SoCaltech

Cloud Sourcing

Caltech climate scientists help bring an artist's cloudy vision to life

How much does a cloud weigh? That was the question on Karen LaMonte's mind when she emailed Caltech climate scientist Tapio Schneider. LaMonte—an artist known for her monumental sculptures—wanted to make a cloud sculpture, but with a twist. She would find a cloud to use as a model and make the sculpture's weight equivalent to that of the original cloud.

"We see [clouds] floating in the air," says LaMonte. "We think of them as fluffy cotton balls. But they're actually amazingly heavy. I thought, wouldn't it be amazing if we could get a 'real' cloud and carve it in marble?"

Schneider, the Frank J. Gilloon Professor of Environmental Science and Engineering, who also has a joint appointment with JPL, was intrigued. His work focuses on reducing uncertainties in climate-change projections—in part through modeling cloud formation to better understand clouds' impact on the environment. Collaborating with LaMonte, he reasoned, could help raise awareness of these issues.

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Cloud Sourcing

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Observations of clouds with enough detail to translate into a sculpture are not available, but the equations governing clouds are known, and so the structure of clouds can be computed. Caltech research scientist Kyle Pressel, who is part of the Schneider lab, worked closely with LaMonte to produce the cloud simulation from which she would create her sculpture.

Their goal: Model conditions that would create a cumulus cloud worthy of sculpting. The result? "A classic cumulus you'd see while lying on a beach in Barbados," says Pressel.

To transform the virtual cloud model into an actual sculpture, LaMonte again turned to technology, using a robot for the initial carving. "Only by using technology could I make the diaphanous solid and the intangible permanent," she says.

It took the robots four weeks of carving and LaMonte an additional four weeks of hand-finishing before the 15-ton block of marble assumed its final form as *Cumulus,* a seven-foot-tall, 2.5-ton sculpture. *Cumulus* will remain on exhibit outside Venice's Palazzo Cavalli-Franchetti during the Venice Biennale, through November 26, 2017.

Read more about Karen LaMonte and Tapio Schneider's collaboration at **magazine.caltech.edu/post/cloud-sourcing**

Meet the class of **2021**

Total # of applications:
7,339
(highest ever)

Offers of admission:
568
(7.7% admit rate, lowest ever)

Enrolling freshmen:
235*

*As of printing

Women:
46%
(ties % record from 2015)

Underrepresented minorities:
16%

From public or charter high schools:
71%

First generation students:
5%

As well as being stellar scholars, our newest freshmen have some impressive talents. Individuals from this class have:

- Baked a replica of the periodic table with cupcakes
- Engineered and designed roller coasters
- Climbed Mt. Whitney three times
- Performed as a stand-up comic
- Owned a perfume company
- Played ice hockey on the Lady Huskies Travel Hockey Team

"I hung up the phone and just sat there for a second. I was going back through it in my mind, saying 'They did say yes, right? And they got the right person?'"

—Caltech postdoc **Jessica Watkins** *on learning she had been selected for NASA's 2017 Astronaut Class*

Class Act:

Graduate student Kelsey Boyle co-teaching (with Rebekah Silva) a tutorial course on DNA and cancer for the newly reinvented Chemistry 101.

Chemistry graduate students Rebekah Silva and Kelsey Boyle reinvented and launched Chemistry 101 during the last spring quarter as a low-stakes way for Caltech undergraduates to explore topics in chemistry that pique their interest. Taught entirely by graduate students and postdocs, the course also gave Silva, Boyle, and their peers a chance to hone their teaching skills.

Bite-sized learning

A group of six tutorial courses, Ch 101 focuses on topics outside of the main chemistry curriculum: revolutionary inorganic molecules, chemical nanoscience, ultrafast laser spectroscopy and microscopy, astrochemistry, a survey of the chemical-biology literature, and a look at trends in cancer-treatment strategies. With these bite-sized offerings, which undergrads can take either for a grade or as pass/fail, "students get a chance early on to explore an area of interest with little risk," says Silva.

Head of the class

"I had opportunities to tutor in college and found a lot of purpose from it," says Silva, who graduated from Stanford in 2012. "I wanted to take the next step of creating course content and being the instructor." Graduate student Olivia Wilkins was excited about the opportunity Ch 101 gave her to bring her fascination with astrochemistry to Caltech's undergrads. "I had this vision of sharing it with people, and immediately a course outline popped into my head," she says.

Next level

Silva hopes her students take away from the course a new way of understanding information. "The way I understand, for example, nucleic-acid biology is very different from when I was an undergraduate," she says. "We thought it would be great to structure a class to help students organize information more in a way that an expert does."

Teaching the teachers

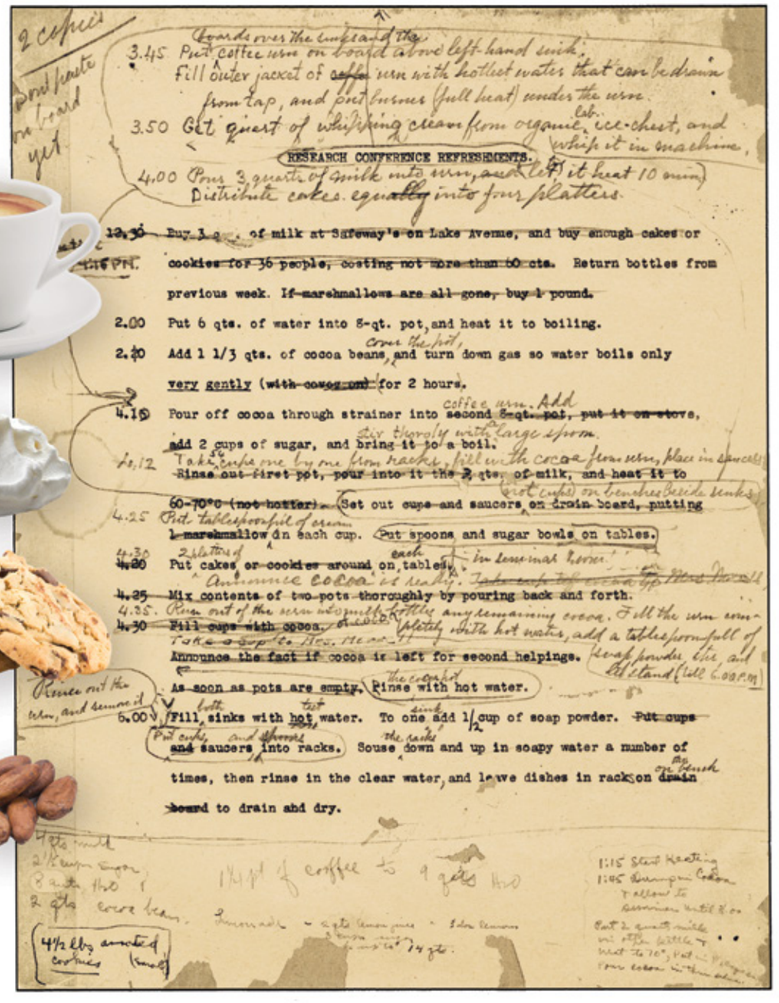
To help the graduate students and postdocs make the leap into teaching, each had a faculty mentor and consulted with the Center for Teaching, Learning, and Outreach. Harry Gray, Caltech's Arnold O. Beckman Professor of Chemistry, was impressed with the dedication of the rookie professors. "The people who signed up are kids who already love teaching," he says. "It's easier to work with them because they really want this, and they're fired up."

Read more about Chemistry 101 at **magazine.caltech.edu/post/chem101**

Classic Cuppa Cocoa

Arthur A. Noyes moved to California—and Caltech—in 1919 to build the Institute's chemistry division, housed in what was then the Gates Laboratory of Chemistry (now the Parsons-Gates Hall of Administration). In addition to shaping the policies that would help create a world-renowned hub of science and engineering, Noyes introduced at least one early Caltech tradition: hot cocoa.

Research meetings, held weekly in Gates, featured cocoa prepared according to this precise recipe, created by Noyes and posted to a bulletin board in the kitchen.



RESEARCH CONFERENCE REFRESHMENTS.

3.45 Put coffee urn on board above left-hand sink.
Fill outer jacket of coffee urn with hottest water that can be drawn from tap, and put burners (full heat) under the urn.

3.50 Get quart of whipping cream from organic ice-chest, and whip it in machine.

4.00 Pour 3 quarts of milk into urn, and let it heat 10 min.
Distribute cakes equally into four platters.

~~3.30~~ Buy 3 q. of milk at Safeway's on Lake Avenue, and buy enough cakes or
~~4:15 PM.~~ cookies for 36 people, costing not more than 50 cts. Return bottles from previous week. ~~If marshmallows are all gone, buy 1 pound.~~

2.00 Put 6 qts. of water into 8-qt. pot, and heat it to boiling.

2.40 Add 1 1/3 qts. of cocoa beans, and turn down gas so water boils only very gently (~~with cover on~~) for 2 hours.

4.15 Pour off cocoa through strainer into ~~second 8-qt. pot, put it on stove,~~ coffee urn. Add
~~add~~ 2 cups of sugar, and bring it to a boil.

4.12 Take cups one by one from racks, fill with cocoa from urn, place in saucers
~~Rinse out first pot, pour into it the 2 qts. of milk, and heat it to~~
~~60-70°C (not hotter).~~ Set out cups and saucers on drain board, putting
4.25 ~~Put tablespoonful of cream~~
~~1 marshmallow~~ in each cup. Put spoons and sugar bowls on tables.

4.30 Put cakes or cookies around on tables.

4.25 Mix contents of two pots thoroughly by pouring back and forth.

4.35 Rinse out of the urn into sink any remaining cocoa. Fill the urn com-
4.30 Fill cups with cocoa. pletely with hot water, add a tablespoonful of soap powder, let it
Announce the fact if cocoa is left for second helpings. stand (till 6.00 P.M.)

As soon as pots are empty, Rinse with hot water.

5.00 Fill sinks with hot water. To one add 1/2 cup of soap powder. ~~Put cups~~
and saucers into racks. Souse down and up in soapy water a number of
times, then rinse in the clear water, and leave dishes in rack on drain
~~board~~ to drain and dry.

Lyman Bonner (PhD '35) recalled, "At these seminars, incidentally, cocoa prepared by the Noyes recipe was always served. Always. No exceptions."

Whipping cream seems to have been stored in the organic lab's ice chest.

Cocoa was accompanied by cakes or cookies purchased at what had been a Safeway store on Lake Avenue.

No pre-ground cocoa here—grad students carefully weighed and boiled cocoa beans.

The former Gates Laboratory of Chemistry, Caltech's oldest standing building, is celebrating its 100th anniversary. Learn more about its history by visiting the Caltech Archives at ***archives.caltech.edu*** *or the Interactive History Map at* ***caltech.edu/historymap.***

Four Questions for:

Peter Collopy

Peter Collopy joined Caltech in May as university archivist and head of special collections.

For more of our conversation with Peter Collopy, go to **magazine.caltech.edu/post/4q-peter-collopy**

1. What attracted you to archival science as a field and to Caltech specifically?

I have a PhD in history of science, and I'm primarily a historian of 20th-century science and technology. Caltech is one of the major places where that history has happened, so it's one of a handful of places where it makes sense for me to be.

2. How is the Archives different from the Library?

We don't collect published materials—that's what the rest of the Library does. Instead, we get things like people's lab notebooks, letters to and from colleagues, perhaps early drafts of publications.

Science is a social activity. You can find evidence of that in publications and things like coauthorship, but you can find richer evidence of it in people's letters to each other and in people's letters to a third party about their colleagues.

3. How does the Archives work?

A lot of our collections are faculty papers, so we'll have conversations with faculty on campus about what will happen to their papers when they're not using them anymore. We make arrangements to get these materials, and, once we have them, we organize them. Then, we keep things under secure and stable conditions so that they'll last a long time.

Researchers come and use the materials or contact us and ask for help in using them remotely, or increasingly view entire collections online.

4. What are your goals for the Archives?

We'd like to supplement our paper collections with an archive of Caltech websites and other electronic media. I would also like to do public history—to not only tell stories about the history of scientific and technical research done at Caltech, but also to allow visitors to touch and experience that research. For example, we could accompany an exhibit about the long history of aerospace research at Caltech by having a small working wind tunnel in which visitors could place models.

"It was like someone dragged me by the hand and took me on the most incredible journey and adventure that humanity had ever undertaken."

—**Carolyn Porco** *(PhD '83), Voyager 1 imaging specialist, on her participation in the Voyager mission, speaking at a July 29 Caltech panel and screening of* The Farthest—Voyager in Space

Work is well underway on the Bechtel Residence, Caltech's newest undergraduate housing facility. A student committee and Student Affairs staff members are both currently exploring how to best use the 95,000-square-foot residence—named for Caltech life trustee Stephen D. Bechtel, Jr.—which is slated to open in the fall of 2018.

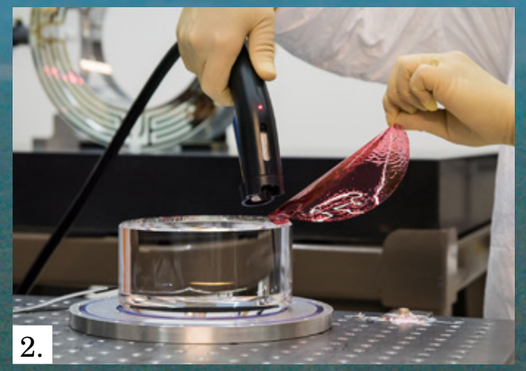
How to:

Clean LIGO

To search for ripples in space and time, the Laser Interferometer Gravitational-wave Observatory (LIGO) uses a laser beam that is split in two and travels down perpendicular 2.5-mile arms containing mirrors at their far ends. The beam reflects off the mirrors and bounces back to converge where the arms meet. A passing gravitational wave will stretch and squeeze space itself, causing the distance a light beam travels to increase or decrease ever so slightly; this changes the way the split beams ultimately converge. So far, so (relatively) straightforward. The tricky part? The setup for LIGO—at its two facilities, one in Washington and one in Louisiana—comprises tens of thousands of pieces of equipment, from massive optics to tiny screws. And if anything has so much as a speck of dust on it, it might contaminate LIGO's optics and diminish the signal of a gravitational wave. Here are some of the things Caltech engineers do to make sure that everything is beyond squeaky clean.

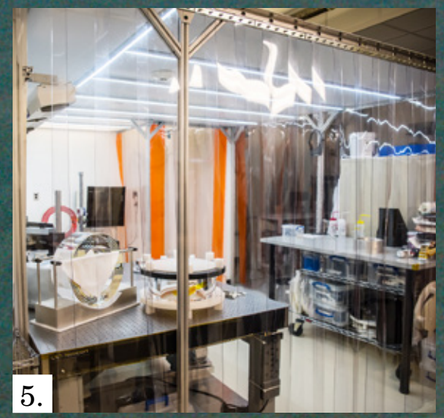
1. To clean LIGO's unique optics, a special polymer blend solution is applied. This technique cleans the surfaces without leaving the tiny scratches associated with the more traditional drag-wipe technique.
2. After the polymer dries, it is peeled from the surface of the optic.
3. A spray of neutralized ions prevents static buildup, keeping dust from being attracted to the freshly cleaned optic.
4. The mirrors are inspected using an extremely bright light kept within a black enclosure, to minimize light from other sources.
5. Final cleaning and inspection takes place in a custom-built clean room.
6. Smaller items like screws and bolts are placed in an ultrasonic bath for cleaning.
7. Post bath, the instruments spend time in a high-temperature vacuum oven that reaches 200 degrees Celsius (upwards of 390 degrees Fahrenheit).


1.


2.


3.


4.


5.


6.


7.

An engineer prepares a light baffle that will capture laser light scattered by dust and imperfect optics, preventing the stray light from contaminating the gravitational-wave signal.

For more information about how Caltech engineers prepare equipment for LIGO, go to **magazine.caltech.edu/post/cleaning-ligo**

David Tirrell Named Caltech Provost

This fall, chemistry professor and Beckman Institute director David Tirrell will become Caltech's 10th provost.

Caltech career: A Caltech faculty member since 1998, Tirrell, the Ross McCollum-William H. Corcoran Professor of Chemistry and Chemical Engineering, chaired the division from 1999 to 2009 and is currently the director of Caltech's Beckman Institute.

Research and accolades: Tirrell focuses on the genetic code and how modifying the molecular machinery of the cell might lead to new approaches in macromolecular design, protein evolution, biological imaging, and proteome-wide analysis of cellular processes. He is one of only 19 individuals elected to all three National Academies: Sciences, Engineering, and Medicine.

The role: The Institute's chief academic officer, the provost is responsible for advancing the academic agenda of the Institute. The provost works closely with the division chairs on program initiatives, serves as coordinator for curriculum development, and aids in development initiatives.

Tirrell's predecessor: Tirrell takes over the role from Edward Stolper, the William E. Leonhard Professor of Geology and the Carl and Shirley Larson Provostial Chair, who held the position for a decade. Stolper plans to return to the faculty full time to pursue his studies of the origin and evolution of igneous rocks on Earth and other planets.

"David Tirrell marshals insights across the intellectual spectrum in his view of Caltech and in his own research."

–Caltech president **Thomas F. Rosenbaum**

Object Lesson: Crushing it

What happens when you take a Styrofoam cup, put it in a basket on a deep-sea submersible, and take it down to a depth of 1,000 or so meters? It shrinks. A lot. This tiny treasure was given to Nathan Dalleska, director of the Environmental Analysis Center at Caltech, by then-graduate-student Abbie Green Saxena (PhD '13), who had the opportunity to go down in the submersible *Alvin* for a project on which the two were collaborating.

The cup had nothing to do with the project. It was just taken along for the ride, to create a fun memento of the dive. And how exactly did it end up so crushed? "A Styrofoam cup is a mass of solidified polystyrene bubbles fluffed up by a gas called a 'blowing agent,'" Dalleska explains. "When you subject it to very high pressure, the bubbles are squeezed down and down so the whole object shrinks. The cup material never returns to its original shape."

Dalleska has it on display, he says, "because I like the story and have fond memories of that particular collaboration. The usual reaction is curiosity, people wondering what it is, and then no small amount of amazement when they find out where it has been."