SoCaltech

- SURF and WAVE students make a much-anticipated return to campus
- Meet CTLO's Mitch Aiken
- Einstein and his sailboat
- Caltech's newest alumnus Nobelist

A Different Take on the Turtle Pond

In *Turtle Pond* (2019), a Caltech landmark gets a modernist makeover with a little help from artificial intelligence. Tomas Aquino, a graduate student in the lab of Fletcher Jones Professor of Psychology John O'Doherty, used a machine learning platform called PyTorch to create this piece of art. The system works by assessing the essentials of just one example of a particular style of art, after which it can transfer those characteristics onto another image.

Aquino and colleague Sanghyun Yi, a graduate student in social science, applied the essential look of the work of Brazilian artist Tarsila do Amaral to a photograph of Throop Pond, Caltech's iconic water feature. The resulting image was displayed as part of the 2019 Caltech *Art of Science* exhibit. "I am originally from São Paulo, where Tarsila established herself as one of the most influential Brazilian artists ever," Aquino says, "so her style was a natural choice for me."

In a recent study, Aquino, Yi, and their fellow researchers in the O'Doherty laboratory used a similar system to demonstrate that artificial intelligence can not only determine the essential elements of a visual style—be it impressionism, realism, or abstract—but also can predict whether a person will like a particular painting based on their previous preferences.

▸ See "The Art of Predicting Tastes in Art" on page 32.

Three Questions for:

Mitch Aiken

Earlier this year, Mitch Aiken, the associate director for educational outreach at the Center for Teaching, Learning, and Outreach (CTLO), oversaw the expansion of the Summer Research Connection (SRC) through the launch of the new Hybrid Summer Research Connection (HSRC). Aiken explains how HSRC will allow more Southern California high school students to connect with Caltech.

1. How have you made Caltech's summertime outreach programs work remotely?

It's been a challenge these last two summers. Many of our groups are doing laptop-based research, using their coding skills to study data, develop website apps, and conduct research online. For the students who are particularly interested in chemistry or biology, in some cases we've been able to supply kits that allow them to engage in hands-on research.

The critical piece has been to make it not feel like school. Typically, when a student comes to campus, it's a special experience that wouldn't be happening in the classroom. We've tried to make sure that the remote components are as engaging and collaborative as possible and not so content-heavy that the students feel like they're in summer school.

2. What kind of research can students work on from home?

With [Gordon M. Binder/Amgen Professor of Biology and Geobiology] Dianne Newman's group, we did an activity with MudWatts, which are devices that detect energy from microbes in mud. Students tried varying samples of mud with different concentrations of water, and they tested which ones contained microbes that generate energy—enough to light a light bulb or power an electronic digital clock. Other groups worked on their laptops, analyzing data from telescopes; this gave them the real sense of being on a path of discovery.

3. What do you hope to accomplish with CTLO's outreach mission?

We want to get students, particularly those who are historically marginalized in STEM fields, excited about STEM.

There are all kinds of paths into science. We don't see our efforts as a direct recruiting path to Caltech, but a recruiting path into the world of STEM. We have always focused on diversity, equity, and inclusion in all our educational outreach programs and continue to view our programs through this lens.

Read more about CTLO at **ctlo.caltech.edu**

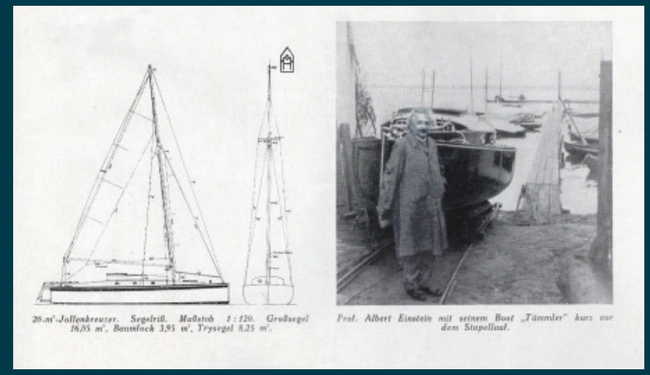
Einstein's Sailboat

When Albert Einstein turned 50 on March 14, 1929, he received a flood of congratulatory wishes. Many of the letters pertained to a birthday present Einstein cherished the most: a single-cabin sailboat, named *Tümmler*, which means porpoise in German.

The Einstein Papers Project at Caltech has released the 16th volume of its massive scholarly collection of the famed physicist's scientific and nonscientific writings and correspondence, in which these documents appear. The volume covers the period from June 1927 to May 1929 and contains 1,600 letters by and to Einstein, many more than contained in previous volumes.

Aside from enjoying his sailboat, Einstein had one great wish for his milestone birthday, according to Diana Kormos-Buchwald, Caltech's Robert M. Abbey Professor of History and director of the Einstein Papers Project: "He wanted to avoid the press, the visitors, the fanfare, and the tributes. He escaped Berlin for the countryside," she says.

Read Volume 16 of *The Collected Papers of Albert Einstein* at **einsteinpapers.press.princeton.edu**

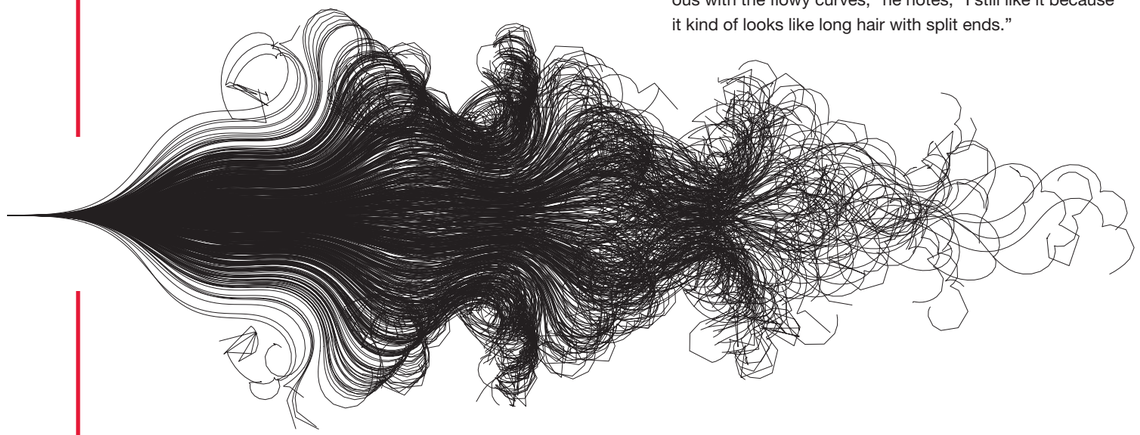


Riderless Bicycle

In 2004, while a graduate student at Caltech, Matthew Cook (PhD '05) created this evocative illustration that shows various paths a bike with no rider might take before it falls over. Developed as part of a study of how artificial intelligence might learn to ride a bike, the visualization has resurfaced and spread on social media numerous times since its publication.

Each line represents one of 800 simulator runs, each of which ends when the riderless two-wheeler topples. The curves that end in straight segments correspond with paths in which the wheels become horizontal as the bike topples over, which leads to large distances between the points where the wheels touch the ground from instant to instant.

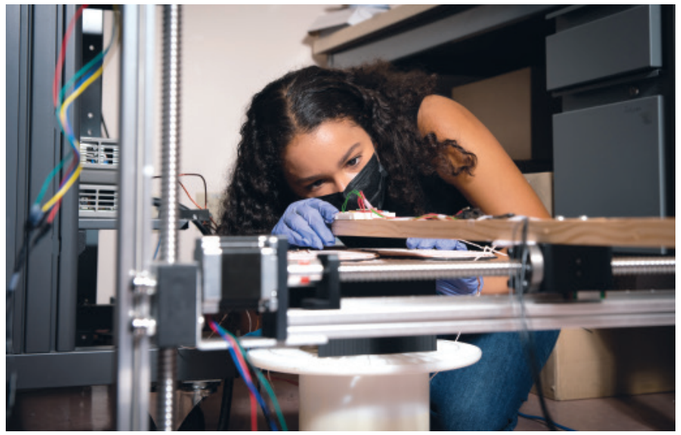
Cook, who recently returned to Caltech as a visiting Moore Distinguished Scholar while on sabbatical from the Institute of Neuroinformatics at the University of Zurich and ETH Zurich, says he receives a flurry of emails about the illustration every few years when it reappears on social media. "Although the segments are visually incongruous with the flowy curves," he notes, "I still like it because it kind of looks like long hair with split ends."



A Summer of *SURFers* and *WAVEs*

After a year of remote learning because of the COVID-19 pandemic, a group of 318 undergraduates were brought back to campus this summer to participate in the Summer Undergraduate Research Fellowships (SURF) and WAVE Fellows programs. Through SURF, Caltech undergraduates can conduct 10-week research projects with faculty; WAVE aims to promote the participation of underrepresented undergraduate students in science and engineering and, like SURF, allows students from other institutions to do summer research at Caltech. "I had never done any research or worked in a scientific setting before the SURF program," says Caltech sophomore Rahul Chawlani. "I learned not only how research works but also how to manage responsibilities in a workplace and lab."

MIT junior **Liliana Edmonds** delicately moves a magnetic sensor 1 millimeter at a time as part of a WAVE project in collaboration with **Azita Emami**, Andrew and Peggy Cherng Professor of Electrical Engineering and Medical Engineering and director of the Center for Sensing to Intelligence. Edmonds was focused on methods to improve researchers' and clinicians' ability to locate and position trackable microscale devices inside the body. The goal is to improve the effectiveness of precision surgeries and medical procedures.



Over the summer, SURFer **Rahul Chawlani** (left) turned up the heat to study the composition of rock samples from the Great Oxygenation Event, a period more than 2 billion years ago when Earth's atmospheric oxygen spiked. In collaboration with **Claire Bucholz**, assistant professor of geology, he warmed the samples in an oven that reached more than 1,000 degrees Celsius to remove trapped water and obtain a pure sample of the rock.

As part of her SURF project, Caltech junior **Diana Frias Franco** (left) designed and built an instrument to measure the torque exerted on a sample of smart fabric, an engineered wearable material that senses environmental stimuli and responds to varying conditions with changes in mechanical properties such as stiffness. She worked with **Chiara Daraio**, G. Bradford Jones Professor of Mechanical Engineering and Applied Physics.

Caltech sophomore **Ann Zhu** worked with **Mikhail Shapiro**, professor of chemical engineering, on a SURF project to improve the diagnosis of inflammatory bowel diseases and pinpoint sites of inflammation. She engineered *E. coli* bacteria to express certain protein nanostructures that the researchers can image in the lab.

Caltech junior **Tyler Nguyen** (second from right) worked on his SURF project with **Mory Gharib** (PhD '83), Hans W. Liepmann Professor of Aeronautics and Bioinspired Engineering as well as Booth-Kresa Leadership Chair and director of the Center for Autonomous Systems and Technologies, on a fish-inspired robot that can propel itself through water and could one day be used to explore extraterrestrial ocean worlds.

Grace Liu (junior)

#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.***

Grace Liu, a junior in biology and biological engineering, discusses her Summer Undergraduate Research Fellowship (SURF) experience in the laboratory of Nobel laureate Frances Arnold, Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry and director of the Donna and Benjamin M. Rosen Bioengineering Center. Liu uses machine learning to predict how certain proteins will interact to catalyze chemical reactions.

"I was working with the Arnold Lab earlier in the school year, but I always felt like the undergrad among grad students. Now, thanks to my SURF, I've merged into the lab a lot more. I go to group meetings, and I can have conversations with the grad students, who are always telling me about papers and new packages of code that might be helpful to my research.

"When I'm doing a SURF, because I'm trying to tackle a bigger project, it has surprised me how many things I have to work on at once. While coding, for example, I will run into a problem and must find a way around it. But then finding a way around it requires me to use a new technique, or use a new package, or learn something new altogether. It's a much more dynamic process. It's constantly changing."

For more #SoCaltech, go to **magazine.caltech.edu/post/socaltech**

Alumnus Ardem Patapoutian (PhD '96) Wins 2021 Nobel Prize in Physiology or Medicine

Caltech alumnus Ardem Patapoutian (PhD '96), Presidential Endowed Chair in Neurobiology and Professor at Scripps Research in La Jolla, California, and a Howard Hughes Medical Institute Investigator, won the 2021 Nobel Prize in Physiology or Medicine, sharing the award with David Julius of UC San Francisco. The two were honored for their "discoveries of receptors for temperature and touch," according to the award citation.

The sense of touch is shaped by sensory information related to both temperature—hot or cold—and pressure. Patapoutian and Julius made major contributions that helped to uncover how these processes work and to elucidate how temperature and pressure stimuli are converted into electrical impulses in the nervous systems. Their work is now leading to new treatments for chronic pain, including the development of non-opioid painkillers.

Patapoutian was honored for his discovery of the cellular sensors in the skin and internal organs that respond to mechanical stimuli such as touch. He and his collaborators first cultured a cell line that gave off a measurable electrical signal when individual cells were poked with a tiny pipette. The team systematically knocked out individual genes in these cells, which allowed them to identify the genes that encode for the receptors that respond to pressure.

As a graduate student at Caltech, Patapoutian worked in the laboratory of Barbara Wold (PhD '78), Bren Professor of Molecular Biology and Allen V. C. Davis and Lenabelle Davis Leadership Chair and director of the Richard N. Merkin Institute for Translational Research. "This is a joy to see," Wold says. "Ardem came with a great love of biology, zest for discovery, and capacity for fine experimental design. And he was always willing to go an extra mile when it required pure work."

"The way genes are regulated—how they are dialed up or turned down—is the basis underlying complexity and cellular function. Much of this process is mediated by proteins that do not have clear shapes. These proteins are so difficult to understand because they don't fold into well-defined structures, and cannot be understood by conventional analytic methods. The 'dark proteome' is another name for these structures. They can be thought of as the dark matter of biology because they make up a large portion of our bodies' proteins and play many roles in our bodies, but we know very little about them."

—Shasha Chong, who recently joined Caltech as assistant professor of chemistry and is a Ronald and JoAnne Willens Scholar

Read Chong's full profile at **www.caltech.edu/chongqa**

2021–2022 Watson Lectures to be Presented via YouTube Live

Last year, due to the coronavirus pandemic, the Earnest C. Watson Lecture Series was presented virtually for the first time. That unexpected shift allowed Caltech's global community to attend the lectures and engage remotely with the cutting-edge research conducted by Caltech faculty.

To continue this reach, the 2021–2022 Watson Lecture Series will be livestreamed via YouTube Live so that viewers can watch and interact virtually no matter where they are.

The season lineup will feature faculty from across Caltech's academic divisions and JPL and cover such topics as artificial intelligence, quantum matter, the long history of managing public uncertainty around health and science, efforts to measure sea level changes, quantum entanglement, life-saving polymers, and more. Visit **caltech.edu/watson** to register to attend, sign up for timely notification of upcoming lectures, and watch past lectures.

"The Caltech Center for Inclusion and Diversity (CCID) team will work with community members to develop realistic goals incorporating inclusive, diverse, equitable, and accessible frameworks and practices to move toward a culture change. I will also prioritize the Institute's goal of 'a more Inclusive Caltech' by working to identify gaps in our support of historically excluded groups in the Caltech community while strengthening programs and resources that have proven to be successful for historically excluded groups."

—Tashiana Bryant-Myrick, *the new director of CCID*

Read her full profile here:

Object Lesson: Feynman Diagrams in Space

One of NASA's newest spacecraft to reach orbit features artwork that is close to home: stylized depictions of Feynman diagrams, laser-etched into the outer emissivity skin of the PACE-1 6U satellite.

The PACE-1 satellite is part of NASA's Payload Accelerator for CubeSat Endeavors (PACE) Initiative, a project to test a series of potential payloads for cubesats, which are tiny modular satellites. In addition to its scientific mission to assess how well certain technologies can survive the harsh environment of space, PACE-1 features an orbital art exhibition. Artists Arno Geens, Selby Sohn, Mike Dabro, and Steven M. Johnson each created work that was specially commissioned for this mission, then curated and integrated by NASA Ames Spacecraft Systems Designer Luke Idziak.

Geens, a designer and former visual strategist at JPL, which Caltech manages for NASA, created the section of the artwork that drew inspiration from diagrams created by the late Richard Feynman, professor of physics and Nobel laureate.

"Feynman developed a uniquely elegant and creative visual language to depict an intrinsically complex process," Geens says. "His diagrams depict the interaction of subatomic particles, such as the kind that would occur from radiation affecting a satellite's scientific payload. By honoring them as true works of art, his diagrams directly reflect the satellite's objective."

The spacecraft engineering team, artists, and Idziak collaborated to determine how to etch art onto the side of the cubesat without affecting its ability to perform its job. "We wanted to find a way to depict invisible things happening inside the spacecraft; to show vanishingly small processes—particle collisions—through an artistic medium that could be accessible to wide audience," he says.

Idziak sees the artwork as both a continuation of NASA's legacy of art in space, which includes the Voyager Golden Record, and an homage to the bygone era of objects that are functional and creative, such as illuminated medieval manuscripts.

"Every spacecraft is a custom-built creation, with countless hours of effort distilled into it," Idziak says. "By including artists in the development process, we have an opportunity to make new spacecraft not only functional, but beautiful and engaging to a wide audience as well."