Spring/Summer 2017

Caltech
magazine

MacArthur Fellows Victoria Orphan and Dianne Newman in conversation

A new institute for neuroscience

Linking gut bacteria and Parkinson's

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Cover image: Caltech microbiologists Victoria Orphan and Dianne Newman
Photographed by Mario de Lopez

Left: Biophysicist Rob Phillips surfing in the Maldives
Photograph courtesy of Jeff Haltiner

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Caltech
magazine

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Left: Outside the Walter and Leonore Annenberg Center for Information Science and Technology

Welcome

For 80 years, *E&S* magazine played an important role at Caltech, serving not only as a vehicle for telling the Institute's story but becoming an integral part of that story itself. It began in June 1937 as a means for disseminating news to and about Caltech alumni, then morphed a few years later into *Engineering and Science Monthly* "to reflect all current development in the fields of engineering and science." By the time the magazine carried the *E&S* logo for the first time in 1967, its focus had broadened to include both alumni and general Institute research. Over the years, generations of Caltech graduates have come to rely on *E&S* as one of the primary ways to stay connected with their alma mater.

At times in its history, *E&S* harkened back to its roots of eight decades ago, serving primarily as an alumni magazine. At other times, it more closely resembled a research publication, focused on the transformative work being undertaken by Institute faculty. We feel the time has come for the next step in its evolution: to become a truly *Caltech* magazine, one that both embodies the entire Institute and serves all its stakeholders.

The magazine you are now reading is that reimagined product, the result of months of audience research, discussions with a broad variety of the magazine's readers, and conceptual design work. This process made a few things quite clear:

- While certain audiences, such as alumni, regularly read *E&S,* there is a significant opportunity to reach others, such as current and prospective students, parents, and visitors to our campus.
- There is great enthusiasm on the part of both existing and prospective readers for a magazine with a stronger online component.
- Readers have a desire for a more robust print publication, one in line with magazines produced by peer institutions.

We hope *Caltech* magazine serves these needs and many more. The print issues have been reduced from four to three per year (with two issues in 2017), allowing for more investment in both the print version as well as a stronger online presence. In each issue, readers will find a wider variety of stories, targeted toward the many different audiences such a magazine serves. Complementary material, including videos, will be available throughout the year on the magazine's website, **magazine.caltech.edu.**

With the thought that "the biggest room in the world is the room for improvement," we look forward to your thoughts and comments on how we can make *Caltech* magazine more useful and compelling for you. You can reach us at **magazine@caltech.edu.**

We hope you enjoy this first issue of *Caltech* magazine.

Farnaz Khadem
CHIEF STRATEGIC COMMUNICATIONS OFFICER

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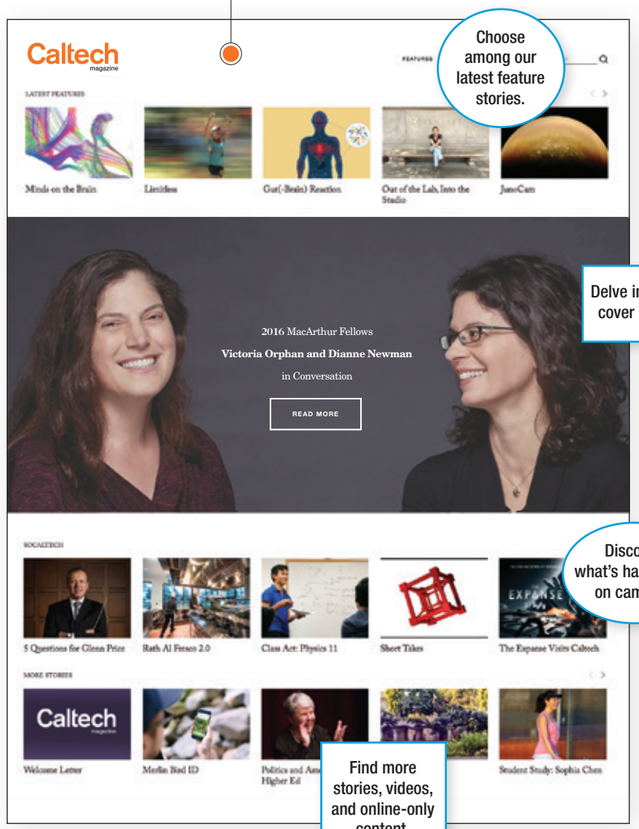
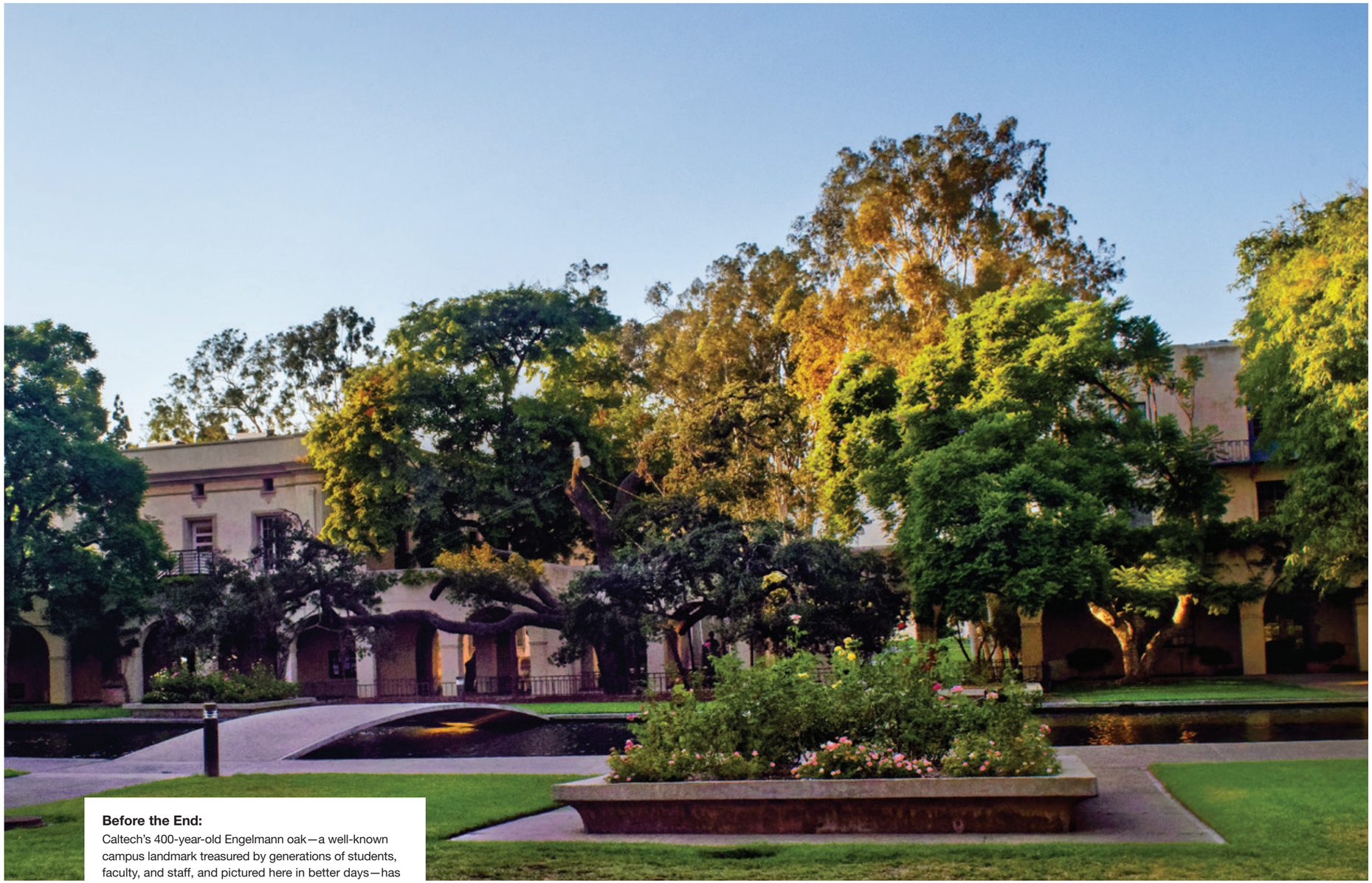




Before the End:
Caltech's 400-year-old Engelmann oak—a well-known campus landmark treasured by generations of students, faculty, and staff, and pictured here in better days—has officially succumbed to disease and old age. To learn more about the origins and history of this iconic tree, which sprouted long before the Institute was ever envisioned, see page 15.

SoCaltech

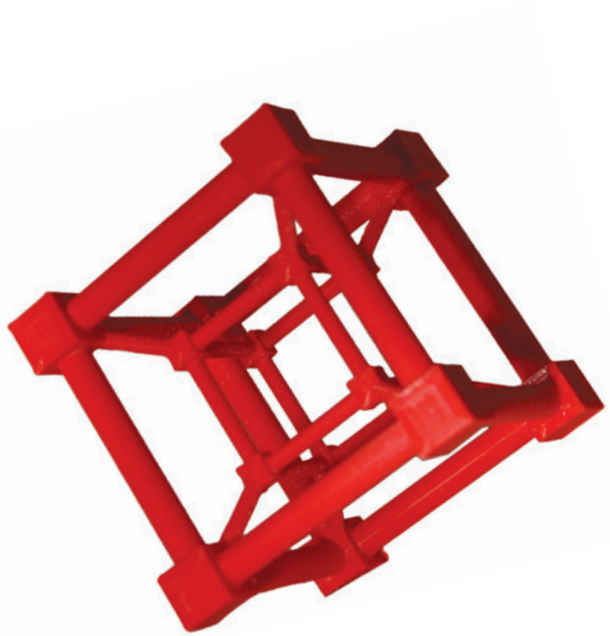
Did you know?

Caltech is a patent-producing powerhouse. Compared with MIT, Caltech is granted twice as many patents per researcher, and three times as many as Stanford. Over the past 22 years, technologies created by Caltech researchers have formed the basis of 238 new companies.

To help inspire the next generation of Institute innovators, Caltech held its inaugural Innovation Week last November, in which a dozen alumni entrepreneurs and investors shared their experiences. The keynote speaker was former astronaut Garrett Reisman (MS '92, PhD '97). After receiving a degree in mechanical engineering at Caltech, Reisman joined NASA as a mission specialist and logged a total of three months in space on two separate missions. He then transferred to the public sector, where he currently serves as SpaceX's director of crew operations.

"The whole lifeblood of [SpaceX] is innovation and disruption," he told the student audience. "The status quo has got to be the enemy. If it's not—if the status quo is a nice comfortable friend—then you're not going to have an innovative culture in your organization."

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



Object Lesson: Matter of Perception

Caltech makes 3-D printing available to anyone with a campus ID card through its TechLab—located on the first floor of Sherman Fairchild Library—which provides hands-on access to a host of technologies related to prototyping and modeling. To help community members turn ideas into objects, workstations throughout the library are equipped with SolidWorks, a software program used to make and manipulate 3-D images for printing. Shown here is a model printed by Ray Sun (BS '20), inspired by *Perception,* a sculpture created by Caltech trustee Ronald Linde (MS '62, PhD '64) to grace the space outside the Ronald and Maxine Linde Center for Global Environmental Science. (Model design by digital design repository Thingiverse.)

Three Questions for : Glenn Price

Director of Performing and Visual Arts and Band Director

Glenn Price joined Caltech last fall with an international reputation as a conductor and music educator. His career has taken him to Japan, Europe, and Russia; he has conducted in more than 30 countries, with full-time positions in Canada and the United States. Most recently, he was director of winds and ensembles at the University of Cincinnati College-Conservatory of Music.

1. What have you learned about Caltech students?

They're smart, retain information very well, and learn quickly. The other characteristic the students share is that they are only participating because they love it; nobody is doing this as a major or degree requirement. Students talk about how music balances their lives, gives them artistic fulfillment, and adds a social component. Those three elements have created an alchemy for many of them that has had a profound impact on their lives at Caltech. I remind myself of that every time I go to rehearsals.

2. What are your first impressions about the arts at Caltech?

We have a lot of arts activities on campus, but in different pockets, and they could be brought together in a more unified way. Awareness, access, and communication are some of my key guiding principles.

3. How are you enjoying life in Southern California?

California arts groups are booming right now, so it's an interesting time to be here. The orchestra scenes in L.A. and San Francisco are thriving, whereas other places that have historically been leaders are struggling. Here, there is a huge appetite for the arts, which makes it an exciting and fulfilling place to live.

For more of our conversation with Glenn Price, go to magazine.caltech.edu/post/glenn-price

"I am probably one of the bigger geeks on the cast, so I was hugely excited to be working on such a science-heavy show. Coming on this kind of panel is a very different experience from the Comic-Con panels that I'm used to. Normally we're talking about comic books and video games. Here we're having discussions about time-sync differentials and gravity wells."

– *Actor* Cas Anvar

(who plays Alex Kamal), at the January 25 Caltech panel

Read about the panel and watch a video at magazine.caltech.edu/post/expanse-visits-caltech

Rath Al Fresco: 2.0

A new 1,900-square-foot kitchen addition opened at the Athenaeum this spring. The Rath Al Fresco Pavilion offers diners a variety of new grab-and-go lunchtime options, including salads and sandwiches. From May through October, members can dine outside in a peaceful, newly landscaped terrace setting under the Deodar cedars.

Read more about Physics 11 at magazine.caltech.edu/post/physics-11

Daniel Mark (BS '20) at the white board during a weekly meeting of Phys 11, the freshman seminar where thinking outside the box is the norm.

Reinforcing the Caltech-Huntington Connection

Who

Barely a mile apart, Caltech and The Huntington Library, Art Collections, and Botanical Gardens have long served as twin anchors of Pasadena's intellectual and cultural life.

What

The Caltech-Huntington Humanities Collaborations brings scholars together across the two institutions for a series of two-year multidisciplinary research modules. "Violence and Order Past and Present," the theme chosen for the 2016-18 module, looks at the role of violence in political and social order.

How

For the module, coordinated by English professor Jennifer Jahner and history professor Warren Brown, Caltech shares a postdoc (Leah Klement, pictured) and two senior research fellows with The Huntington. Workshops and lectures have brought an array of scholars to Pasadena, including Bruce Hoffman, from Georgetown University's Edmund A. Walsh School of Foreign Service, who spoke on terrorism and counterinsurgency.

Why

For Jahner, the project is an extension of the interdisciplinary work that is the norm in the humanities and social sciences division. "Warren and I are used to talking across our disciplinary divides," she says, "and so basically we've widened the scope so we can get more people involved in the conversation. It's great to collaborate with art historians, political scientists, and people working on contemporary terrorism."

Class Act:

Physics 11

Among the classes a Caltech freshman can take, Physics 11 stands out. Before even gaining entrance to the popular seminar, students must jump through a series of intellectual hoops. The few who are accepted embark on a singular learning journey.

Jumping hurdles

Late Caltech Robert H. Goddard Professor of Physics Thomas Tombrello, who created the class almost 25 years ago, challenged prospective students to complete two "hurdles" as a test for admittance to the class. These were questions—riddles really—that had no right answer and often seemed to have little to do with physics.

Class culture

The class gathers once a week without a set agenda. "We might talk about the science of the movie *Interstellar* or the physics of breaking waves," says Rob Phillips, the Fred and Nancy Morris Professor of Biophysics and Biology, who has co-taught the class since 2014.

How to wonder

"What's cool about Phys 11, and why I feel passionate about it," says Phillips, "is that we're challenging students by giving them things we don't know the answers to and not being so focused on making them into technicians. Instead, we're teaching them how to ask questions, how to wonder."

Tackling the open-ended

As class and Caltech alum Charles Tschirhart (BS '15), currently a graduate student in physics at UC Santa Barbara, puts it, Phys 11 is meant to "train young scientists how to attack the kinds of difficult, poorly defined, open-ended problems often encountered in research."

Launching pad

Phys 11 graduates have secured Hertz, National Science Foundation, and Marshall scholarships as well as entrance to top graduate schools. Is it a springboard to success? "I don't know how you would decide that," says Dave Stevenson, the Marvin L. Goldberger Professor of Planetary Science, who has co-taught the course for more than two decades. "I think these students are destined to excel anyway. But for the small subset of students who take this course, it's something very special."

"Touring the campus, I was struck by what an amazing time it is to be a student at an institution like Caltech. In every field—from engineering and biology to chemistry and computer science—I learned about phenomenal research underway to improve our health, find new energy sources, and make the world a better place."

– Bill Gates, writing on his blog about his October 20 visit to Caltech

ON LOCATION

In February, geography was temporarily upended as the cast and crew of the Emmy Award–winning HBO series *Silicon Valley* visited Caltech to film an episode for the show's fourth season (which kicked off April 23). As co-executive producer Jim Kleverweis noted, "The main challenge of shooting on a college campus is not to interrupt classes and to be respectful of the professors, staff, and their workspaces." For the one-day shoot, trucks began arriving before dawn and by the time students were up and about, Beckman Lawn had been transformed into a base camp with catering trucks and tents; extras were being schooled on their roles; and series regulars Thomas Middleditch, Josh Brener, Martin Starr, Kumail Nanjiani, and Zach Woods were prepping for the first scene of the day.

30	82	125	187
Trucks	Extras	Crew	Meals Served

augmented poetry [n]

1: a way to create poetry using rule-based and statistical-probabilistic computer algorithms that generate text using the internet, similar to how Google automatically completes search terms and mobile phones make suggestions when a user starts typing a text message.

2: a subject that is being taught on campus this spring by Israeli computer programmer, poet, and new-media artist Eran Hadas, whose residency at Caltech is sponsored by the Schusterman Visiting Israeli Artist Program.

"I think it will be the first time I am going to be outgeeked," says Hadas of Caltech's code-savvy students, "not by just one or two students, but by the entire class."

Hadas's previous projects include a headset that generates poems from EEG brain waves and a software-based rewrite of the Torah in haiku verse.

For more about Eran Hadas, go to magazine.caltech.edu/post/eran-hadas

Politics and American Higher Education

Caltech president Thomas Rosenbaum hosted presidents from Harvey Mudd College, Pomona College, and ArtCenter College of Design in Ramo Auditorium on January 24 for "Politics and American Higher Education," a discussion about the roles and responsibilities of colleges and universities in America's new political landscape.

Academic institutions traditionally do not take political stands, "and yet in another way we are manifestly political," Rosenbaum told the audience. "Unless you pay attention to educating your students in a way that they will become good citizens of the country, that they will embrace the value of looking at data, seeking truth, then we as universities will fail and we as a country will fail."

Moderator Terry McCarthy, president and CEO of the Los Angeles World Affairs Council, asked about the debate over safe spaces. Pomona president David Oxtoby said small groups wanting to meet in private are granted safe spaces on his campus. Publicly announced events, however, cannot be exclusionary. "That crosses a line, at least for Pomona, and we say no, you cannot discriminate for a public event."

Instead of focusing on safe spaces, Oxtoby suggested academic institutions do more to encourage "daring spaces," where groups from different backgrounds and opinions can come together to respectfully share their views and feel comfortable disagreeing with one another.

That diversity of thought, background, and experience is important in higher education, Rosenbaum said, and American universities are so successful because they have been able to attract talent from across the world.

The panel also agreed that selectivity in admissions is not a negative for any institution, provided that it offers opportunities and access for qualified students in every community.

ArtCenter president Lorne Buchman noted that his institution has a responsibility "to reach into communities where students would never even dream of what it might mean to have a career in art design and create some kind of bridge for them to get there."

Harvey Mudd president Maria Klawe said it's important colleges and universities never limit where they look for the next Nobel laureate. "We have the opportunity to be an existence proof that [regardless of whether] you are female or transgender or Muslim or a football player or a poet…there is absolutely nothing about any of those characteristics that has an implication about whether you can be a great physicist, biologist, engineer, computer scientist, or mathematician."

In his concluding comments, Rosenbaum noted that teaching quantitative skills alongside the liberal arts equips students to surmount any challenge, political or otherwise, now and into the future.

"If we do our job right we will see, one student at a time, the effects of that," he said. "One of the great things about being an academic is that each year you get another group of incredibly bright, wonderful students who are going to go out and change the world."

Educating "good citizens"
Presidents from four Southern California institutions of higher education, including Caltech president Thomas Rosenbaum, came together on January 24 with moderator Terry McCarthy of the Los Angeles World Affairs Council to discuss their evolving role in the current political landscape.

Student Study

Sophia Chen (BS '17)

If senior Sophia Chen had to choose between her studies in electrical engineering and her role as co-captain of the Caltech women's tennis team, she would choose her studies, she says . . . but she'd do so reluctantly.

"I hope I never have to choose. I would still want to be seen as an athlete because it's such a big part of my identity," the 21-year-old Newport Beach native says.

Athletics, she adds, has provided her with the support of fellow scholar-athletes facing the same athletic and academic challenges she's encountered, as well as opportunities to lead others, a strength she had not previously realized she possessed.

When she's not studying or playing tennis, Chen unwinds by watching science-fiction-themed shows like *The Flash* and *Stranger Things*, socializing with peers around Lloyd House, and managing her addiction to boba drinks—for which she makes frequent runs with friends.

She says Caltech allows her to indulge her twin passions in a way that would not have been possible if she had opted to attend a large NCAA Division I school: "I made the right choice. Caltech was definitely a better fit for me."

For full story and a video, go to magazine.caltech.edu/post/student-study-chen

Origins

The End of the Oak

Long before the Institute was ever envisioned, an Engelmann oak sprouted on what would become Caltech's campus. More than 400 years later, it has become one of the Institute's most well-known landmarks, treasured by generations of students, faculty, and staff. Recently, however, the oak officially succumbed to disease and old age despite numerous attempts to revive the sprawling and ancient tree.

Stressed by drought, windstorms, and a systemic fungal infection, the oak—located between Dabney Hall and the Parsons-Gates Hall of Administration—had been in declining health for more than a decade despite repeated efforts by campus arborists and outside consultants to prolong its life, says Delmy Emerson, director of buildings and grounds.

"People are shocked and sad," she says. "People are so attached to that tree. It's seen the growth of this Institute."

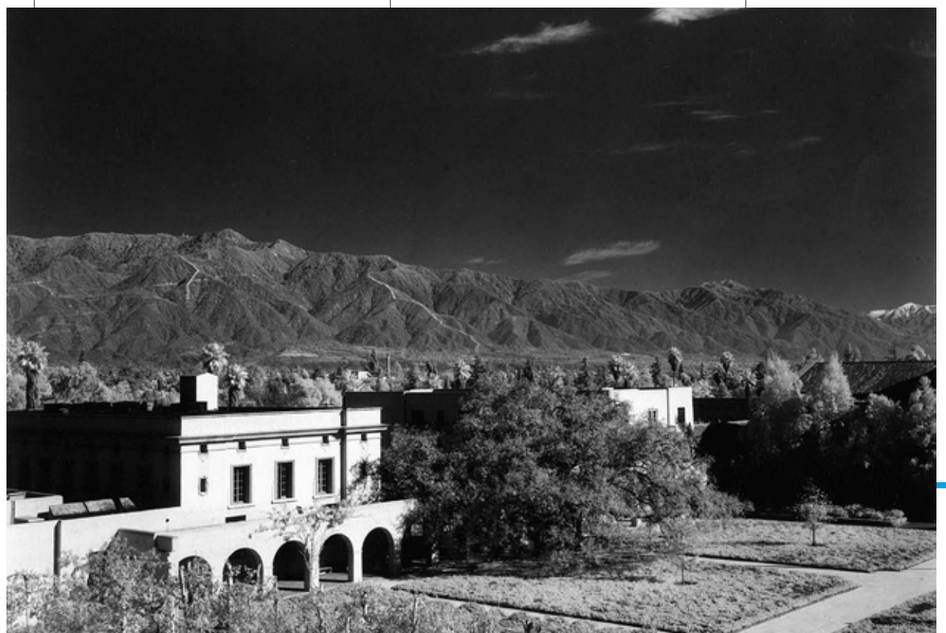
Based on estimates of its age, it is likely the tree had stood sentinel—on land first inhabited by the Tongva, then claimed by the Spanish and later becoming part of the United States—for three centuries before sharing its space with Caltech. When Caltech trustee Arthur Fleming gave the original 22-acre tract to the Institute in 1908, the Engelmann oak stood almost at the exact center of the plot, and it would soon stand just west of the first building constructed on campus: Pasadena Hall, later renamed Throop Hall. The oak survived longer than the building, which was demolished after suffering damage in the 1971 San Fernando quake.

In the Institute's early years, the oak provided shade to students and spectators at graduation ceremonies in front of Throop Hall. In more recent years it has served as a backdrop for countless wedding photos and also served as a subject of portraits drawn by students from the nearby ArtCenter College of Design.

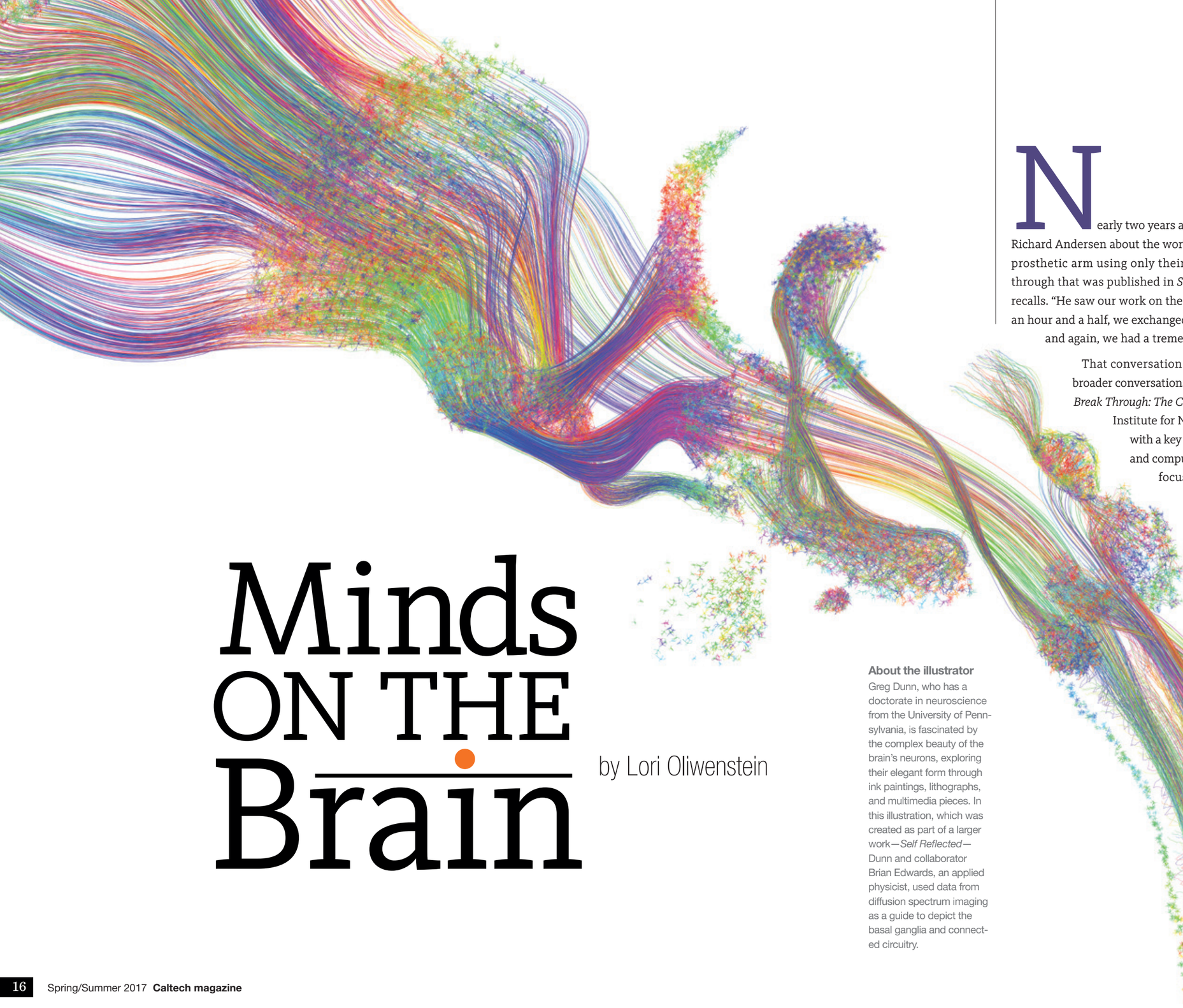
The tree, which once stood as high as 80 feet and spread its branches as wide as 75 feet, will need to be removed. It had already exceeded the usual lifespan of an Engelmann oak—about 350 years—and had lost several large branches in the 1990s, necessitating the addition of three structural supports. Soon after, it began to require regular delivery of fungicides to its roots to stave off an infection by an incurable soil fungus. Emerson says the loss of another major branch in 2006 eliminated much of the tree's canopy, leaving it vulnerable to additional stress from the sun's heat; to help keep it cool, campus workers painted parts of the tree white.

Early 2016 brought rainstorms followed by heat—conditions that favored rapid fungal growth. Tree samples taken soon after showed widespread necrosis of its bark and roots, and a last-ditch effort to save the tree using 23 injections of fungicide failed.

Emerson says most arborists would have given up on the oak in 2006, "but we decided to let it live as long as it could. We take our trees seriously and we only remove one when there's nothing left we can do."



A Campus Fixture
Caltech's Engelmann oak tree in its prime, circa 1930.



Minds ON THE Brain

by Lori Oliwenstein

About the illustrator

Greg Dunn, who has a doctorate in neuroscience from the University of Pennsylvania, is fascinated by the complex beauty of the brain's neurons, exploring their elegant form through ink paintings, lithographs, and multimedia pieces. In this illustration, which was created as part of a larger work—*Self Reflected*—Dunn and collaborator Brian Edwards, an applied physicist, used data from diffusion spectrum imaging as a guide to depict the basal ganglia and connected circuitry.

Nearly two years ago, philanthropist Tianqiao Chen emailed Caltech biologist Richard Andersen about the work Andersen was doing to help paralyzed patients operate a prosthetic arm using only their thoughts and intentions. "We had just had a big breakthrough that was published in *Science* and was reported throughout the world," Andersen recalls. "He saw our work on the BBC, and so he came here to meet with me. We talked for an hour and a half, we exchanged ideas. A month later, he came with his wife, Chrissy Luo, and again, we had a tremendous conversation."

That conversation sparked an idea that became a proposal that led to broader conversations and, last December, to a $115 million gift that—as part of *Break Through: The Caltech Campaign*—created the Tianqiao and Chrissy Chen Institute for Neuroscience at Caltech. The Chens' gift dovetailed perfectly with a key Caltech initiative: to apply Caltech's unique interdisciplinary and computational strengths to the study of the brain, with a particular focus on what these approaches can reveal about the brain's biology, chemistry, and even its engineering, as well as about human emotion and behavior.

In announcing the gift, Rosenbaum said, "There are few problems as important as understanding the brain: understanding how people think; understanding how people interact with the world; understanding how we can translate that knowledge into interventions that improve people's lives and improve their ability, both mentally and physically, to operate in society.

"The Chen Institute for Neuroscience at Caltech will let us do something special because we are now bringing individual talents together to transform the study of the brain.

"Together, the Chens and Caltech have identified this as a major area of investment, and together we will establish a partnership that will change the world."

What Their Charge Is

David Anderson, the Seymour Benzer Professor of Biology and a Howard Hughes Medical Institute Investigator, has been named the inaugural holder of the Tianqiao and Chrissy Chen Leadership Chair and director of the institute. In an interview, Anderson talks about how the new institute will shape neuroscience at Caltech.

The motivation for inquiry into the brain is twofold. One is to satisfy our innate curiosity about how this complex machine works. The other is to try to gain understanding that will help improve human health and welfare in general.

Advances in our understanding of the brain circuits of emotion, for example, will help us to understand and treat psychiatric disorders. Advances in understanding how we learn and remember will help us to treat learning disabilities and perhaps to improve memory and retention. On the other side of it, understanding how the brain functions as a computing device will help inform our engineering of computers that are inspired by the biology of brain-circuit architecture.

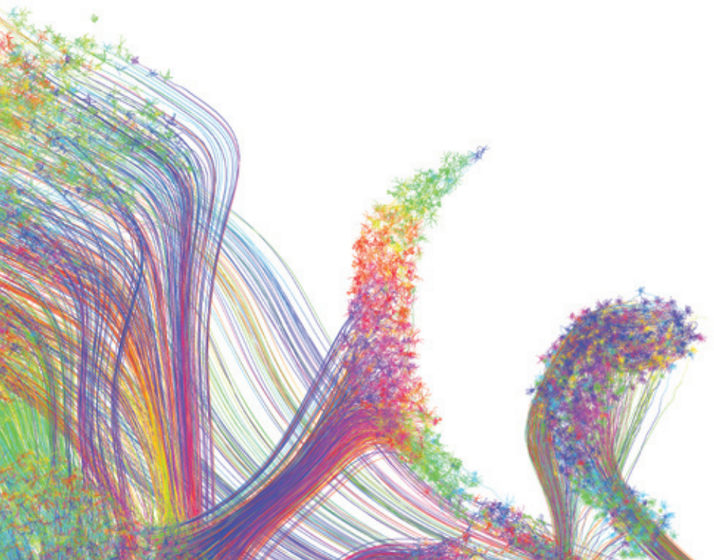
The Chen gift will allow us to encourage exploration into areas that are not yet ready for government funding and, most importantly, that are at the interface between different scientific disciplines, particularly biological sciences and physical and computational sciences.

Neuroscience, arguably more than any other aspect of biology, is a science that requires intense computation, because understanding the brain is about understanding how billions and billions of neurons function in orchestras to regulate our thoughts and behavior. To do that we need new engineering-based technologies to make measurements, which in turn generates big data. This data requires computational approaches to make sense of it and theory to model it. What Caltech has to offer to a greater extent than most other institutions is the marriage between the biology of the brain and the mathematics of the brain.

I see my role as institute director as maximizing the engagement of the Caltech community in neuroscience research, particularly in recruiting people who have not previously participated in research into this area. The opportunity that the Chens have provided us with is the chance to change not only the type of problems that we can solve here but the way we approach those problems.

How They'll Get It Done

The Chen Institute at Caltech involves faculty from across Caltech's six academic divisions, creating a campuswide interdisciplinary community of neuroscientists, biologists, chemists, physicists, engineers, computer scientists, and social scientists, all with the shared goal of understanding the fundamental principles that underlie brain function. It comprises five centers, each with a unique charge and each led by a researcher whose work is already shaping the future of neuroscience at Caltech.



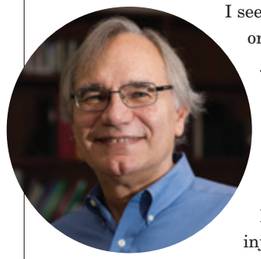
For more information about the Chen Institute at Caltech, go to neuroscience.caltech.edu.

The T&C Chen Brain-Machine Interface Center

Led by Richard Andersen, T&C Chen Brain-Machine Interface Center Leadership Chair; James G. Boswell Professor of Neuroscience

A brain-machine interface is a method of recording or stimulating the brain and connecting it bidirectionally to a machine. An example of this in our research would be decoding the intent of paralyzed subjects, then using that information to control a robotic limb or computer.

The advance we have made at Caltech is to record from a more cognitive part of the brain so we can, in a fraction of a second, decode the intent of the subject and execute the movement. When the subject thinks, "I want to pick up a glass of water," we can decode that and then with smart robotics achieve very smooth movements. It is both an intuitive and a very smooth operation, so it's been a real advance in the field.



It takes my breath away every time I see the subject sitting there in his or her wheelchair being able to, just through their thoughts, control robotic limbs or play a virtual piano or type on a virtual keyboard. It is just an amazing thing, and it thrills the patients as well. It is the first time since their injury that they can actually interact physically with the world around them in tasks that previously required limb movements.

Through the T&C Chen Brain-Machine Interface Center, we hope to achieve three major goals. One is scientific, discovering how populations of neurons work together to produce these sensations, perceptions, and intentions. The second is clinical, helping paralyzed patients and patients more generally with neurological diseases that affect both perception and movement. The third is advancing neurotechnologies to allow for less invasive or noninvasive recordings of high detail from the human brain. This will be, to my knowledge, the first brain-machine interface center more broadly examining perception, intent, and the capabilities of the human.

This gift from the Chens will be so central to what we can do. In patient trials, continuity is critical. We need funding stability over a period of years for a complex, large interdisciplinary group that is centered on the patients and also the environment around them. Now, we can be sure that we will have no disruption in the research or in the clinical trials as they progress.

The T&C Chen Center for Social and Decision Neuroscience

Led by Colin Camerer, T&C Chen Center for Social and Decision Neuroscience Leadership Chair; Robert Kirby Professor of Behavioral Economics

We are interested in what's going on in the brain when people are making decisions that mostly affect themselves, and when they are interacting with other people.

We will attack problems such as limited willpower and self-control, particularly in decisions about food, drug addiction, and procrastination. Early evidence indicates that an area called the dorsolateral prefrontal cortex, underneath your temple, keeps in mind the distant, bad outcomes from tempting choices in order to exert self-control.

One of the hallmarks of the T&C Chen Center for Social and Decision Neuroscience is that we use many different tools. Working closely with the technicians in the Caltech Brain Imaging Center (the CBIC), we use functional magnetic resonance imaging, or fMRI, to enable us to see bloodflow throughout the brain. We also use EEG, which measures activity near the cortical surface at a rapid time scale (every one millisecond) to see fast and slow thinking. We also study people with damage in certain areas: If a person has a broken amygdala, for example, and they cannot tell whether another person is afraid, we can be sure that the amygdala is a necessary part of a circuit for detecting fear.

Fact:

Caltech helped create the field of neuroeconomics, in which researchers use experimental approaches to understand how the human brain makes complicated decisions.

The establishment of this center is an acknowledgment that the study of the neural activity that creates human decisions, based in the Division of the Humanities and Social Sciences, is an important part of neuroscience at Caltech. It also will help us plan long-run studies, five or 10 years, in which we can build up a solid understanding of the brain brick by brick. We can try a dozen new approaches, some of which will be dead ends, knowing that when one approach does work, we have the capacity to pour time and energy into it to see where it takes us. We can turn money into science, knowing we can afford to follow the science wherever it leads us.

The T&C Chen Center for Systems Neuroscience

Led by Doris Tsao, T&C Chen Center for Systems Neuroscience Leadership Chair; professor of biology; Howard Hughes Medical Institute Investigator

To think, remember, imagine, and see—all these amazing capacities of the brain come from billions of neurons with quadrillions of precise connections interacting to form the most remarkable dynamical system in the universe. Caltech has a strong emphasis on understanding things at a deep, fundamental level, exemplified by the founders Hale, Millikan, and Noyes. Will we ever be able to understand the brain completely, at the level that we now understand the basic laws of physics? That is what this new center seeks to find out. We are at an infant stage in this quest right now: mostly still describing how single neurons respond under different conditions. To move forward, we will need new experimental tools for observing large populations of neurons and new computational approaches for analyzing this data. The new center will help build this infrastructure.

Our lab's approach is unique in two ways. First, we want to understand the complete problem of vision—not just how an object is recognized or how it's localized but how the entire system works, including all the interfaces. Second, we are fearless about combining different techniques. We were one of the first labs in the world to combine fMRI with electrophysiology. That led to a whole new picture of how the part of the brain that's involved in object recognition is organized.

Systems neuroscience right now is a collection of silos, with researchers studying emotion, or vision, or decision making. This new center will inspire and enable us to work toward the larger goal of understanding how these different systems are talking to each other. How does a sensory percept trigger formation of a memory? How do internal states and sensory inputs interact to generate behavior? How does the brain decide when to route information from one area to another? Is there a general programming language that the software of the brain is written in? How do answers to these questions change across brain evolution?

The Center for Molecular and Cellular Neuroscience

Led by Viviana Gradinaru (BS '05), assistant professor of biology and biological engineering; Heritage Medical Research Institute Investigator

My group works on understanding neural correlates of behavior. The main problem we are currently working on is understanding how a very powerful therapy, deep-brain stimulation, works. There are difficulties around that, because the brain is a very complex organ. It is highly heterogeneous; it is difficult to map. These are our challenges.

The brain is not only difficult to study but also difficult to access since it is protected by the blood-brain barrier. This keeps pathogens at bay, but it also makes it difficult to deliver therapies to the brain. We are very excited about our latest work, where we've been able to engineer viral vectors to cross the blood-brain barrier and deliver products brain-wide. Those products can take the form of labels for anatomical mapping, but also therapies.

The Center for Molecular and Cellular Neuroscience will be instrumental in giving us a hub to exchange ideas and amplify these technologies. We are excited about the potential of the teaching lab that's planned through the Chen Institute at Caltech, where students and teachers will work together on technology transfer and enhancement.

The Chen Institute at Caltech is instrumental in allowing us to understand the brain in all of its complexity, because there is an understanding that the brain is not about the molecules alone, or the cells alone, or behavior alone, but rather it is the interaction across the levels. The Chen Institute at Caltech has centers that address each of these levels and unifies them under one umbrella, with lead investigators working together for an integrated understanding of the brain.

The Caltech Brain Imaging Center

Led by John O'Doherty, professor of psychology

The Caltech Brain Imaging Center, or CBIC, was founded in 2003 through a gift from the Gordon and Betty Moore Foundation, and, over the last 13 years or so, we have been providing Caltech faculty, staff, researchers, and students with the research tools to obtain images of the living brain.

Here in our center, we can take structural pictures of the brain as well as use fMRI, which takes a second-by-second look at how activity in the brain changes in relation to the functions it is implementing. If a particular part of the brain is working more than another part, this causes a change in the amount of oxygenated blood flowing to that part of the brain. We can detect that signal, giving us insight into which portions of the brain are working at particular moments in time.

My main research question is trying to understand how the brain learns from experience to make good decisions for the future. Knowing this is fundamental to understanding ourselves as humans, and also impacts our comprehension of what happens when things go wrong in our capacity to make decisions.

The brain imaging center is a critical component of the overarching Chen Institute for Neuroscience at Caltech, providing facilities to faculty across not only humanities and social sciences but also biology and biological engineering as well as chemistry and chemical engineering. Through the facilities we offer here, we can provide a bridge between different types of research activities taking place across the Chen Institute at Caltech.

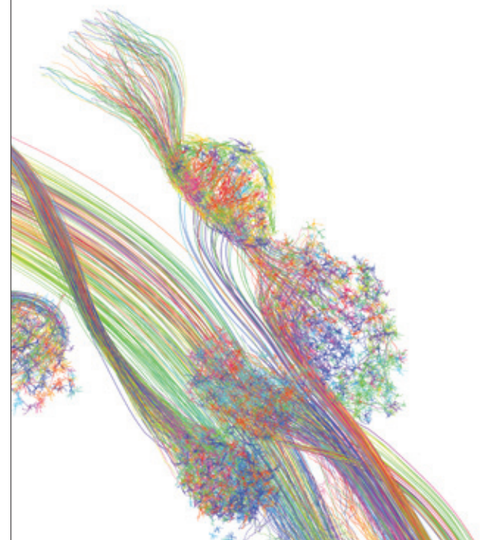
Fact:

In 1986, Caltech established the world's first graduate program in computation and neural systems, which continues to this day.

The philanthropists behind the Chen Institute at Caltech, Tianqiao Chen and Chrissy Luo, are committed to support brain research that promotes and improves the well-being of humanity. "We believe uncovering how the brain perceives, interprets, and interacts with the world is pivotal in so many aspects," says Chen. "This is the mission of our philanthropy."

"We chose Caltech as our first partner not just for their strong reputation as a leading research institution, but also for the admiration in their natural alignment with [our institute's] culture, which is focused on creating excellence and discovery," adds Luo.

To learn more about the Chen Institute at Caltech and to see a video about the institute's inception, visit magazine.caltech.edu/post/minds-on-the-brain.



in conversation:

Victoria Orphan

and

Dianne Newman

—2016 MacArthur Award-Winning Scientists—

on Friendship, Microbes, and How to be a Role Model.

THE AWARD

Awarded to individuals across multiple fields who show extraordinary creativity in their work, the MacArthur Fellowship comes with no strings attached and a stipend of $625,000 over five years.

THE PLAYERS

Victoria Orphan (left), a James Irvine Professor of Environmental Science and Geobiology, studies the molecular microbial ecology of anaerobic communities (microbes that exist without free oxygen in their environment), with a particular focus on microorganisms that live in deep-ocean sediment beds and consume large quantities of methane released from seeps in the ocean floor.

Dianne Newman (right), the Gordon M. Binder/Amgen Professor of Biology and Geobiology, focuses her work on microbial stress responses, with an emphasis on how microbes generate energy and survive when oxygen is scarce. Her research looks at microbes in everything from ancient sedimentary deposits to chronic infections, yet all of her projects involve asking similar physiological questions.

Watch Newman and Orphan discuss "the call" and what came next at magazine.caltech.edu/post/in-conversation.

THE PHONE CALL

Dianne Newman [DN]: I was in my office. Where were you?

Victoria Orphan [VO]: I was in the kitchen. I had just come back from a run and, of course, this was during the political season, and there were lots of morning election calls and you're not typically inclined to pick up the phone.

DN: I was meeting with my postdoc and I saw my cell phone ring, and I ignored it. Ten minutes later, the same number called and that time I picked it up.

VO: I kept thinking, "Come up with something very profound to say." And I was just, "Oh my God! Oh my God!"

DN: I actually asked if it was a joke. I didn't see it coming at all. I never in a million years thought this was going to happen. I got quite emotional and expressed to them just how touched I was, how honored I was, and stunned actually.

VO: You feel like you're in shock!

DN: Being able to share it with [you,] one of my best friends, made it a lot nicer. It deflected a bit of the awkwardness and made it something that could be a shared, joyous experience, and the fact that we're both women in a similar field allowed it to transcend us and be something positive for our fields and a celebration of women in science.

This week we're going together to talk to a sixth-grade class in Ventura, and I think we'll be aware that we are showing all of those kids, boys and girls, that if you're passionate about what you do, you really can go far.

VO: I didn't quite appreciate the value of being an outward role model for women as much as I do now. We've had a lot of fun talking about creative ways we can do outreach. This amazing teacher in Ventura had her class write us letters. They had read about us and had very specific questions about our research. For me, I think that was a peak moment since this award, getting letters from these students.

DN: That was, by far, the highlight. No question.

JUMPING OFF MOUNTAINS

DN: I hired you; I have to claim credit for that. I was the chair of the search that hired you.

VO: Yes! But even before that, we were in Switzerland together at a geochemistry meeting. That was the first time I met the famous Dianne, and I remember being so impressed with you because you went parasailing off the top of the Alps even though you were scared to death. I thought, this is where I want to be, with these fearless women. Then I came to interview here, and you were already on the faculty.

DN: It became immediately clear how much you could contribute to the division and how you really walked the line beautifully between someone who was sincerely interested in what was going on with Earth's systems processes and also someone who was a serious molecular ecologist and knew how to apply state-of-the-art tools to those problems, which is what the MacArthur Foundation also, I'm sure, appreciated when they selected you.

VO: I remember thinking that, at first blush, it seemed surprising that a geological and planetary science department would start a geobiology program, but it showed this amazing vision for the future that they could embrace that and put together, with your help, this all-star team of geobiologists who have come together in a very synergistic way to cover many of the different elements of geobiology.

SCIENTIFIC JOURNEYS

DN: How did you first get into science?

VO: My dad was an engineer and a physicist, so there was always that sort of element in the household, and I really loved the outdoors, especially the oceans. I grew up in San Diego, right near the beach, and I spent a lot of time at Scripps aquarium, and was very curious about how the ocean worked.

DN: When did you discover microbiology?

VO: In college. I had the opportunity to go on an oceanographic research cruise and there was a graduate student who was studying bacteria in the ocean. It didn't look like much, you know, little bright blobs under the scope, but the sheer numbers of microorganisms in a seawater sample is just awe inspiring. I got off the cruise and took a course from his adviser. How about you?

DN: It took me a little longer.

VO: Yeah. You had a very circuitous route.

DN: I did not have geobiology on my radar in college. I was a German studies major, and I was struggling between going on to graduate school in engineering or going on to study comparative literature or going to law school. It wasn't until my first semester in graduate school at MIT, where I took a class in environmental microbiology, that I suddenly discovered the wonderful world of microbial metabolism, and it was a revelation.

It took me a while to land on a problem that I wanted to commit to. Since I had studied a lot of classics as an undergrad, I always had an interest in the past, and when I had the opportunity to come here to Caltech and be in the GPS division, I felt an interest and also an obligation to work on things that were of relevance to Earth scientists.

VO: I think you hit on something too that I have really valued being within the GPS division. Being with the Earth scientists, you get little tidbits of information about where the interesting questions are and how you can bring together disciplines in new ways.

SCIENTIFIC INTERSECTIONS

VO: Over the past 14 years or so that we've been at this institution together, I feel like we have really learned from each other and appreciated our own individual approaches to science in a way that has enhanced our own research.

DN: Definitely. At our core, we're both environmental microbiologists and I think we both recognize the myriad ways that diverse microorganisms shape our entire world, whether it's the atmosphere, lithosphere, hydrosphere, or even, you know, the human body.

I think we are cut from the same cloth in recognizing that any of these areas of existence is critically dependent upon microbes. What I've always seen as something really amazing about what you do is your ability to study them in nature, in places that are remote and hard to access.

Now, for students, they don't need to choose between being someone who's out in the field versus someone who's doing mechanistic research at the bench. You can and should do both if you want to get to the heart of a problem in a rigorous way. It's possible these days to navigate back and forth between these two poles of a problem. That's an exciting thing!

VO: It's also the nice thing about the CEMI [Center for Environmental Microbial Interactions], a virtual center at Caltech that brings together all the people who are enthusiasts of microorganisms or work with microorganisms. Really the value is being able to draw on your colleagues' expertise to help enrich your project or answer specific questions as they come up.

DN: Yet, very few of them are actually microbiologists.

VO: Yeah. Very few would call themselves microbiologists, but ...

DN: Which is what makes it so great! The thing is, you don't need to be a microbiologist to love microbes, right? Microbes represent the best systems you can study in many ways because they are so tractable and they're so important in so many disciplines.

For that reason, we have people from chemical engineering, people who are applied physicists, applied mathematicians, neuroscientists even, whose techniques are now being adapted to studying the microbial world! That all these people have coalesced to form this entity we call CEMI is such a quintessentially Caltech thing.

VO: Historically, I don't think people would have equated microbiology with Caltech...

DN: Definitely not.

VO: ...because we were so diffusely distributed among the divisions, so to have this virtual center, we are now on the radar screen and we're getting people who want to come to Caltech to do microbiology.

SPREADING THE WORD

DN: I do think that while the MacArthur Fellowship is at its core an award to individuals, there is something inescapable about them having chosen two women at the same university in a similar discipline, whether you call it environmental microbiology or geobiology, that speaks to where the field has come from when we started here.

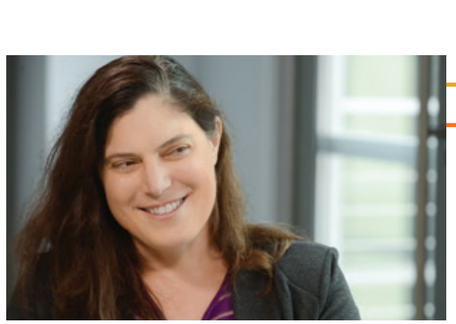
The response of our geobiology community was really extraordinary. That's one of the things that's so rewarding in general about a life in science, that you have the chance to work with talented and generous people from all over the world.

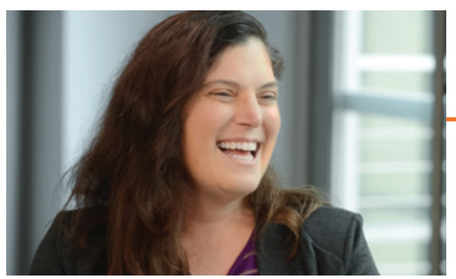
VO: It sits at the core of what geobiology is about. Our successes are grounded in diversity—diversity of disciplines, diversity of ideas, diversity of cultural backgrounds from around the globe—and it's made this very fertile ground to strike out in new directions and make new discoveries about how the earth works and the roles that life has played in shaping the changes in the chemistry over the earth's history. It's going to require an international effort to do that to its fullest potential.

DN: Absolutely. I know it's something we've talked about in light of recent changes in Washington, D.C., and attitudes toward immigrants. Really any science at any major university these days is an international enterprise and is something that absolutely depends upon the ability to attract the best and the brightest from anywhere in the United States or abroad to help in opening up new frontiers of human endeavor and knowledge.

VO: We've talked a lot about how we can use this award as a platform to increase recognition and appreciation for the role science plays in everyday life. I've taken it to heart that we can get out there in the communities and in schools outside of the Pasadena area to help share our own excitement about science and, hopefully, give people some sense that we're just regular people; down-to-earth people who are just passionate about what we're doing.

It's the best-kept secret in the world. The fact that we can walk into this university every day and follow our passions and our curiosity as a career. It is just amazing and something we need to be able to share with everybody.





Gut(-Brain) Reaction

Do your gut bacteria contribute to or maybe even cause the shaking, stumbling, and overall deterioration of motor skills that are the hallmarks of Parkinson's disease?

by Lori Dajose

In December 2016, a team led by Sarkis Mazmanian, the Luis B. and Nelly Soux Professor of Microbiology and a Heritage Medical Research Institute Investigator, published a paper detailing the first demonstrated connection between the gut and this ravaging disorder.

How would such a link work?

It starts with the microbiome, "a diverse community of beneficial and sometimes harmful bacteria," Mazmanian says. In a series of experiments, he and his colleagues looked at mice whose guts harbored the usual complex collection of bacteria, and compared them to mice who were microbe-free.

Both sets of mice were engineered to overproduce a protein in the gut called alpha-synuclein that, in Parkinson's patients, also clusters in the brain's neurons, resulting in debilitating clumps and snarls. And that was indeed what happened in mice with a full complement of gut microbes. On the other hand, mice without a microbiome—the germ-free mice—tended to be almost or completely symptom-free.

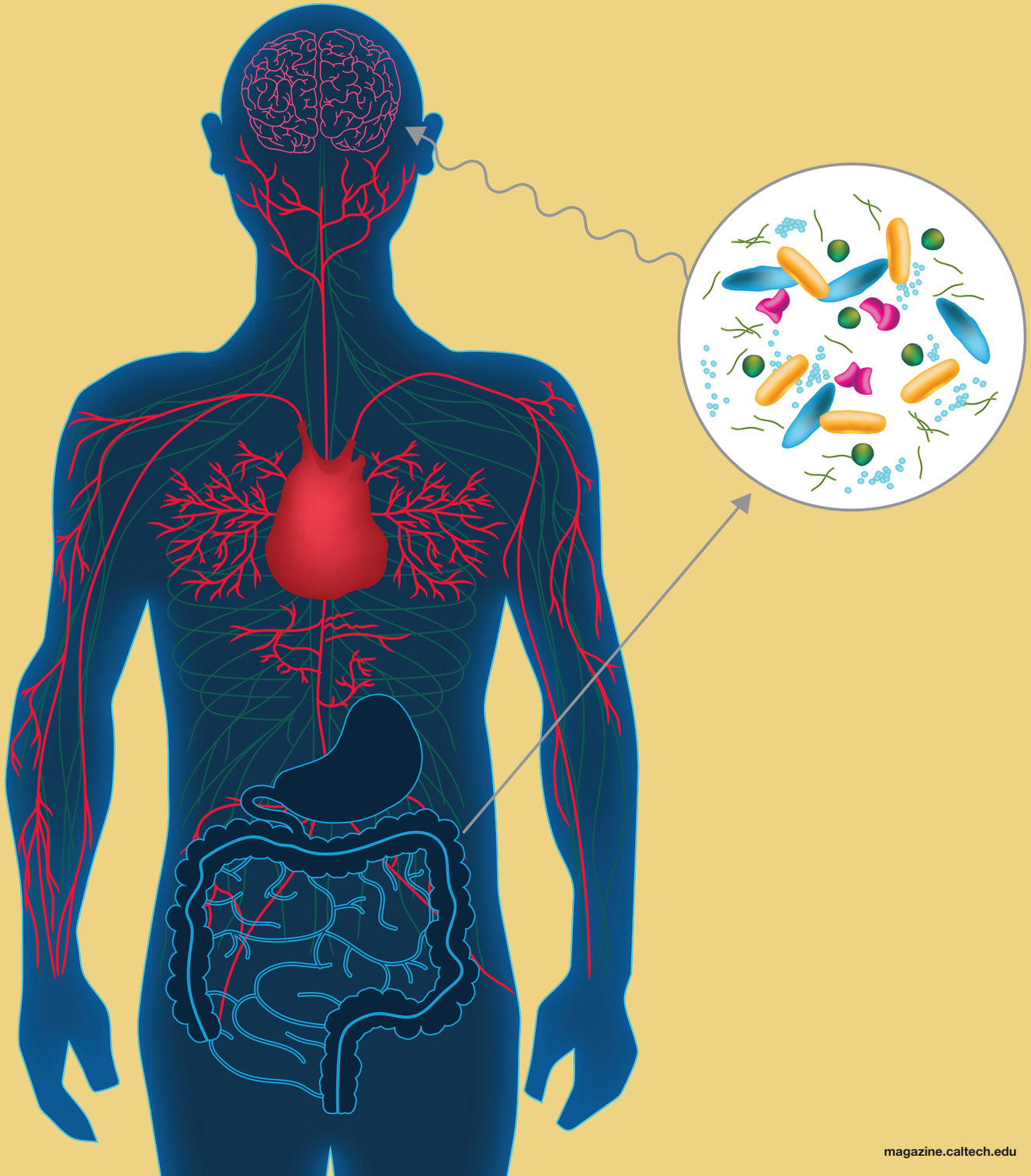
What made the difference? Further experiments suggested it could be molecules called short-chain fatty acids (SCFAs)—produced by gut microbes when they break down fiber in the gut—interacting with the overabundance of alpha-synuclein. When the germ-free mice (who produced no SCFAs since they had no microbes) were fed SCFAs, they began to show Parkinson's symptoms again.

The researchers also confirmed that, in order to stay symptom-free, the mice need to stay free of germs ... but not of all germs. While mice given samples of the microbes found in the feces of human Parkinson's patients again began to show Parkinson's symptoms, microbe samples from healthy humans had no such effect.

"[T]he fact that you can transplant the microbiome from humans to mice and transfer symptoms suggests that bacteria are a major contributor to disease," Mazmanian says. Next up: trying to figure out which bacteria are a problem, and which are innocuous.

For more on the hows and whys of this intriguing gut-brain connection, check out the original story and its accompanying short video at **caltech.edu/news/parkinsons-disease-linked-microbiome-53109.**

This research was funded by the Larry L. Hillblom Foundation, the Knut and Alice Wallenberg Foundation, the Swedish Research Council, Mr. and Mrs. Larry Field, the Heritage Medical Research Institute, and the National Institutes of Health.



LIMITLESS

Whether they're hanging off a rock face or hanging ten atop a wave, Caltech and JPL scientists seem drawn to hard-core sports. Meet five of our most intrepid adventurers.

by Judy Hill

A rock-climbing biologist. A JPL research scientist who unicycles up mountains in her spare time. An Earth scientist turned ultramarathoner.

Caltech is home to extreme athletes of every stripe, from runners to surfers to enough rock-jocks to support an active Alpine Club, whose members—mostly graduate students, postdocs, and faculty—gather regularly to plan trips, talk about technique, and watch rock-climbing movies.

What is it about feats of physical daring and endurance that calls so irresistibly to the science-and-engineering minded? Meeting just a sample of the hard-core competitors at Caltech and JPL provides a tantalizing glimpse of why the highest peaks and the longest trails beckon to those who otherwise spend their lives in labs.

Riding the Crest
Rob Phillips

› Fred and Nancy Morris Professor of Biophysics and Biology

› Surfer, mountaineer, snowboarder

Phillips grew up in San Diego close to the beach, so surfing is something he has been "doing forever," he says, noting that he feels most himself when he's in the ocean.

"Surfing is one of those weird sports that causes people to be obsessive. It's a dynamic environment. Every instant depends on the tide, the wind, the swell. To be in the ocean and to be a part of the ocean when it's doing its thing is really so cool."

Still, he says, "as I've gotten older, I'm a bit more grumpy in the water." So, last year, Phillips traveled to Alaska to find his surfing sweet spot. "I try to go places where there's no one else. In Alaska I found a place never surfed by anybody." He has also sought surf nirvana in Sumatra, the Maldives, Biarritz, and—closer at hand—off Carpinteria State Beach in Santa Barbara County.

Pushing Past
Far left: Rob Phillips seeks surfing solitude in the Maldives. Kai Zinn, at left, shows his Caltech pride atop Tibet's Cho Oyu, with Everest in the background. Previous page: JPL scientist Susan Owen finishes the Angeles Crest 100.

On the connection between sports and science, Phillips says, "One of the things I notice about the people I admire the most in science is that they're still in touch with a childlike enthusiasm, an intensity, a curiosity."

Born to Climb
Kai Zinn

› Professor of Biology

› Rock climber, mountaineer, mountain biker

Zinn spent his childhood in Los Alamos, New Mexico, where cliffs rise up right at the edge of town. As a graduate student at Harvard, Zinn climbed frequently in New Hampshire with his then-girlfriend (and now wife), Pamela Bjorkman, Caltech's Centennial Professor of Biology. After moving to California to become a Stanford postdoc, Zinn began tackling the big rock faces of Yosemite.

But when Zinn arrived at Caltech in 1989 to set up his lab, climbing took a back seat. With the advent of "sport climbing" in the '90s—in which permanent bolts on a cliff face mark the route—he found his way back to the sport. "With that kind of climbing, you could go out with the family and bring the kids along," he notes.

For a while, Williamson Rock in the San Gabriel Mountains was a popular spot for Zinn and his colleagues, who would get up at 5 a.m. once a week, climb for four hours, and make it back to campus by the afternoon.

When that rock was closed in 2005 to protect an endangered species of frog, Zinn found other climbs in Joshua Tree, around Bishop, and at a rock quarry in Riverside.

Today, although he climbs outdoors less—"There aren't really any other people my age who do this stuff," he laments—Zinn still visits the downtown LA Boulders rock gym three times a week. And, last year, he ascended Tibet's Cho Oyu, the sixth-highest mountain in the world.

The appeal to a scientist, he says, is obvious. "Climbing is a way to focus your attention entirely and intensely on one thing. Also, a climb is like a puzzle. When you rehearse a move, you're creating an engram—a sequence of muscle movements, stored in the motor cortex or premotor cortex."

Breaking the Century
Susan Owen

› Earth Science Deputy Section Manager, JPL

› Ultramarathon runner

Though Owen had run for exercise all through college and graduate school, she did not enter her first marathon until she moved to Los Angeles after earning her PhD from Stanford. She's been distance running ever since, signing up for her first 50K race in 2007 and her first 50-mile race in 2011, and completing the Angeles Crest 100, a 100-mile endurance run, in 2015.

For her 100-miler, Owen trained from November through August. "A lot of evenings, I was going down to the Rose Bowl and running around there, and weekday mornings I'd get up and go running with our dog on the trails behind Descanso Gardens. If I had time in my work schedule I'd run up the Arroyo right behind JPL too, or around Hahamongna Park. But the bulk of my training was long runs on weekends, where I'd run in the San Gabriel or Santa Monica mountains for many hours."

The Angeles Crest run follows the Pacific Crest Trail over the San Gabriel Mountains and ends in Altadena's Loma Alta Park. Halfway through, runners can pick up a friend to pace them as they run. Both of Owen's pacers were from JPL, one of whom ran through the night with her in the Angeles National Forest. After 32 hours and 40 minutes, an exhausted but triumphant Owen crossed the finish line.

As a geophysicist, Owen analyzes data from space to better understand earthquakes here on Earth. Much of that work involves sitting at a computer. "Running involves a lot more movement," she says. "Another thing I find appealing is the linear relationship between the time you put into training and the result. As a scientist, there's a lot of uncertainty. But if I put in 45 minutes running, I know what the result will be."

Perfect Preparation
John Doyle

› Jean-Lou Chameau Professor of Control and Dynamical Systems, Electrical Engineering, and Bioengineering

› Runner, cyclist, record breaker

Doyle's athletic résumé is almost as impressive as his scientific one. In 1994, he won the speed time trial in the International Human Powered Vehicles Association championship in Eureka, California. That year he also broke the world record in indoor rowing at the World Masters Games in Brisbane, Australia. Over the years, he has finished first in triathlons in San Bernardino, Santa Barbara, and throughout California. Duathlon wins include Chicago's Powerman Sprint, the Sundgau in northern France, and the Big Bear Duathlon, among others.

Still, he has been beset by injuries throughout his athletic career. "Broken bones, torn rotator cuff, ankles totally shot, back's a wreck. I'm sufficiently injured now that I'm just rehabbing all the time. I have a world-class nervous system in terms of speed, but it's connected to a relatively weak body, which easily breaks."

In fact, although Doyle played football in high school and basketball in college, and as a child hoped to be a professional athlete, he deems his athletic career a disaster in the sense that he never had a season in which he was not badly hurt and consistently made mistakes despite his natural talent.

Because of this tendency toward injury, Doyle has reduced his daily workouts from three hours a day to two. "I live a mile from the downtown Equinox," he says, "so in the morning and evening I run there and back, and when I'm there I lift weights and use machines and stuff. I work around my injuries."

In the end, though, he says all the effort and pain might have been worth it, and a perfect preparation for his scientific career. "Athletics let me experience a lot of failure in things I cared about, and that was probably healthy for me as an intellectual," says Doyle. "When you get into research it's like that—you're mostly wrong most of the time. At least I am."

Falling Hard
Morgan Cable

› Research Scientist, JPL

› Mountain unicyclist

While an undergraduate, Cable spent a summer as an intern at JPL, where she met fellow intern Josh Schoolcraft, who had brought a unicycle with him. "It didn't look like a normal unicycle," says Cable. "It had a tall, fat tire and a handle in front."

Schoolcraft explained that it was a mountain unicycle; Cable, intrigued, asked for lessons and caught on quickly. Nothing, she says, could have prepared her for such an extreme workout. "Falling is part of the deal, too. When you're pushing yourself by trying difficult terrain, sometimes gravity wins."

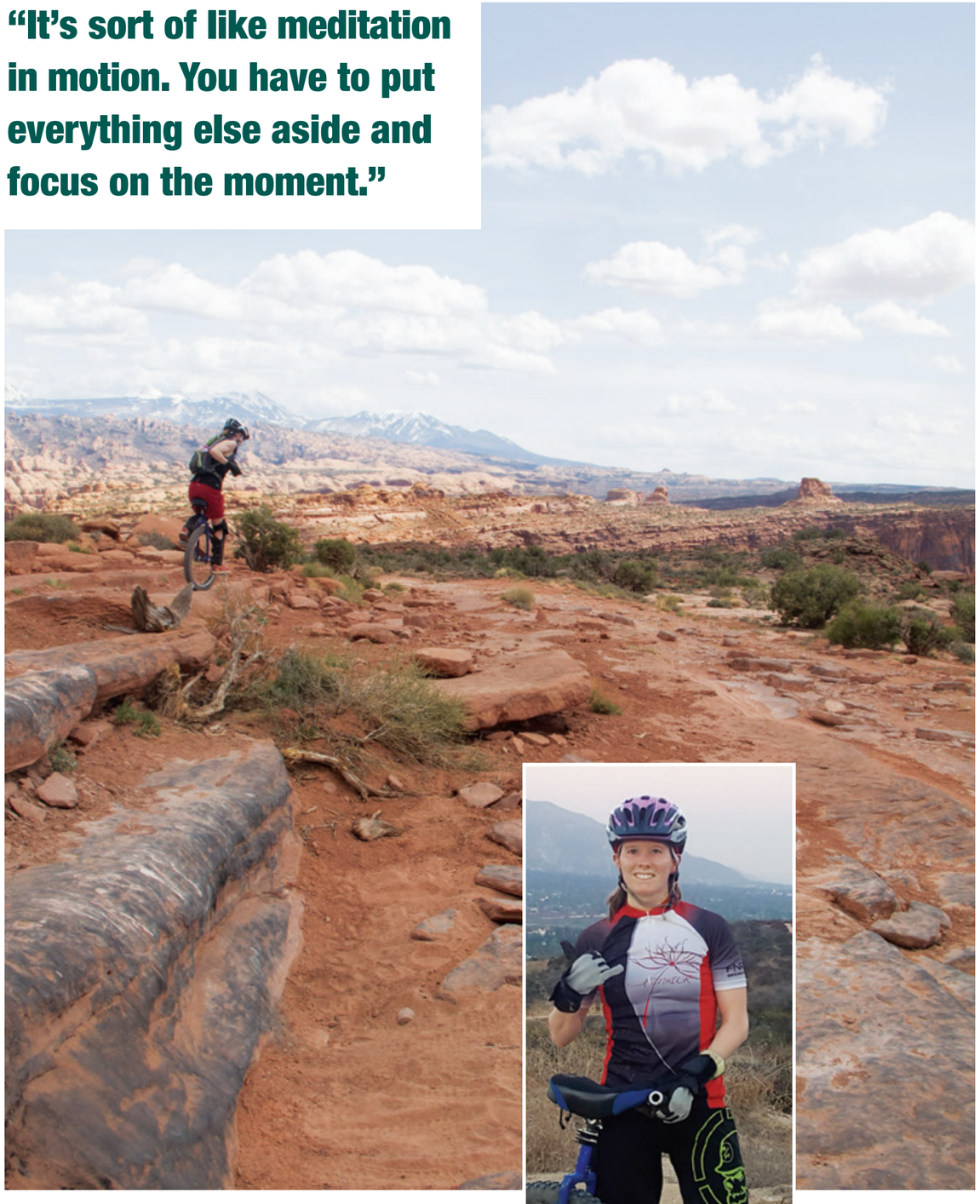
Still, she says, "it's a lot of fun because of the other people who do it. It reminds me of what surfing must have been like when it started out—a group of people doing a crazy thing no one thought possible."

Cable takes to the trails behind JPL as well as at nearby Cherry Canyon and up the coast near Santa Barbara. Once a year she and Schoolcraft—who married in 2011—make the trip to Utah for the annual Moab Munifest. "Ninety percent of everyone who does the sport—about 50 or 60 people—converge for a long spring weekend," she says.

Cable, who counts many engineers among her unicycling peers, says the sport appeals to "intense people who like things that require their full attention and like to push themselves. It's sort of like meditation in motion. You have to put everything else aside and focus on the moment. If you don't, you'll fall."

Trail Ride
JPL scientist Morgan Cable (right) heads to Utah once a year to hit the trails on her mountain unicycle and take part in the Moab Munifest.

"It's sort of like meditation in motion. You have to put everything else aside and focus on the moment."



Out of the Lab, Into the Studio

Teagan Wall (PhD '15)

Teagan Wall (PhD '15) recalls watching Bill Nye the Science Guy *on television as a child growing up in Tempe, Arizona, enthralled by the scientist's fast-paced demonstrations. Fifteen years later, with a doctorate in computational and neural systems from Caltech in hand and a budding career as a science communicator, Wall had what she calls the "strange and exciting experience" of not only meeting Nye, but working as a writer on his new Netflix show,* Bill Nye Saves the World, *which began airing this spring.*

Wall's journey to the writer's room has been circuitous. As an economics undergraduate at the University of Arizona, she became interested in the biological and physical questions explored by neuroeconomists, who study human decision making as part of a field Caltech helped to establish. She eventually found a niche in the Caltech lab of Henry Lester, Bren Professor of Biology, studying nicotine addiction.

It was through her participation in Caltech's theater program, however, that Wall began to connect her passion for science with its performance aspect; in 2014, she and fellow alum Crystal Dilworth (PhD '14) brought those worlds even closer by cofounding the Nerd Brigade, a group of LA-area science communicators who use the tools of "edutainment" to engage the public in scientific storytelling.

Since receiving her Caltech degree, Wall has appeared as an expert on the TV shows How to Build Everything *and* Xploration Fab Lab. *Her work with Nye completed, she is currently writing for PBS's* BrainCraft, *a video series on YouTube that aims to explain "psychology, neuroscience, and why we act the way we do."*

Wall recently reflected on what she calls the "dream come true" of working with her scientific hero.

In person Bill Nye is exactly who you expect him to be. He is a science teacher in every situation. The second time I met him, he brought in a slide rule and spent probably an hour trying to teach me how to use it.

He will be able to tie almost anything you say back to a cool science demonstration that you "just have to see right now." He'll produce a balloon that gets sucked into a bottle out of thin air to show you how the universe works. Everyone in the entire room stops whatever they're doing to watch Bill demonstrate whatever science he's brought in that day.

During one meeting with Bill I made a joke about how my pocket should be in the Navy because of all the knots it knows how to tie in my headphones. Bill immediately went and got some pieces of string and, for the rest of the meeting, any time our show runner was out of the room, he would teach us how to tie different knots. It was both very informative and sort of frustrating because you're actually trying to write a TV show.

This show targets an older age group: the people who watched Bill Nye's show when they were kids and who are now adults and still interested in science, but are maybe interested in more of the political or socioeconomic issues that often collide with science. It's a scientific take on what you'll see in the news, but it's also a political, socioeconomic, and comedic take on what we're seeing in science.

Netflix built a giant, amazing lab set for us. It was like Bill was a kid in a candy store. The show has science demonstrations, things moving, things on fire, and lots of biology happening under a microscope.

The demonstrations were actually one of my favorite parts. I wasn't the only PhD to work on the show, but I

was the only PhD in a lab-science field. The head writer on the science side was Dr. Phil Plait, also known as the Bad Astronomer, whose research is all in astrophysics and astronomy, so a lot of the demonstrations that we did were actually designed by me and Bill. They had to be informative, quick, and look really, really cool. We only had one that didn't work, and we were able to fix that with lighting.

I started on the show as an associate producer and was in the writer's room helping the science team do research. About four weeks in I was pulled aside by one of the other writers and asked to write an actual segment for the show. A few weeks after that I was pulled in to our show runner's office and Bill, who was on Skype, asked me if I would like to be a full writer on the show. It was beyond anything I could have hoped for.

I'm really excited for the show to come out and for people to see it and hopefully love it so that I get to do it all again next year. I also want to continue to find ways to discuss science with the public in a way that's fun for me and productive for the people taking in that content, whether that's doing stuff in front of the camera or continuing to write for other people.

I also plan to continue to take in as much science-communication content as I can, making it clear to people in Hollywood and in positions of power that science is something that people love, that is wonderful and helpful, and that we want more of in our lives.

— As told to Crystal Dilworth (PhD '14)

Jupiter's 'String of Pearls'

This image, taken by the JunoCam imager on NASA's Juno spacecraft, highlights the "string of pearls" on Jupiter—massive counterclockwise rotating storms that appear as white ovals in the gas giant's southern hemisphere. Since 1986, these white ovals have varied in number from six to nine. There are currently eight white ovals visible.

The image was captured on December 11 as the Juno spacecraft performed its third close flyby of Jupiter. At the time the image was taken, the spacecraft was about 15,300 miles from the planet. Juno, which launched from Cape Canaveral, Florida, in August 2011, arrived at Jupiter on July 4, 2016.

JunoCam is a visible-light camera designed to capture pictures of Jupiter's poles and cloud tops. As Juno's eyes, it affords a wide view, helping to provide context for the spacecraft's other instruments. JunoCam was included on the spacecraft specifically for purposes of public engagement; although its images will be helpful to the science team, it is not considered one of the mission's science instruments.

For more information on Juno, visit **www.jpl.nasa.gov**

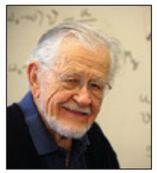
An image from the JunoCam imager of massive rotating storms in Jupiter's southern hemisphere.

In Memoriam

To learn more about their lives and work, visit **magazine.caltech.edu/post/in-memoriam**.

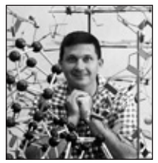
Rolf H. Sabersky 1920–2016

Rolf H. Sabersky, Caltech professor of mechanical engineering, emeritus, passed away on October 24, 2016, at the age of 96. Sabersky made pioneering contributions to our understanding of boiling heat transfer, free convection, granular flows, and indoor air quality.



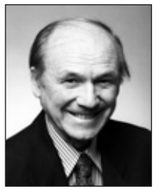
John D. Roberts 1918–2016

John D. ("Jack") Roberts, Institute Professor of Chemistry, Emeritus, at Caltech and former provost, passed away on October 29, 2016, at the age of 98. Roberts was a pioneer in the field of physical organic chemistry, bringing nuclear magnetic resonance (NMR) spectroscopy to the field.



Richard Marsh 1922–2017

Richard Marsh, senior research associate in chemistry, emeritus, at Caltech, passed away on January 3, 2017, at the age of 94. Marsh was a crystallographer, and a colleague, mentor, and friend to generations of scientists.



Anatol Roshko (MS '47, PhD '52), 1923–2017

Anatol Roshko, Theodore von Kármán Professor of Aeronautics, Emeritus, at Caltech, passed away on January 23, 2017. He was 93 years old. Roshko was known for his research in several areas of gas dynamics and fluid mechanics.

Harold Rosen (MS '48, PhD '51), 1926–2017

Harold Rosen, known as the father of geostationary satellite communications, passed away on January 30, 2017. He was 90. Rosen formed and led the team that designed and built the first geosynchronous communications satellite, Syncom, for Hughes Aircraft Company.

Neil Gehrels (PhD '82), 1952–2017

Neil Gehrels, a Caltech Distinguished Alumnus who earned his PhD in physics in 1982, passed away on February 6, 2017, at the age of 64. Gehrels was a pioneer in the study of gamma-ray bursts, which are blasts of high-energy radiation that come from deep space.

Warren G. Schlinger (BS '44, MS '46, PhD '49), 1923–2017

Chemical engineer Warren G. Schlinger, a pioneer in developing processes to produce clean energy from fossil fuel, passed away on February 10, 2017, at 93 years old. Caltech's Warren and Katharine Schlinger Laboratory for Chemistry and Chemical Engineering was named in honor of the Schlingers.

Stephen A. Ross (BS '65), 1944–2017

Stephen A. Ross, an alumnus and senior trustee at Caltech, whose work helped shape the development of the field of financial economics, passed away on March 3, 2017. He was 73 years old. Ross was perhaps best known for his arbitrage pricing theory and agency theory.

Ronald W. P. Drever 1931–2017

Ronald W. P. Drever, professor of physics, emeritus, at Caltech, passed away on March 7, 2017, in Edinburgh, Scotland. He was 85 years old. Drever was co-founder of the Laser Interferometer Gravitational-wave Observatory (LIGO), which made the first-ever observation of ripples in the fabric of space and time.

Endnotes

We asked alumni: What's the one thing every Caltech student should do or see or experience before graduation?

Walk slowly down the halls of the Athenaeum when you dine with professors, and consider the genius, from Anderson to Zewail, that walked ahead of you.

Tanya Schlusser (BS '99)
BRIDGEVIEW, IL

Zuma beach.

Ryan Zeidan (PhD '07)
CHATHAM, NJ

Experience an activity through the Caltech Y: a speaker, a hike, tutoring, or Make-a-Difference Day.

Michael Stefanko (BS '70)
WEST COVINA, CA

Get away from the lab, at least for a moment, to spend some time in nature. This may be your last chance before you enter the real world.

Paul Gazis (BS '76)
MOUNTAIN VIEW, CA

See the LA Basin from Mount Wilson on a clear night.

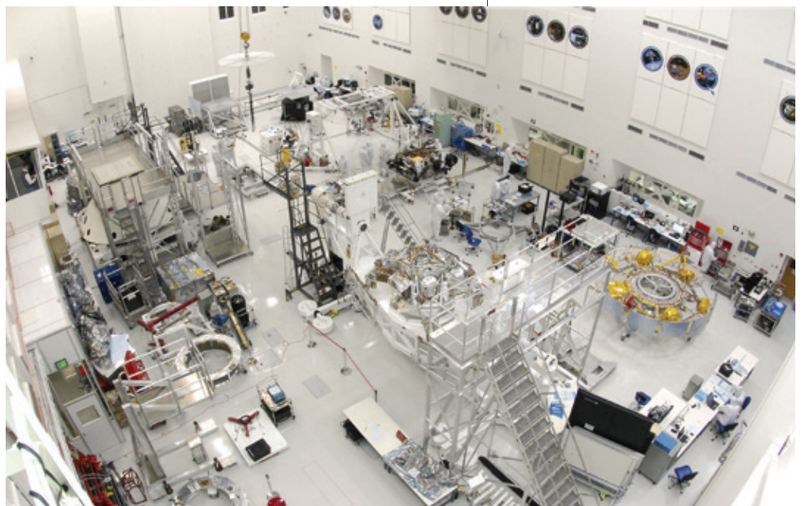
Phil Neches (BS '73, MS '77, PhD '83)
SUMMIT, NJ

Eat at Ernie's food truck!

Henry Ngo (PhD '17)
PASADENA, CA

JPL. Work there, meet their people, or at least tour the place. Ain't nothing like it nowhere!

Saif Hussain (BS '78)
WOODLAND HILLS, CA



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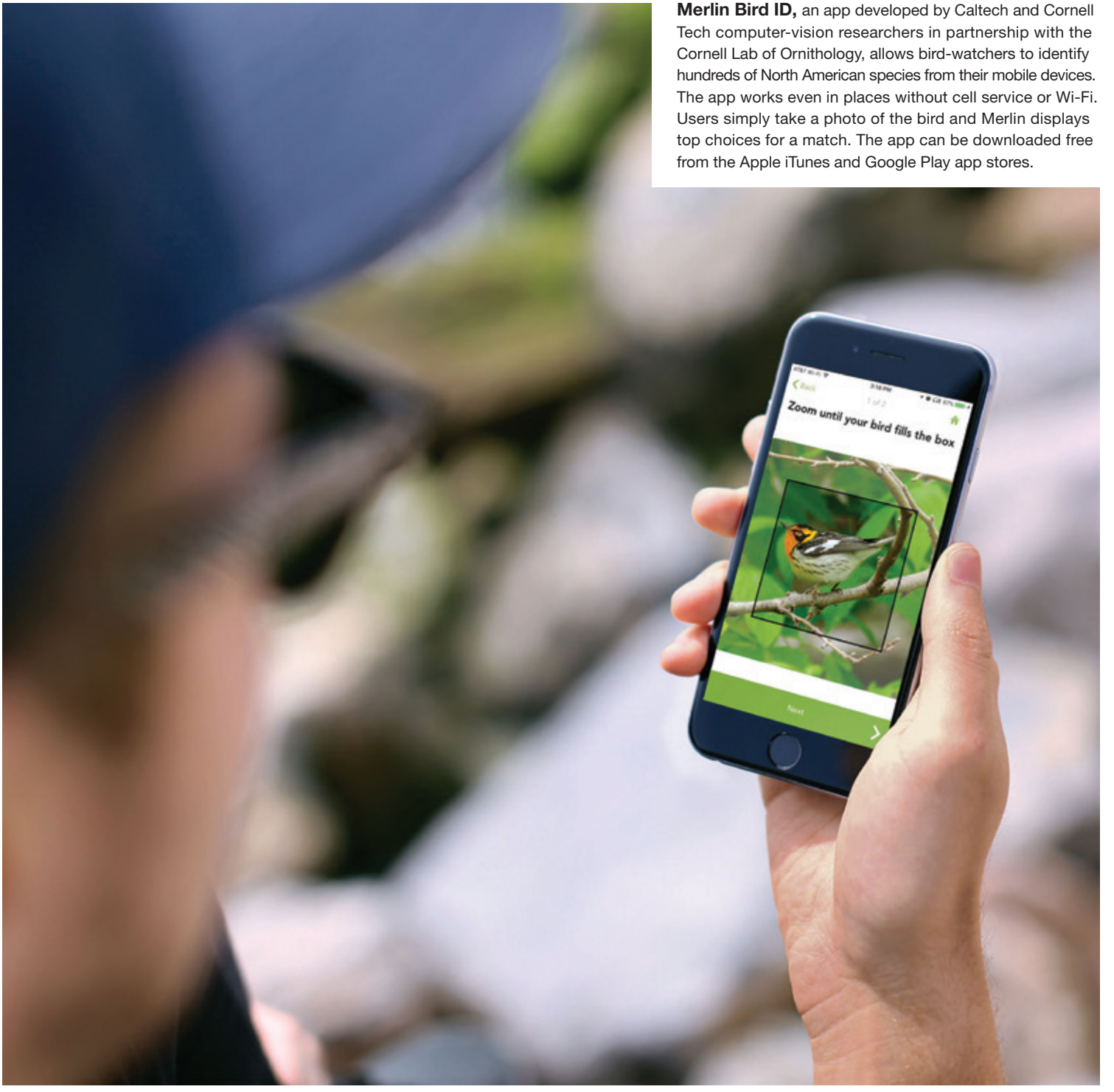

Merlin Bird ID, an app developed by Caltech and Cornell Tech computer-vision researchers in partnership with the Cornell Lab of Ornithology, allows bird-watchers to identify hundreds of North American species from their mobile devices. The app works even in places without cell service or Wi-Fi. Users simply take a photo of the bird and Merlin displays top choices for a match. The app can be downloaded free from the Apple iTunes and Google Play app stores.