. "I would expect to see them at the top worldwide with the high-performance rockets they'll develop. I wanted to make this gift so they would have everything they need to reach their full potential."

The center will replace the small garage behind the Guggenheim

Aeronautical Laboratory, in which PARSEC currently works, with a sleek, two-story building. The ground floor will serve as lab space for PARSEC students to design, manufacture, and test noncombustible components. Engine testing will happen off campus. The second floor will house a multiuse lab and collaborative meeting space. "Having a permanent home for PARSEC is going to be a game changer," Caldwell says.

Stanback's donation will also solidify the Institute's role at the cutting edge of aerospace innovation, says Mory Gharib (PhD '83), the Hans W. Liepmann Professor of Aeronautics and Medical Engineering, who serves as GALCIT's director and as faculty advisor for PARSEC.

"Foster's contribution is a testament to the outstanding vision of the students in PARSEC," Gharib says. "Any collegiate team can fire a rocket and crash it, but Caltech students are interested in a deeper understanding of what can be done, in studying components, and in coming up with a more scientific approach to a problem."

—Julia Ehlert