Pushing the Limits
of Engineering Education and Research

A key ingredient of the celebrated Caltech culture is the student body. To gain insight into the current student experience at Caltech, *ENGenious* sat down with 14 students who have chosen to get their degrees from the Division of Engineering and Applied Science. Two were selected from each of the seven EAS departments. For the three departments with the largest number of undergraduate students, Computing and Mathematical Sciences, Mechanical and Civil Engineering, and Electrical Engineering, one of the students chosen was an undergraduate and the other was a graduate student.

All the students shared a passion for research and excitement about the unique opportunities in the EAS division to work closely with faculty and interdisciplinary research groups. The students are involved in a broad range of research, including packaging big antennas into small satellites, designing color-splitting optics, modeling the behavior of large groups in social media, developing ultra-low power systems for medical devices, studying the critical moments when earth structures move, understanding the role of single-cell eukaryotes in climate change, building new oxygen-delivery systems for hypoxic cells, and using carbon nanotubes in seawater desalination.

Caltech has also created many opportunities for the students to contribute to companies and startups, including hedge funds, a Japanese company making spider-fiber composites, SpaceX, and Northrop Grumman. This experience has encouraged some to become entrepreneurs and others to join larger and more established companies where they can push the limits of technology and innovation.

Furthermore, the intense yet intimate Caltech culture has allowed the students to get involved in an equally diverse set of activities. Several are advocates for STEM education in underserved communities, some are engaged in science policy at the state and national level, and others are contributing to the arts as members of the Caltech orchestra and chamber music society.

As you read the following student profiles, we encourage you to share your thoughts and impressions with us at engenious@caltech.edu.

Arnold Durel Deffo Nde

Graduate Student: Aeronautics

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

Arnold Durel Deffo Nde grew up in Central Africa, and studying at Caltech was a longtime dream. While still in high school in Cameroon, he met a JPL fellow from Mali who told him about JPL and Caltech.

The connection stuck. When Deffo Nde went to the United States for college to study aeronautical engineering, he began at Wichita State University in Kansas. "But I always wanted to go to grad school," he says, "and when it came time to apply for grad school, Caltech was the first school that came to mind. Thankfully, I was admitted. So here I am today."

Deffo Nde, who is now conducting research in materials science and specifically in dislocation dynamics with Professor Michael Ortiz, learned a crucial lesson early in the talent-rich Caltech environment. "You have to accept the fact that other people at Caltech are better than you in some aspects. And instead of looking at it in terms of competition, you must accept it and go to them if you need help. Caltech also made me realize that science is usually done as a collaborative effort."

The Caltech engineering approach was also different, he found. "At Caltech it's still engineering, but engineering at the more fundamental level. Caltech prides itself in dealing with fundamentals. The depth to which professors go is something that makes Caltech quite different from the experience I had as an undergrad."

The professors are only part of the Caltech difference. "In grad school, it's all from within," Deffo Nde says. "You must be willing to make that effort, because no one is forcing you to go read those extra papers. This not only makes research very rewarding but also makes you a better-rounded person, because you have knowledge of all the other aspects."

Deffo Nde had critical help in getting from his city of Douala in Cameroon to the United States. As a senior in high school, he placed first in the Cameroon national graduation examination, which led to a newspaper article that brought him to the attention of a nearby entrepreneur and philanthropist, Bernard Fokou, who gave him a scholarship to go abroad for his education.

He is still grateful, and he is giving back by working with Base 11 students interning at Caltech. The nonprofit partners with Caltech to train the next generation of leaders in STEM (science, technology, engineering, and mathematics) from underserved communities. Deffo Nde finds this work very gratifying, and he is proud to report on the progress of one of the Base 11 students he has worked with: the student is now headed for the University of California, Riverside. ENG

What languages do you speak?
Besides English, I also speak French and Bansoa, the latter being my mother tongue.

What is your favorite online activity?
Playing the soccer video game FIFA online with friends.

What is your favorite story?
L'Enfant Noir by Camara Laye. It's an autobiography by an African writer that reminds me of my own story in many respects.

What is your favorite destination?
Douala, Cameroon (of course)!

What languages do you speak?
English and Russian

What is your favorite online activity?
Browsing travel photography

What is your favorite story?
"The Rocket" by Ray Bradbury

What is your favorite destination?
New Zealand

Maria Sakovsky

Graduate Student: Aeronautics
Advisor: Sergio Pellegrino, Joyce and Kent Kresa Professor of Aeronautics and Professor of Civil Engineering; Jet Propulsion Laboratory Senior Research Scientist

Maria Sakovsky engineers twenty-first-century origami structures. She works in Professor Sergio Pellegrino's lab on components that can unfold from compact packages to form large space structures of complex shapes. She is also a Keck Institute for Space Studies graduate fellow.

Her research is developing novel deployable antennas for small satellites. The idea is to pack big, very-high-performance antennas into very small volumes. Elegantly folding them up stores strain energy so they unfold themselves autonomously. "We're able to get a lot more data back, and this is a very efficient way to get into space, so everybody's excited about the technology," Sakovsky says. "We are pushing the communications envelope."

Sakovsky has had the opportunity to work with prototypes in numerous venues. "I actually got to go to Albuquerque last year to take one of these antennas into their anechoic chamber, where we measured the performance of the antenna. We put the antenna on one end and the receiver on the other end. We then attached the antenna to a CubeSat and rotated it to measure its performance in all directions."

Sakovsky, who was born in Russia and later lived in Israel and Canada, came to Caltech from the University of Toronto, where she became passionate about aerospace. When she arrived at Caltech, she needed to deepen her understanding of electrical engineering. "At first I was terrified, because circuits and any electrical engineering was outside of my comfort zone, but I was pleasantly surprised to learn more about the interaction between electrical engineering and structural engineering, and that's now what I do," she says.

When not folding and unfolding antennas, Sakovsky reaches out to an extended Caltech community. "I really love working with the Caltech Y on the Rise tutoring program for high school kids," she says. "I get to work with students who are struggling with math and science. I find this work to be a lot of fun because the students ask very good questions, and they get so excited when they hear that a tiny little math equation that they're working on can be applied to building spacecraft. Then they start asking even more questions." ENG

Evan T. Miyazono

Graduate Student: Applied Physics
Advisor: Andrei Faraon, Assistant Professor of Applied Physics and Materials Science

Evan Miyazono is a graduate student in applied physics and spent multiple summers as an intern at Northrop Grumman before coming to Caltech. He has worked on various electrical engineering, data processing, and hardware testing problems, as well as on the setup for thin-film research. He explains, "I learned a lot about how engineering is done in industry, and to a large extent, it motivated me to apply to PhD programs."

His research with Professor Faraon at Caltech centers on optical storage of quantum information using rare-earth atomic dopants, a complex problem that requires wide-ranging expertise, including software engineering, nanofabrication, optics, vacuum systems, and even, occasionally, plumbing. To Miyazono's surprise, he has found all of this expertise among his own group members. He recently scored a breakthrough in this cooperative environment while working with his graduate student mentee, Ioana Craiciu. Miyazono says, "We have made devices for coupling to rare-earth dopants using electron beam lithography techniques. This allows us to scale our coupling platform to easily make arrays of interconnected devices. Our previous work used focused ion beam devices, which were individually sculpted by what could be described as sandblasting with gallium ions. Our new devices are a big step forward!"

He has an anecdote to share about the Caltech attitude toward learning: "I had a friend who told me that they absolutely loved getting the book for a class, opening it up to almost the last page, and just staring at what was basically incomprehensible and thinking: I'm going to understand this book in 10 weeks or a year. I love that. I love that classes are really a great excuse to better yourself without any sort of external metric for success."

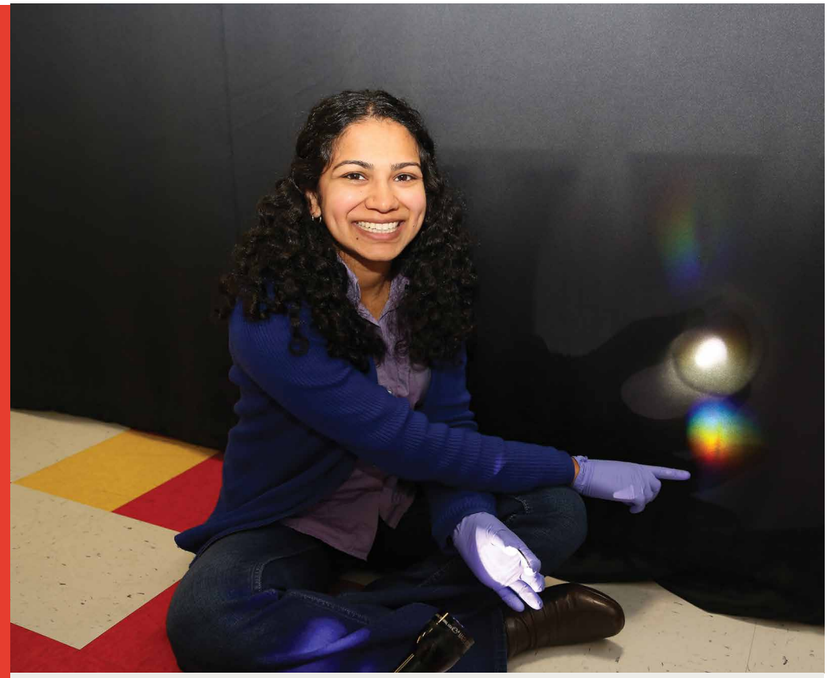
Miyazono also enjoys STEM outreach, and he fondly recalls a recent trip funded by the Institute for Quantum Information and Matter (IQIM) to the Navajo Preparatory School in Farmington, New Mexico. Between his planned lectures to physics classes, Miyazono visited some of the school's math classes. "I just sat at the front of the room and answered the age-old math student's question, 'When will I ever use this?' And I had answers! This led to an impromptu lecture about the properties of ellipses and parabolas and the applications of conic sections from orbits to optics. It was really fun to improvise and get the students enthused about the subject. I will try to go back before I graduate from Caltech." ENG

What languages do you speak?
I'm a native English speaker, can read and hold a slow conversation in Spanish (took four years in high school), and have been recently trying to learn German, because I thought it would be fun.

What is your favorite online activity?
Reading articles on politics, economics, sociology, and the occasional popular science article from a variety of sources, ranging from the *Guardian*, the *New Yorker*, and the *Economist* to *Wired*, *Medium*, and *TechCrunch*.

What is your favorite story?
God's Debris by Scott Adams or *The Martian* by Andy Weir (honorable mention to Andy Weir's short story "The Egg"). I'm convinced stories are one of the best tools humanity has to foster empathy, and I also love optimistic stories that show potential worlds that people actually want to live in; the first step in engineering an improvement is believing that things can improve.

What is your favorite destination?
The nearest uncrowded beach with clear water, sunny skies, and good surf.



Sunita Darbe

Graduate Student: Materials Science
Advisor: Harry Atwater, Howard Hughes Professor of Applied Physics and Materials Science; Director, Joint Center for Artificial Photosynthesis

Sunita Darbe is a graduate student who found her way to the stage at the most recent Caltech presidential inauguration, where she sat next to Nobel Prize winners.

Darbe's research focus is on designing color-splitting optics. "Sunlight is broadband white light," she says, and a solar cell with a single absorber material is most efficient at extracting power from a narrow color range of sunlight. So her devices separate the incoming colors, sending them to different solar cells with different absorber materials.

Darbe has been working on the project in Professor Harry Atwater's laboratory since soon after her arrival at Caltech in 2011 with a BS from MIT and a master's degree from France's École Polytechnique. Seven Atwater students cooperated in writing the initial proposal for her research focus the summer after her first year. The team has stayed together as the project has moved all the way from fundamental physics to fundraising and financing. It has been a great learning experience for her.

In the meantime, Darbe has become involved with the greater Caltech community. For the Graduate Student Council and other groups such as Women Mentoring Women, she frequently finds herself behind podiums, where her experience with the Atwater group has come in handy: "One thing that Harry emphasizes quite a bit is oral presentation skills."

One notable occasion was when she represented Caltech graduate students at the inauguration of President Thomas Rosenbaum in the summer of 2014. "Speaking in front of a thousand people from a script is a very different thing than giving a conference talk in front of even 50 or 100 people," she says. Despite a moment when she lost her place in the script, she treasures the memory. "It was a very fun event to participate in. I got to sit up on the stage next to Nobel laureates from Caltech and the past president," including David Baltimore and Thomas Everhart.

In addition to presentations she is organizing, Darbe has started an Applied Physics and Materials Science student group with the department's executive officer, Professor Kerry Vahala. Beyond Caltech, she is interested in being part of the technology pipeline between more fundamental research and technologies that are impacting the world. "I want to spend my career on that trajectory, to be part of the whole process," she says. "I think, moving forward, it's going to be smaller pieces at a time, but I'm excited about a career bringing new technologies into the world. Right after graduation, I will start working in Japan with a company called Spiber Inc. that is commercializing spider silk. Specifically, I will be working on developing spider-fiber composites." ENG

What languages do you speak?
English, French, some Telugu, and I've just started learning Japanese for my new job!

What is your favorite online activity?
I'm a big fan of streaming podcasts. I just started listening to *More Perfect*, about significant Supreme Court cases.

What is your favorite story?
A new one!

What is your favorite destination?
My hometown, Edmond, Oklahoma.

Carlos A. Pérez-Arancibia

Graduate Student: Applied & Computational Mathematics
Advisor: Oscar Bruno, Professor of Applied and Computational Mathematics

Carlos Pérez-Arancibia came to Caltech from Chile because he knew exactly how and what he wanted to study. He had also identified the best place and person to learn from. "I came to work with Oscar," he says. "I have Oscar telling me, with all his characteristic passion, 'We're going to solve this problem! It's really hard, but we're going to do it.' That combination of intellectual ambition and determination to achieve something outstanding in terms of research is really hard to find anywhere else, I think. It is one of the best things Caltech has offered me."

Pérez-Arancibia's work is highly mathematical and abstract, and the resulting algorithms can be used to tackle a wide range of problems in different areas of science and engineering, such as electrical engineering, physics, and astronomy. It focuses on new, fast, high-order integral equation methods for solving PDEs (partial differential equations). "PDEs come from physical models most of the time," he explains. "That's why I got involved with this particular branch of mathematics—because I love physics."

The current state of the art of integral equation methods involves pushing beyond the general understanding of simple shapes to model intricate, real-world objects. "PDEs allow you to extract very detailed information about the physical world, as long as you take some of the complexity of the physical world into account in your model," he says. "To extract reliable information from a PDE, you have to develop efficient algorithms and implement them in the computer to then produce approximate solutions that you need to analyze, to make sure you're computing the right thing. This whole process is what excites me about applied math."

He offers the example of visualizing interior structures: "Let's say you have layers of various kinds of dielectric materials, and you're interested in solving the scattering problem they create when you illuminate them with an electromagnetic or acoustic wave. If you can solve this problem accurately and efficiently, you can extract very useful information. For instance, you can determine if there is an object buried underground, and, even more, you can theoretically determine the shape of that object and the materials it is made of by solving an inverse problem."

At Caltech, Pérez-Arancibia is relishing the experience of diversity in people and cultures. Chile, he notes, is a very "homogenous country. It has been wonderful to get to know people from all parts of the world. I have friends from Syria, India, Poland, Argentina, and Mexico. In fact, very few of them are born Americans. I think that's an experience that very few places can give you."

There is something, though, he's been missing: "I like philosophy, and I have not yet met anyone at Caltech who is interested in philosophy." But he will soon be moving on. "I accepted an offer from MIT. I'll be a postdoc in the math department starting this fall. I'm very excited about that," he says—and perhaps he will find philosophers in Massachusetts. ENG

What languages do you speak?
Spanish and English

What is your favorite online activity?
Get to know new bands, especially progressive rock and jazz

What is your favorite story?
"El Aleph" by Jorge Luis Borges

What is your favorite destination?
New York City

Nikita A. Sirohi

Undergraduate Student: Computing and Mathematical Sciences

What languages do you speak?
I speak English and some Spanish.

What is your favorite online activity?
My favorite online activity is going on food and travel websites.

What is your favorite story?
My favorite books are *One Hundred Years of Solitude*, the *Harry Potter* series, and *The Caine Mutiny*.

What is your favorite destination?
My favorite destination would be anywhere exotic, with new food to try and sights to explore.

Undergraduate student Nikita Sirohi enjoys finding unexpected connections, both engineering and human. Speaking of her computer science courses, she says, "I like classes where I can see different ideas coming together, where you approach a problem from very different angles, where you get similar insights from really different approaches."

She is applying that strategy to work on two very different problems: the behavior of subatomic structures, as in the search for dark matter, and the behavior of large groups of human beings in social media and financial markets.

She began working on dark matter with a Caltech team of 40 faculty and students associated with the research being conducted at the Large Hadron Collider (LHC) in Switzerland. While still a freshman, Sirohi helped to model particle collisions, seeing if the particle models predictably matched what was being found in the LHC.

Her other internship involved very different models, analyzing trade in commodity futures. "I was working with a Caltech alum and his partner at Crabel Capital, a quantitative hedge fund based in Century City, on creating an algorithmic trading system by analysis of a 20-year universe of daily and monthly data for 24 commodities futures markets," she explains.

She helped to develop two momentum-based strategies now close to implementation, a process that involved generating long and short signals signing certain moving averages. "I never really explored the world of finance before then," she says. "And it was amazing to understand how complicated it is and how the things I'm learning at Caltech are so applicable."

The Caltech environment has, according to Sirohi, allowed her to move out of the restrictive "girl science-math student" she felt like during high school in the suburbs of Seattle. "There weren't many others who were as interested in the things I am interested in," she says—but Caltech has allowed her to broaden her identity. "I define myself through different things because I now know so many people that are interested in the same things I am. It's allowed me to explore other parts of myself."

For example, she is now involved in student government and is a mentor. "This type of work never really occurred to me as something I would enjoy," she says. "But it's been very rewarding. It's taught me skills like how to manage my time and how to communicate effectively. I am now thinking much more about how I can do things for other people."

As for career plans, Sirohi says, "I think in the immediate future, I want to go into finance or the computer science industry. I'm not sure exactly what combination of finance and programming I would want to do. I'm hoping to figure that out and learn more about both fields this summer." ENG

Manuel Alejandro Monge Osorio

Graduate Student: Electrical Engineering
Advisor: Azita Emami, Professor of Electrical Engineering; EAS Division Deputy Chair

What languages do you speak?
Spanish and English

What is your favorite online activity?
Reading or watching reviews and news about technology and cars; following sports like NBA, swimming, soccer; watching Netflix

What is your favorite story?
Science fiction

What is your favorite destination?
Places near water, like seas, lakes, rivers

Manuel Monge Osorio is originally from Lima, Peru. He graduated first in his undergraduate university class in electrical engineering and won a Caltech Atwood Fellowship and US State Department Opportunity Grant that brought him to Pasadena.

At Caltech, he works with Professor Emami on advancing ultra-low power systems for novel implantable, wearable, and point-of-care medical devices. One of them is a fully intraocular epiretinal prosthesis that helps patients suffering from severe vision loss due to degenerative retinal diseases.

As he works toward his PhD, Monge Osorio is appreciating the compact academic and scientific power he finds characteristic of Caltech, as well as its focus on collaboration. "I do not take many classes as a graduate student, but there are still many opportunities to learn more about my area, and I get exposed to so many other fields," he says. He adds that his faculty mentors "really appreciate a student's interest to get to know other areas, because it makes their vision grow. Originally, coming here, I just wanted to learn more and deeply about electrical engineering. But now, I focus on how I can incorporate other ideas and approaches. You think about your research in the context of the greater goal rather than just yourself. You start looking into, 'How can I solve this particular problem in a better way?'"

Monge Osorio's approach is broadening. "I'm excited about biology, chemical engineering, applied physics, materials science, medicine," he says. "And when I see a class that relates to what I want to do in the future, I try to go and sit in on it."

One of his favorite Caltech traditions involves the Summer Undergraduate Research Fellowship (SURF) program, in which graduate students can serve as mentors to undergraduate students. He's been a mentor four times. "I'm very happy with the results," he says. "My first SURF student won one of the poster competitions. Now she's a very talented graduate student and my friend. I have also served as a SURF judge a few times."

He also enthusiastically participates in international-student orientation events. "It is great to share my own experiences and meet new students. I try to answer questions and provide some perspective about being new to this country, the academic life, and, in general, interacting with others," he says.

As for his next steps, he offers: "I would love to continue in academia. One of my goals is to become a professor, because I love doing research and mentoring students. Those are two things I want to keep doing throughout my career, no matter where it takes me." ENG

Aashrita Mangu

Undergraduate Student: Electrical Engineering

Aashrita Mangu came to Caltech from next door: her home is in South Pasadena, only a few miles from campus. She jokes, "My parents threatened to send me to Pasadena City College, but they chose Caltech because it was closer."

Mangu has found much to like at Caltech. "I chose Caltech because I feel there's a lot more opportunity to take classes across disciplines, which I do a lot. And then, on top of that, research opportunities at Caltech are a lot easier to get."

She also likes the Caltech approach: "I have so many friends in other schools, and they're caught up in rote-learning material rather than figuring out how to learn things quickly and how to apply them. That's one of the best things I learned at Caltech, and probably one of the most important life skills."

She has used this skill during her summers of research, first in applied physics at the Joint Center for Artificial Photosynthesis and then in high-energy physics at Fermilab. Next, she spent time at Princeton, where she did cosmic microwave background radiation research, building a user interface for a Fourier transform spectrometer. This year, she was at JPL doing avionics. "It's kind of interesting to work on flight hardware, because it is so different from the typical hardware I'm making at school."

Mangu is also a student leader and is the outgoing Institute of Electrical and Electronics Engineers (IEEE) student chapter president. She also served on the liaison committee between faculty and students, the Academic and Research Committee. "I loved going to meetings and hearing about what's going on around Caltech," she says. "You get to talk to some amazing people. You talk about what work they're doing, the sort of things they're interested in. It gets you inspired to do other things." Furthermore, she was on the Student-Faculty Committee for the electrical engineering department, where she led meetings and wrote a report on changes to the curriculum. "The faculty ended up implementing a few of them!" she reports.

As for what's next, Mangu says, "I'm going to take a year off before I go to graduate school. I hope to do a PhD in experimental physics. I'm definitely going to be doing research during that year, and I have a few options."

Wherever she goes, she'll carry with her the unusual, remarkable culture of the school a few miles from her home. "I think Caltech, precisely because outsiders label students as dorks or nerds, ends up being a tighter community. There are stereotypes with every school, but I really think that Caltech has some of the sweetest people you'll ever find and also some of the most humble." ENG

What languages do you speak?
I speak Hindi and English. I can also understand some Telugu, I took Chinese (Mandarin) in high school for three years, and I took a year of German this past year.

What is your favorite online activity?
I'm not really sure I have a favorite online activity—usually I'm online to waste time, so it never really feels too good afterward.

What is your favorite story?
I have so many favorite stories, and most of them come from Indian history! I'll choose the *Mahabharata* because it's so intricate—there are stories within stories within stories.

What is your favorite destination?
My favorite destination is India, where I get to visit family every few years and reconnect with my culture more personally. It's always incredibly fun and filled with adventure.

Natalie Higgins

Graduate Student: Mechanical Engineering
Advisor: Nadia Lapusta, Professor of Mechanical Engineering and Geophysics

How do earthquakes initiate, and can one notice this process before the destructive shaking comes? Natalie Higgins is trying to deepen our understanding of foreshocks, small seismic events that sometimes occur close in time and space to the large earthquake.

She performs numerical simulations to study earthquake nucleation and foreshocks, and along with her advisor, Professor Nadia Lapusta, she is zeroing in on critical moments when earth structures move "from still to motion, the moment between when a fault is not doing anything to when an earthquake is happening."

Higgins underlines a crucial distinction: "The ultimate goal of my research," she says, "is to contribute to earthquake forecasting. But equally critical is to improve early warning, a process that only works once the earthquake has already begun. It can warn people by indicating that in a few seconds the waves will be in their area and they will feel the shaking and therefore they should get ready."

Moving beyond early warning to actual earthquake forecasting—that is, the ability to translate monitoring data about the fault's current behavior into information about when and where the upcoming quake will happen—is far, far more difficult, Higgins says, but she is looking for ways. "We do not have the mechanical understanding of the Earth in order to do real earthquake forecasting. And that's why we do the research we do."

Higgins came to Caltech from a small all-undergraduate college in Oregon; she had previously worked on a Fulbright grant study of wave-based damage detection in overhead power lines. On her visit to Caltech as a prospective student, she met with Professor Lapusta to discuss research, and a bell rang: "It's completely new, but it's still vibrations." Higgins has fully embraced Caltech's interdisciplinary identity. "I like that the boundaries between departments and divisions are blurry, so it is easier to do what you want and fill in there," she says. Her classroom experiences have been rewarding, as well: "All the professors are here because they're at the top of their field. Attending their classes is exciting in a celebrity sort of way."

Higgins has become increasingly interested in organizational structures as well as geological ones. She has served as the vice chair of the Graduate Student Council. She was also one of the leaders of the Society of Professional Students and has been instrumental in redesigning the Big Sib mentoring program for mechanical and civil engineering students. "I spearheaded the revamping of the program, from the basic matching of contact info to a more careful structure where the incoming students fill out a survey about what they want in a mentor, and then we do the matching based on that," she explains.

"I'm learning a lot about how the administration works and how universities are run," Higgins adds. "Because I have enjoyed it, I'm wondering if there is a way to add this aspect to my career as an academic. It is great to be at a place like Caltech, where I can explore all that academia has to offer." ENG

What languages do you speak?
English is my native language, and I also speak German.

What is your favorite online activity?
Netflix!

What is your favorite story?
I love a good underdog story. For example, the story of Erin Brockovich.

What is your favorite destination?
Sauvie Island U-pick farms.

Edward D. Fouad

Undergraduate Student:
Mechanical and Civil Engineering

Edward Fouad has compiled an impressive set of both theoretical and hands-on talents on his way to a BS in mechanical engineering. And not just with his human hands: at JPL, he joined up with the Extreme Environment Robotics Group to construct a robotic gripper that could pick up a large boulder from the surface of an asteroid and bring it back.

In constructing the first full-scale prototype of the gripper, it became clear to the group that the existing design presented critical fabrication and assembly challenges. So Fouad developed an entirely new approach by using a flexure-based mechanism, which addressed the manufacturing concerns and showed improved grasping ability on the various surfaces tested. "The best part of that experience was the relationship I had with my mentor, Aaron Parness," Fouad says. "He has incredible experience with these types of systems, but he didn't hold my hand throughout the process. He gave me the freedom to pursue my own designs."

Fouad has also been working with students as an undergraduate teaching assistant (TA) in the introductory mechanical engineering design course (ME 14) and the robotics competition course (ME 72). "Being an undergrad TA was one of my favorite parts of the Caltech experience," he says. In both courses, the instructor, Michael Mello, gave Fouad and the other TAs tremendous responsibility in making modifications and improvements. "It fills me with pride to know that the current curriculum is even better now than what it was when I first came in," Fouad says. "I know that Caltech's progressive teaching approach will allow it to continue improving in the years to come."

Beyond the classroom, Fouad served as project manager and mechanical lead on the Caltech Robotics Team, an undergraduate group that has constructed three autonomous underwater vehicles for the International RoboSub Competition. He also was co–editor-in-chief of the *Caltech Undergraduate Research Journal*, a Hixon Writing Center peer tutor, a Caltech Y Rise tutor, and an active violinist in the Caltech orchestra.

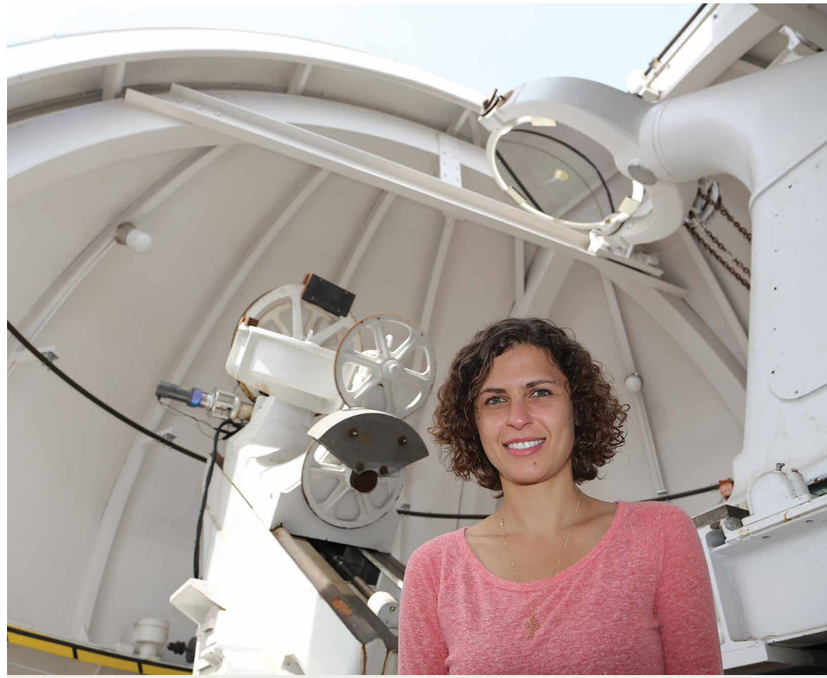
Fouad is now at SpaceX, where he will be working on mechanism design for the Dragon 2 spacecraft. "I interned in the same group last summer and was blown away by the talent, intensity, and commitment of everyone I worked with," he says. "I couldn't be more excited to join the team and be contributing to SpaceX's ultimate mission of bringing about the first human colony on Mars." ENG

What languages do you speak?
English, French

What is your favorite online activity?
Watching *How It's Made* videos

What is your favorite story?
Pocahontas

What is your favorite destination?
Mars



Katherine M. Saad

Graduate Student: Environmental Science and Engineering
Advisor: Paul Wennberg, R. Stanton Avery Professor of Atmospheric Chemistry and Environmental Science and Engineering; Director, Ronald and Maxine Linde Center for Global Environmental Science

Katherine Saad had been in graduate school in Boston for two years before transferring to the Caltech Environmental Science and Engineering (ESE) program because the research of Professor Paul Wennberg captured her imagination and fit her scientific vision.

She has now found that besides research power, Caltech's academic culture has provided an excellent pathway for her efforts to solve a pressing world problem that she is passionate about, as well as to understand and enhance the role of science in doing so.

Saad is investigating subtle changes and feedbacks that occur in the gas composition of the lower atmosphere. "We can measure abundances of different molecules because we know how each one of them absorbs and emits light," she explains. Using data from a network of instruments, including a sophisticated spectrometer that measures minute changes in the solar spectrum, she creates continuous and accurate assays of the chemical composition of the atmosphere the sun's rays transit.

The molecule she is focusing on now is methane, a greenhouse gas that is a product of a vast set of different human processes and the subject of many ongoing policy debates. "But because we don't know which of the myriad sources have been changing in the last 10 years, we don't know how effective these policies and regulations are going to be," she says.

Saad is attacking the methane problem on an instrumentation and analytical level—but also on a person-to-person level at Caltech, with the aim of understanding (and someday perhaps influencing) science policy. She founded the student organization Science & Engineering Policy At Caltech to discuss key questions related to this work: Do we have any say in the way that science is used in this country? If so, what are the ways we can engage? And if not, how do we change that? She explains, "It was really important to me to create this organization not just as an outlet for my own interests but also as a resource that serves the needs of the community in such a way that people would always want to invest in it."

A Southern Californian, Saad visited Caltech years before enrolling. At her visit, she says, "It wasn't clear how vibrant of a community there is at Caltech. There's so much here, not just in terms of interaction and communication but [in terms of] interest in other people's work and research. Even if it's not directly relevant to your work, you're still interested in it because you're interested in science. And that doesn't exist everywhere." ENG

What languages do you speak?
I speak Arabic and French, but neither well enough to claim fluency.

What is your favorite online activity?
Looking up new recipes and baking techniques.

What is your favorite story?
If you mean any story, I would say the biography of St. Katherine, whom I was named after. If you mean a story found in a book, probably *The Alchemist*.

What is your favorite destination?
My favorite destination is the beach, but I also love going out into the desert.

Chanel A. Valiente

Graduate Student: Environmental Science and Engineering
Advisor: Jared Leadbetter, Professor of Environmental Microbiology

What languages do you speak?
English and some Spanish

What is your favorite online activity?
Listening to podcasts or TED Talks

What is your favorite story?
Gone with the Wind

What is your favorite destination?
Mo'orea (I studied abroad there for three months)

Chanel Valiente came to Caltech three years after she obtained a BS in ecology at UC Berkeley. Her initial motivation for graduate school was to continue her career in microbial ecology, but once at Caltech she was struck by how much besides ecology was on her educational plate. "Environmental science and engineering requires you to have a fundamental knowledge of most fields, so I was learning oceanography, atmospheric science, geological sciences. It was amazing to learn all of this, and it's given me a good foundation for understanding most fields. So I can go to a seminar now, and although I might not know the fine details, I can understand the basic goal, the higher purpose of the work."

Her research focus is single-celled eukaryotes, microorganisms with genetic affinities to larger, multicellular plants and animals, that exist in astonishing, still-little-understood abundance and variety.

This abundance and obscurity motivates her research: "Because there's so many of them and they're so abundant and basically ubiquitous in the environment, they have to be doing something important." Working with Professor Leadbetter, she is finding out what part they may be playing in climate change and the global carbon budget.

Caltech is near Valiente's family home in the San Fernando Valley, so it is relatively easy for her to reach out to others who share her roots. She reflects on how Latino students who live nearby often know little about Caltech: "When I tell my friends or old coworkers that I go to Caltech, I have to explain that it is a top-ten university, leading the way in many research areas. Then I say, 'Those people who talk about the earthquakes on TV, that's Caltech.' Or 'You know JPL? That's Caltech.'" She is reaching out and spreading the word, "mostly with my old high school, but I also speak to my nephews. I focus a lot on them because most of my family members do not have a college degree, and my nephews are asking questions that I can answer!"

She has been involved with outreach on campus, as well. "Last term, I was involved with Club Latino, which is for graduate students," she says. "There's another undergrad club that is dedicated to undergrads and in some ways is more active. But as graduate students, we are so focused on our research that it is sometimes hard to get together and socialize. We are trying to change that by organizing more events." But her spare time is scarce: "I'm mostly focusing on my research, because that's why I'm here! I also make sure my fiancée doesn't feel neglected. I have another at least three or four years here. So I'm just buckling in." ENG

Colin A. Cook

Graduate Student: Medical Engineering
Advisor: Yu-Chong Tai, Anna L. Rosen Professor of Electrical Engineering and Mechanical Engineering; Executive Officer for Medical Engineering

Colin Cook, an aspiring entrepreneur, is working with Professor Yu-Chong Tai on new ways of delivering oxygen to hypoxic cells for applications including cancer therapy, pancreatic islet transplantation, and ophthalmology.

Some eye diseases arise from lack of oxygen. Cook explains: "In diabetic retinopathy, the blood vessels that supply the retina start to die, and patients experience progressive vision loss but also subsequently get the pathological ingrowth of new blood vessels, which causes blindness by obstructing vision."

Cook and others on Professor Tai's team are working on solutions. "We have an implant that sits just below the surface of the eye, exposed to the atmosphere, where oxygen is 21%. This implant has a hollow conduit to shuttle this oxygen back to the retina, where it can nourish the retinal cells," Cook says.

Beyond the technical, design in medical engineering requires clinical, regulatory, and commercial considerations. It's the need for multidisciplinary and creative solutions that keeps Cook engaged in the work, he says. Ultimately, he'd like to "create some kind of IP-driven company that's developing new technologies and translating them as efficiently as possible."

He's glad to be at Caltech. "I had been looking at all the top medical and biomedical engineering schools in the country," he says, "and I saw Caltech pop up as introducing this new medical engineering program. So I visited, and the passion and the energy here and also the nimbleness of the Institute attracted me to it."

The closer was his meeting with Professor Tai. "I spent about two hours with him, interviewing and talking about research interests, going around the lab," Cook recalls. It was Professor Tai's commitment to building working medical devices that really caught Cook's attention. "He let me sit in on a patent call that he was making, and we kind of looked at each other afterward and he said, 'Do you want to come to Caltech?' And I said, 'Yeah, I think I do.' And soon I was here," part of the inaugural class of the new Department of Medical Engineering.

Soon after arriving, Cook started engaging his classmates and organizing events. "Because we were the inaugural students, we worked to set up something of a social committee or a government body to create events to help the medical engineers network with each other and create the cohesion that you would like in a new class," he explains. He found examples in other departments: "I had an opportunity to go to Northrop Grumman with the aerospace students, and I thought: if we could start doing that with the medical engineering department as we grow, that would be really important."

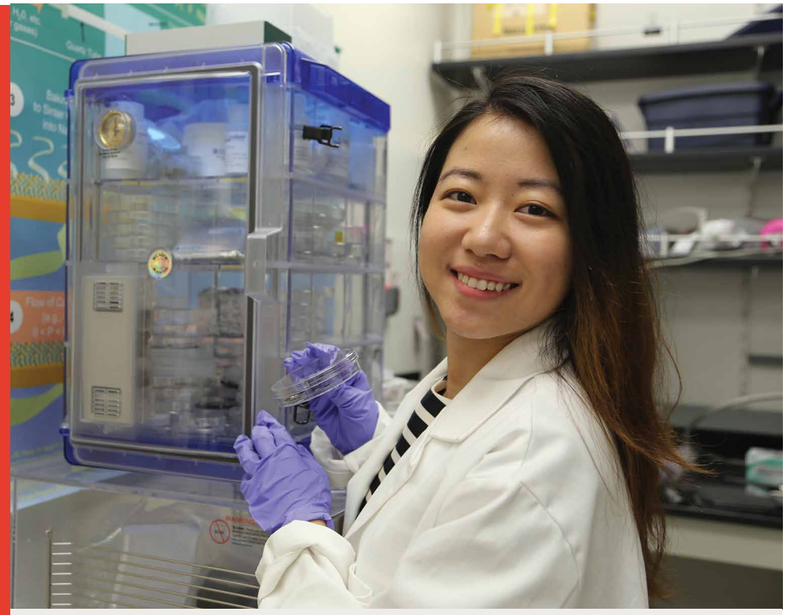
One of his first mentors was his grandfather, Dr. Wilfred Goodman, who was a professor of otolaryngology and developed open rhinoplasty. But, Cook says, "I saw that it took him close to 20 years before it became widely adopted. So rather than going to the clinical side, I decided I would go to the engineering side, where we can develop these technologies and then disseminate them globally, to have the maximum impact possible." ENG

What languages do you speak?
English and a little German and French

What is your favorite online activity?
Reading academic journals (I'd rather be outside than online)

What is your favorite story?
A story my grandfather told me about his father and a little pig named Funny Face

What is your favorite destination?
Vanaheim, a cherished family farm in beautiful Ontario, Canada



Jinglin (Alice) Huang

Graduate Student: Medical Engineering

Advisor: Morteza Gharib, Hans W. Liepmann Professor of Aeronautics and Bioinspired Engineering; Director, Graduate Aerospace Laboratories

Jinglin Huang works at the borders of disciplines, interests, and nationalities. She is mentored and advised by Professor Morteza Gharib, whom she admires for his innovative and entrepreneurial approach. "I want to have my own company and make my own products," says Huang. "I am learning from him to be creative and spontaneous."

Two projects she is working on in Gharib's lab illustrate the range of both the laboratory and her interests.

As a Resnick Institute Graduate Fellow, she is investigating the potential applications of carbon nanotubes in seawater desalination. "Drinkable water could be an urgent problem in the near future. So I'm glad that what I am working on right now has the potential to be of benefit to many people," she says.

She is also involved in microneedle research efforts to create an extremely small, painless drug administration system. She explains: "There are lots of things we can do to make minimally invasive surgery possible. Microneedles are just the beginning."

Huang identifies potential needs in the medical field by shadowing a physician. He gave her some key advice: "He said, 'It is important for the engineer to go from benchside to bedside.' I find this to be a broader way of getting into the engineering theory, because you include the needs of the physician."

Huang relishes the entrepreneurial possibilities of her work—but only in ways that will benefit others as well as herself. "I really want my own patent, a working patent. I want to collaborate with great people, build devices, and sell them. I also think it's important to come up with a product that works well and is reasonably priced so that more people can benefit from it in the developing world."

One of the keys to her success is her network of learning, family, and social relationships. She's part of the Caltech Chinese Students Association, Smith College Club of Los Angeles, and the Junior League of Los Angeles. "Through my network, I was able to get connected with people with similar interests and mindsets," she says. "It keeps me up to date on front-end technologies, allows me to listen to voices from different perspectives, and gives me a chance to embrace various opportunities in the field."

Huang did her undergraduate work at Smith College, which shares, she says, the intimate cross connections of Caltech. There, she studied engineering science and music. Continuing her passion for music, she is a pianist with Caltech Chamber Music. ENG

What languages do you speak?
I speak Chinese and a bit of French.

What is your favorite online activity?
I like watching documentaries on the BBC.

What is your favorite story?
Alice's Adventures in Wonderland by Lewis Carroll. Alice is adventurous, curious, logical, and rational. She has to re-establish her identity in a whole new world, but she's not scared. She always tries to maintain her good manners, even at moments when she's facing fears and loneliness. She stands up for herself and her beliefs but still tries to understand and assimilate into the nonsense world. I think she has a lot of good qualities for me to learn from.

What is your favorite destination?
London!

Caltech Graduating Class of 2016

54% of Caltech graduates are from the Division of Engineering & Applied Science (EAS)

53% of BS degrees earned are in EAS

69% of MS degrees earned are in EAS

44% of PhD degrees earned are in EAS

To learn more about degrees offered in EAS, visit eas.caltech.edu/dept.