

- How much does life on Earth weigh?
- Introducing undergrads to conceptual art
- Picturing the planets
- Where blackboards rule

## Chalk One Up for Science

"I loved the idea of an art-and-science collaboration. My two worlds coming together!"

That was Sarah Flores's enthusiastic response to an invitation from the Pasadena Chalk Festival this past spring to work on a chalk mural with colleagues from the Caltech campus and from JPL, where Flores is a software engineer.

Flores—who, in addition to her scientific day job, has been a street painter for 15 years and took art classes in high school and college—is no stranger to the annual June chalk fest, having participated in it since 2010. But the idea for an art-and-science collaboration came from Tom Coston, president of the Light Bringer Project, the nonprofit art organization that runs the festival.

With the chalk mural, titled *Out-of-This-World*, Flores says she and Coston hoped to convey the idea that art and science are "both important, and it's exciting when they collaborate." Art, she adds, "can inspire the next generation to dream about what can be possible."

Putting together a team of artist-scientists was easy, Flores says. "Engineering and science, by nature, require a lot of creativity and problem solving. I'm not surprised that so many JPLers are also artists."

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A team of artists represented campus and JPL at the Pasadena Chalk Festival, held in June at the city's Paseo Colorado (see story at right). Their artwork, titled *Out-of-This-World*, featured past, present, and future space missions including Juno, OCO-2, and Mars InSight. The paintbrush-wielding astronaut (above) is drawn in the style of Alan Bean, the late astronaut who was also an artist.

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Irena Li and James Keane spent hours crouched on the concrete at the Paseo Colorado bringing life to their chalky solar system.

## Chalk One Up for Science

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Irena Li, a mission operations systems engineer at the Lab who has a background in chalk art, signed up first, and introduced Flores to Caltech planetary science postdoc James Keane, who regularly turns his hand to science illustration. Keane's partner Aaron Rodriguez, a graphic designer, came on board as well, and the team was completed with Jamie Molaro, a JPL planetary scientist who advised on the design of the mural, and Eugenie Song, a JPL Mars operations engineer with arts training.

Starting out with a simple solar-system concept during the design phase, the group decided ultimately to showcase missions past, present, and future, including Juno, the Orbiting Carbon Observatory-2 (OCO-2), and Mars InSight. A late addition was the astronaut wielding a paintbrush, drawn in the style of Alan Bean—an Apollo 12 astronaut and the fourth person to walk on the moon—who passed away in May of this year. After retiring, Bean had pursued an interest in painting and become a full time artist.

As they set to work at the Paseo Colorado site, each member of the team focused on different elements. As they progressed in filling in the mural, says Li, “we referenced each other’s work or asked to trade areas so it ended up being a blend of all our individual artistic styles. I had a lot of fun learning new chalk techniques from the rest of the team.”

For Keane, working in chalk posed some unique challenges. “I usually use pen and pencil for my artwork, on nice, smooth paper,” he says. “Sidewalk chalk is a lot messier and more physically demanding. You’re on your knees for hours at a time, blending and breaking chalk into the rough concrete. I needed to ice my knees after each day of work. Also, the sheer size of the piece was daunting compared to my usual pen-and-paper sketches.”

The effort was worth it, though, he says. As festival visitors strolled by, they stopped to ask questions about the planets and missions in the mural. “I hope they left with a sense of excitement for the work going on at Caltech and JPL, and for how beautiful the solar system is.”

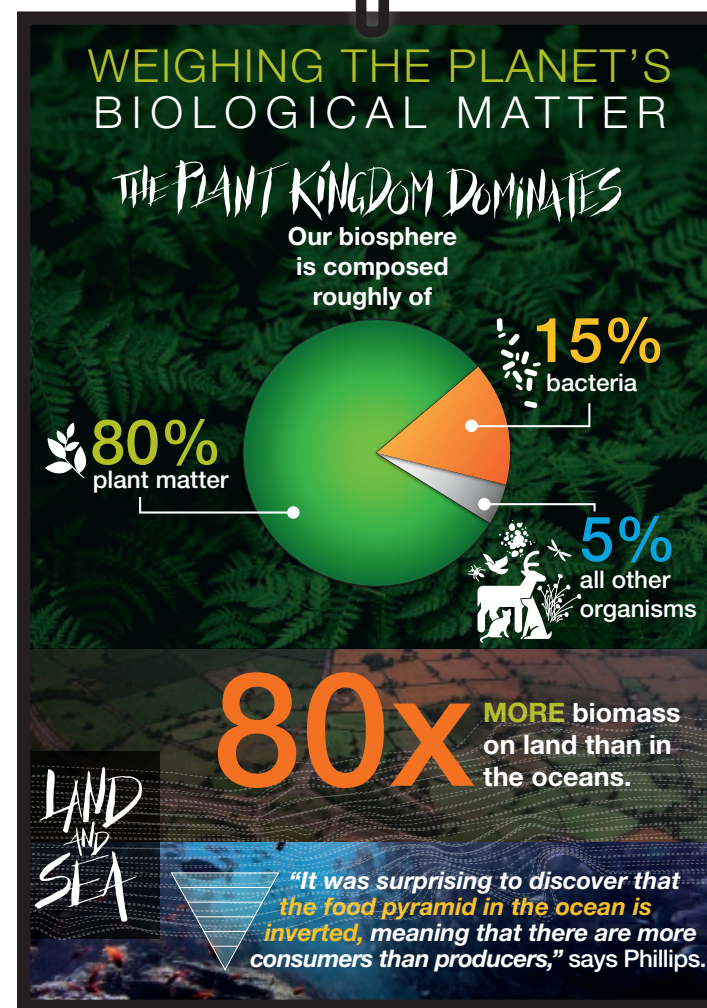
On a more practical note, says Keane, “the crowd was pretty good about not stepping on the artwork—except for the occasional rogue toddler or curious puppy.”

**“I know each and every one of you are committed to science, to technology. I urge you also to study the way of peace. Study the way of love. Study the philosophy of nonviolence, the teaching of Gandhi and Thoreau. And help humanize that little planet, that little spaceship we call Earth. I say to you, as you leave this beautiful campus, go in peace. Be unafraid.”**

— Representative John Lewis, Caltech Commencement 2018

## EARTH IN THE BALANCE

Just how much living matter is actually on this planet? A recent study—a collaboration between Yinon Bar-On and Ron Milo of the Weizmann Institute of Science in Israel and Rob Phillips of Caltech—tried to answer that question by making the first global estimates of the total weight, or biomass, of life on Earth. “Understanding these numbers,” says Phillips, the Fred and Nancy Morris Professor of Biophysics, Biology, and Physics at Caltech, “is crucial for understanding what I like to call the ‘human experiment’: How exactly are we shaping the planet?”



## Four Questions for : Hillary Mushkin

Now in her seventh year at Caltech, Hillary Mushkin is a research professor of art and design in mechanical and civil engineering. She teaches critical thinking about visual perception to future engineers and scientists.



### 1. What is the value of ensuring that scientists and engineers take art into account in their work?

First, to be clear, it's not art in the sense of aesthetics; I'm not talking about bringing a nicer-looking graphic design to people's posters. It really has more to do with critical thinking and thinking through ideas about perception. So, for example, researchers in Caltech's Data Visualization Summer Internship Program use perception and visual strategies to understand, interpret, and organize their data for themselves and for their colleagues. Along with the other program organizers, I collaborate with researchers and mentor interns so that they can create more effective interactive visual tools to answer questions about their data. What we offer is expertise in gleaming understanding about the world through visual practice.

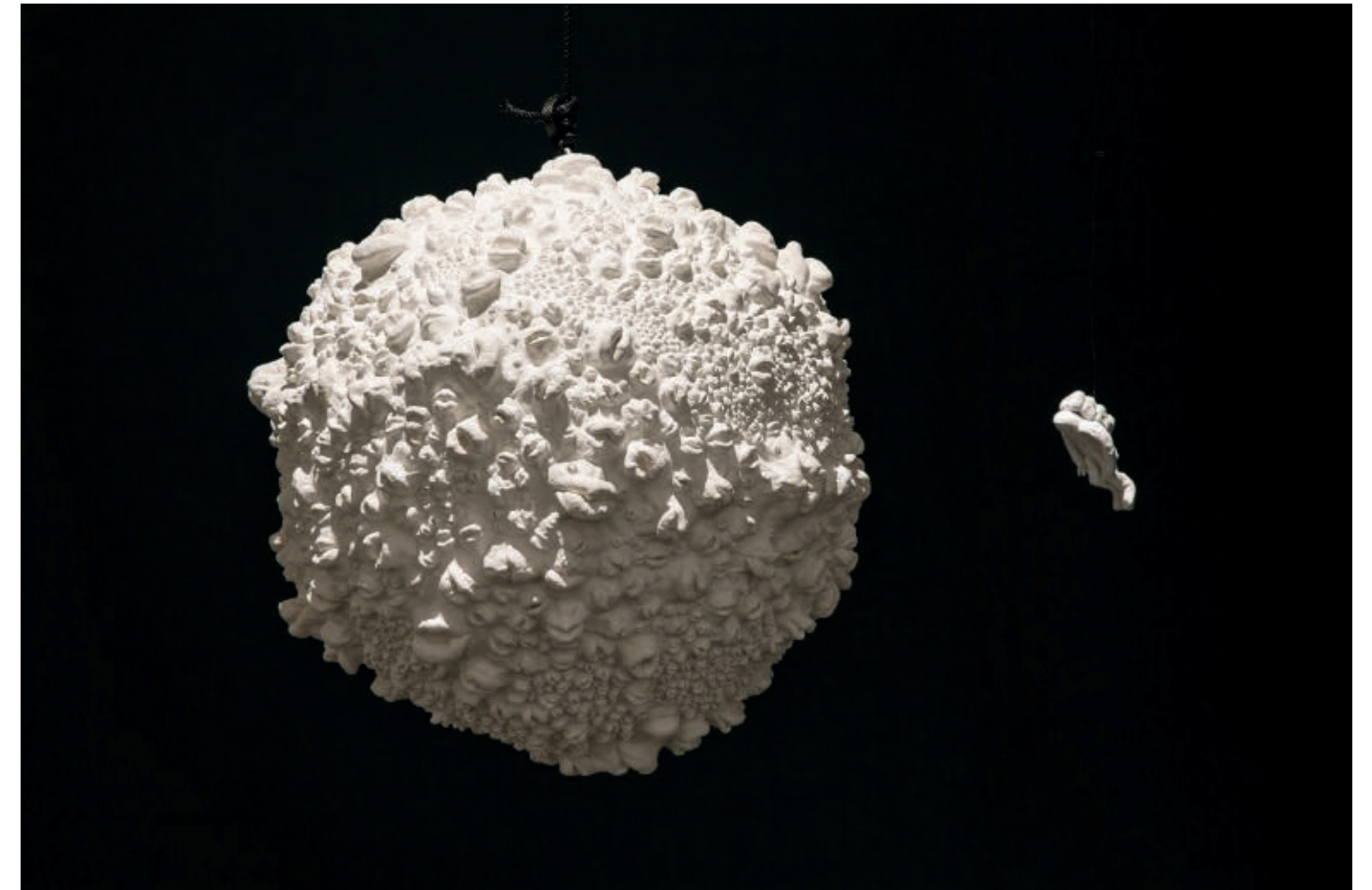
### 2. It sounds like it's a question of communication.

That's right. And not just in public but also among themselves. I think when people talk about communication, usually it's outward, like, "How can I explain myself to the public?" But it doesn't take into account that researchers interpret their data, and they have to make sense of it for themselves and their colleagues before they make it public.

### 3. Does that have the potential to shift how they think about their projects?

Yes, absolutely. I've been teaching this class called New Media Art History and Projects. It focuses on artists who have been working with the new technology of their time. I go back to the turn of the last century to talk about Marcel Duchamp and the sculptures he called "Readymades." He selected factory-made objects and then displayed them in an art gallery. The first one was a urinal that he called *Fountain*. He talks about the artist as somebody who needs to have ideas, rather than skills, to do their craft.

As an artist working and collaborating with nonartists, I continually ask the question, "What is the role of the artist in society?" One role is to be a conceptual thinker, to be a provocative thinker, to be somebody who does not necessarily think with utility in mind but who thinks outside of that and can push the margins of how we expect things to function. I encourage scientists and engineers to think similarly. Creative thinking is often risky and impractical at first. It may, in the end, solve a problem, but it's not because you started off that



**MOONS**, an exhibit currently on view at ArtCenter College of Design's Williamson Gallery, draws on both art and science to explore the lure of celestial bodies. Conceived in conjunction with Pasadena's City of Astronomy partnership—in which Caltech plays a leading role—the exhibition (on view through December 16, 2018, and curated by Williamson Gallery director Stephen Nowlin) includes contemporary artwork as well as artifacts from Mount Wilson Observatory, The Huntington Library, Art Collection, and Botanical Gardens, and the Caltech Archives, among other institutions. Pictured here is *Thumbsucker*, by locally based artist Tim Hawkinson, which features a moonscape created from lips and mouths alongside a floating thumb-astronaut.

way. Sometimes it was because you started off thinking in a much more blue-sky way. For example, "What kinds of ridiculous things can we do with this?" or "What kinds of possibilities are there for critiquing the way technologies are currently used in culture?"

### 4. How does the "maker" class that you started last year fit into your overall vision?

It's related to the new media arts class in that it asks questions about the role of the engineer or the technologist in society. The term "maker" is interdisciplinary; a maker can be a designer, a craftsperson, an engineer, or a scientist. The maker term, and the maker movement, is very broad and also fairly new. The class is looking closely at what science and engineering students can gain from maker culture and is also looking at the limitations of mainstream maker culture and how we can understand the relationship between technology and society more broadly.

## Michaëlle Mayalu

### Postdoctoral scholar

**#SoCaltech** is a social media series designed to celebrate the diverse individuals who give Caltech its spirit of excellence, ambition, and ingenuity. A postdoctoral scholar in computing and mathematical sciences, Michaëlle Mayalu arrived at Caltech in the fall of 2017 after a decade on the East Coast, during which she earned her bachelor's, master's, and PhD degrees at MIT. Hailing from Tucson, Arizona, Mayalu—who is a 2017–2018 AGEP\* scholar—is working on ways to use mathematics and control theory to model how genetically engineered cells execute new decision-making behaviors.

One piece of advice I received about becoming a professor is that you want to be able to see how people learn from different viewpoints, different perspectives; to see how people teach, how problems are solved. Here at Caltech, at least in the lab of Richard Murray [control and dynamical systems and bioengineering professor], I've noticed there is more emphasis placed on doing research for discovery and scientific advancement than on doing research for publication. Instead of publishing right away you can think of alternatives to solve a problem and have maybe a more complete paper that might be potentially more impactful because you're getting different perspectives and ideas.

\* The California Alliance for Graduate Education and the Professoriate (AGEP) was established to provide a path for underrepresented minority PhDs from California's top research institutions to aspire to and populate the ranks of the postdoctoral population, the faculty at competitive research and teaching institutions, the federally funded national laboratories, and scientific think tanks.



For more #SoCaltech, go to [magazine.caltech.edu/post/michaelle-mayalu](https://magazine.caltech.edu/post/michaelle-mayalu)

## Modern Math



Since 1960, when Caltech's math department first took up residence in Sloan Laboratory, the physical space had remained essentially unaltered. So when Ronald (MS '62, PhD '64) and Maxine Linde endowed The Linde Center for New Initiatives at Caltech, renewing that historic structure was a top priority.

The new Ronald and Maxine Linde Hall of Mathematics and Physics includes spaces for both teamwork and quiet contemplation and—because the building will be home to more than 125 mathematicians—an abundance of blackboards throughout. Lest an eager scholar's chalkboard chatter become too vigorous, each board is backed with sound-absorbing material.

"The new Linde Hall will be transformative for our mathematics program," says Fiona Harrison, Benjamin M. Rosen Professor of Physics and Kent and Joyce Kresa Leadership Chair for the Division of Physics, Mathematics and Astronomy. "It will help us attract the best and brightest faculty, students, and postdocs, and will provide interactive space for collaboration."

## Cosmic Craft

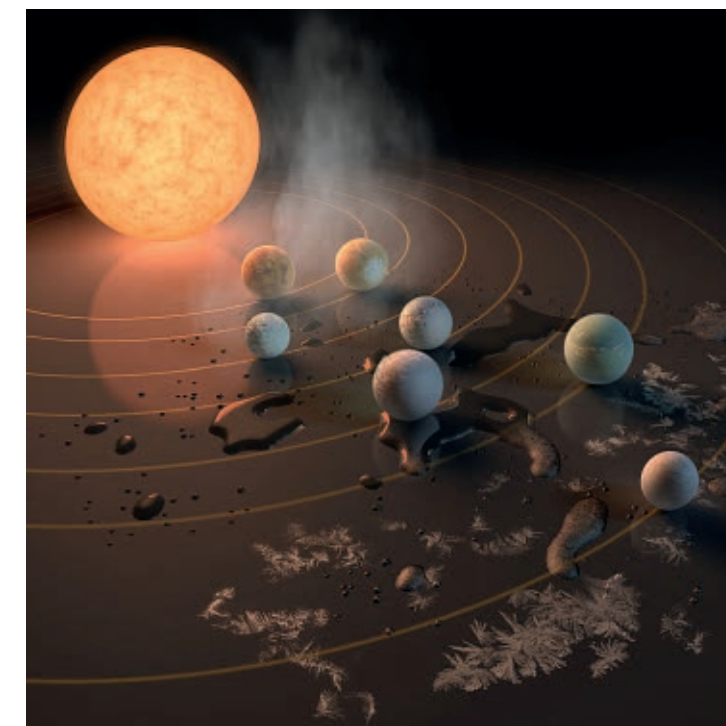
In June, some of the world's top space artists met on campus to exchange ideas at AstroViz 2018, a conference put together by IPAC, Caltech's science and data center for astronomy.

"The idea was to reestablish a community of practice for astro-visualization professionals," says Janice Lee, an astronomer at IPAC and an organizer of the event, which was facilitated by NASA's Universe of Learning education and outreach program.

Keynote speaker Rick Sternbach, an astronomical visualization expert who worked on Carl Sagan's 1980 TV series *Cosmos*, described how he and his group built models of the planets and then took pictures of them for the show. Around that same time, the Voyager mission started sending back stunning pictures of the planets, changing everything the group thought they knew. "Our special effects were being made obsolete every week," said Sternbach.

IPAC visualization scientist Robert Hurt says this still happens. "You do the best you can given the current data, and then, yes, sometimes you have to go back and change the artwork when more data are captured." Hurt and multimedia engineer Tim Pyle created artwork to illustrate the Spitzer TRAPPIST findings—information about the first known star system to host seven Earth-size planets. The pair had to redo all of their TRAPPIST artwork after Spitzer and other telescopes gathered more-precise data on the planets' compositions.

"The level of creativity and inspiration displayed at the conference was truly awesome," says Hurt. "From swapping ideas and techniques to showing off innovative ways that data can be heard or touched, we all have a lot of new tools in our arsenal for communicating the wonders of the universe."



In Robert Hurt's concept of the **TRAPPIST-1** system of exoplanets, the idea of a "habitable zone" is captured through water splashes that vaporize when too close to the star and freeze when too distant.

Watch videos of conference sessions at [magazine.caltech.edu/astrovids](https://magazine.caltech.edu/astrovids)

# Introducing Bechtel

The Bechtel Residence—Caltech’s first new student residence in more than two decades—is due to open its doors on September 23, 2018. Located on the north side of campus along Del Mar Boulevard, Bechtel adds 211 beds to campus housing; this means that, for the first time in Institute history, all undergraduates will be able to live on campus.



A landscaped central courtyard will allow students to make the most of the sunny SoCal climate, while study rooms throughout the building, along with larger community lounges and kitchens, round out the living experience.

All student rooms in the residence are singles, but most are configured to create suites for four, six, eight, or 12 undergrads. Each suite includes a lounge, refrigerator, and bathrooms, while the individual rooms boast—along with the requisite beds, dressers, desks, and chairs—polished-cement flooring and roll-up window shades as well as a thermostat.



**70 Years (and Counting):** At 70, Palomar Observatory’s 48-inch Samuel Oschin Telescope is still in the prime of its life. One of the most productive survey telescopes ever built (construction started in 1938 and finished a decade later), it has completed a dozen sky surveys since the 1950s. After several upgrades over the years, the telescope now has wide-field imaging capabilities that can scan large regions of the sky to search for transients—objects that change apparent brightness and/or position—such as fast-moving solar system objects, variable or pulsating stars, flares, novae, supernovae, gamma-ray bursts, and other stellar explosions. Currently, the telescope operates robotically: its newest instrument, the Zwicky Transient Facility, scans the skies nightly and returns vast amounts of astronomical data.

Watch a video created for the telescope’s anniversary at [magazine.caltech.edu/post/palomar-vid](http://magazine.caltech.edu/post/palomar-vid)

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