**Teaching and Writing at Caltech:
Past, Present, and Future**

Exhibit Text, Captions, and References

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# Introduction

From the austere classrooms of the early days of Throop University to the diverse scenes of Caltech today, the activities of teaching, learning, and writing have intertwined in complex ways. In this exhibit, we explore those interrelationships as they echo across eras, through photographs and manuscripts that are unique to our institute.

The exhibit explores Caltech’s dynamic history of teaching and learning through six frames: **Laboratory Learning**, **Field-based Learning**, **Informal Learning**, **Thinking at the Board**, **Classes and Demonstrations**, and **Acts of Writing.** These frames help us to understand and appreciate the incredible diversity of the scenes and acts of learning that characterize the Caltech experience.

Within each grouping, we encourage you to examine how some fundamental learning experiences seem to persist across many decades as well as how they evolve over time, changing in subtle or significant ways. Who teaches and who learns—their demographics and circumstances—are themes that are readily apparent in the images and relevant in light of Caltech’s history. How they teach and how they learn—the intensity, energy, engagement, collaboration, and thinking—also emerge as strong elements in these images, enduring across the decades.

Over the past five years, the Center for Teaching, Learning, and Outreach and the Hixon Writing Center have intentionally incorporated photographs and an interest in visual rhetoric into their approaches to communicating about the nature of teaching and writing at Caltech. The use of images has helped to raise the profile of these central activities, engage internal and external audiences in reconsidering their importance, and reenvision their methods and meaning. An article and photo essay published in Caltech’s *Engineering and Science* Fall 2013 edition is an example of such communication, which we now expand through this exhibit to include historical examples and show a wider range of recent images.

Historical photographs and manuscripts in this exhibit, along with information about their origins, are drawn from the Caltech Archives. Recent photographs feature the work of Martin Springborg and are part of a national, multi-institutional photo documentary endeavor, the Teaching and Learning Project. Also featured in the exhibit are photographs made by Caltech staff and students.

This exhibit was co-curated by Martin Springborg, photographer and faculty member at Minnesota State; Cassandra Volpe Horii, director of the Caltech Center for Teaching, Learning, and Outreach; and Susanne Hall, campus writing coordinator in the Hixon Writing Center and lecturer in writing. It was created in collaboration with Peter Collopy, university archivist and head of special collections, and staff of the Caltech Archives; support was provided by the Twenty-Seven Foundation as part of TeachWeek Caltech. The exhibit opened on April 23, 2018 on the third floor of the Center for Student Services building.

# Laboratory Learning

Teaching and learning in laboratories of all kinds—those devoted to classes and those dedicated to research—play central roles in the lives of Caltech professors and students. Here, we explore and celebrate some of those settings.

We see examples of the intense focus and interaction it takes to make new discoveries in the research labs of Caltech professors Ken Libbrecht, Henry Lester, and Nate Lewis, where Summer Undergraduate Research Fellows devote their summer breaks to research—something that approximately 75% of Caltech undergraduates do at least once, often with mentoring not only from professors, but also from postdocs and graduate students in labs. Today, Caltech also welcomes future scientists and engineers into labs: high school students in programs like Summer Research Connection and Community Science Academy explore their interests alongside undergraduates, graduate students, postdocs, research staff, and faculty.

Based on what we see in these photographs, it is not always easy to distinguish learning in a laboratory class from learning in a research lab. Are the students in lab coats making a research discovery or learning to do research in their chemical engineering lab? How about those in the electrical engineering lab in the early 1970s? Here, too, are glimpses of Caltech’s earliest teaching labs—some situated in Pasadena Hall (later renamed Throop Hall, which stood until the San Fernando earthquake of 1971), the first building establishing Throop Polytechnic Institute at Caltech’s current location in 1910. We see students in the original chemistry lab, up under the eaves of the building, students in physics class on the second floor, and students in the Electrical Testing Laboratory in the south half of the basement. Chemistry moved to a new building, Gates, in 1917—and the freshmen chemistry lab with it. We could find similar postures and moments in today’s lab classes—leaning on a lab bench, crouching to examine an experiment more closely, and working together—though unlike the early 1900s, Caltech students today include people of color and women.

The central image in this cluster brings us to a unique moment in Caltech’s history during World War II, when the institute worked with the U.S. government to offer courses relevant to the war effort, including a meteorological training course, in which we see a student calibrating a meteorgraph; elsewhere in this exhibit, we revisit this period through other WWII courses conducted outside the classroom/lab environment, dedicated to women learning
engineering.

**Captions:**

1. Floyd Humphrey (BS ’50, PhD ’56), Professor of Electrical Engineering and Applied Physics, in the Electrical Engineering lab with students. Year unknown (ca. 1970s). Photo: Caltech Archives.
2. LIGO SURF student working on the Thermal Noise Interferometer under the mentorship of Eric Black. 2002. Photo: Bob Paz.
3. Chemistry lab in Throop Hall (originally called Pasadena Hall). Year unknown, ca. 1910s. Photo: Caltech Archives.
4. Student calibrating an aircraft type meteorgraph in a Caltech-Armed Forces meteorological training course. 1941-1942. Photo: Caltech Archives.
5. Freshman chemistry lab, Gates Hall. 1921. Photo: Caltech Archives.
6. Student researchers in the Burdick group work on the development of a collapsible wheel for the Axel Rover. 2008. Photo: Bob Paz.
7. SURF student, Dongjin Seo (BS ’11; SURF ’08, ’09, ’10), working in the Kavli Nanoscience Institute cleanroom. 2009. Photo: Bob Paz.
8. Physics class on the 2nd floor of Throop Hall. ca. 1911. Photo: Caltech Archives.

Note: images in this section continue on the east foyer wall.

1. Junior, James Adler (BS ’07; SURF ‘06), researching the nucleation of ice in electric fields with Ken Libbrecht (BS ’80; SURF ’79), Professor of Physics. 2006. Photo: Bob Paz.
2. Henry Lester, Professor of Biology, in the lab with postdoctoral fellow Jeanne Nerbonne. 1979. Photo: Caltech Archives.
3. Students conducting experiments in the “Biomolecular Engineering Laboratory” course (ChE 130). 2013. Photo: Martin Springborg.
4. SURF student, Corinna Zygourakis (BS ’06; SURF ’02, ’03, ’04, ’05), examines the role of the frontoinsular cortex in social cognition under the mentorship of John Allman. 2005. Photo: Bob Paz.
5. Students in the Electrical Testing Laboratory, Throop College of Technology. 1914.
6. Nate Lewis, George L. Argyros Professor and Professor of Chemistry, and a student in the lab. 1993. Photo: Caltech Archives.
7. High school students taking part in the Community Science Academy summer program, learning how to perform limonene extraction from citrus peels. 2017. Photo: Mitch Aiken.

# Field-based Learning

Creating opportunities to take learning out into “the field”—real-world environments for applying lessons, investigating applications, and testing prototypes—is another enduring feature of a Caltech education.

Robert Sharp, Caltech geologist and professor, often led geological field trips for students, as these 1956 photographs likely show. In the same tradition, and with a similar combination of unfettered enjoyment, exploration, and community shown in the images, professors Paul Asimow, Bethany Ehlman, and their colleagues lead field trips for Caltech courses today. In his day, Sharp also suspected that “non-academic” colleagues in the department—“the lab technicians and the secretaries”—would have an interest in the kinds of work that students and faculty were doing in the field. He started to lead geological field trips specifically for those staff members to places like Owens Valley, where student field trips continue to this day.

In a lesser-known chapter of Caltech’s history, we find groups of women at the institute in the early 1940s. During World War II, the U.S. Civil Service and Office of Education worked with over a dozen universities to offer free evening courses to women, such as this “Engineering Fundamentals for Women” course, including instruction in surveying. Amy Sue Bix comments in *Girls Come to Tech! A History of American Engineering Education for Women*:

Even all-male Caltech agreed to set up a class, temporarily reversing its exclusion of female students. Thirty women suddenly appeared on campus, and male engineering students nicknamed them “Jennies,” short for their future posts as “junior engineers.” Caltech’s civil engineering instructor reported that women displayed “excellent” interest and were “doing better work than we at the Institute anticipated.”

This positive experience was not enough to change the institute’s admissions policies until several decades later.

In 2018, women outnumbered men in the two-term mechanical engineering design laboratory course, Me 72, for the first time in its 33-year history. The “final exam” consists of a competition among robotic devices designed and built by the students, which the campus community and local elementary school classes attend as spectators. In this case, locations around campus—in 2018, Beckman Lawn, and in earlier years, Millikan Pond and other locations—become the “field,” as students’ designs must perform under realistic and sometimes unexpected conditions. In 2018, an all-women team, The Riveters, won the Me 72 competition.

The “field” has also at times included other kinds of sites. Locomotives were of interest to students of professors Robert Knapp and Robert Dougherty, shown here on a 1925 field trip that may have helped inform the launch of the first laboratory at Caltech to conduct research on the hydraulics of centrifugal pumps soon after—an important development because the lab was not beholden to any specific pump manufacturers.

**Captions:**

1. Paul Asimow (MS ‘93, PhD ‘97), Eleanor and John R. McMillan Professor of Geology and Geochemistry, with students during a “mandatory (yet fun)” 3-day field trip to Owens and Long Valleys, part of “Introduction to Geology and Geochemistry,” (Ge 101). October 2012. Photo: Michael L. Wong.
2. William Michael, Caltech professor, with students and surveying equipment, in a tuition-free evening course entitled “Engineering Fundamentals for Women.” 1942-1943. Photos: Caltech Archives, likely by "Dick" Whittington.
3. See caption 2.
4. A student crouches to work on a robot tank designed and built as part of the “Engineering Design Laboratory” course (Me 72), in preparation for the competition that serves as the final exam for the course. March 8, 2018. Photo: Leslie Rico.
5. Geological field trip, likely led by Robert Sharp (BS ’34), Sharp Professor of Geology. 1956. Photo: Caltech Archives, Robert Sharp Papers.
6. Students taking a break on the dunes during a field trip for a course taught by Bethany Ehlmann, Professor of Planetary Science, “Fundamentals of Planetary Surfaces” (Ge 151). Fall 2013. Photo: Michael L. Wong.
7. See caption 5.
8. Students from “The Riveters” team prepare their robot tank for competition as part of the “Engineering Design Laboratory” course (Me 72). March 8, 2018. Photo: Leslie Rico.
9. Caltech professors Robert Knapp (front row, fourth from left), Robert Daugherty (front row, far right), and W. Howard Clapp (top row, third from left) with students on an Engineering field trip. 1925. Photo: Caltech Archives, by Paralta Studio, Los Angeles
10. Paul Asimow with students during a field trip for the course, “Introduction to Geology and Geochemistry” (Ge 101). Fall 2012. Photo: Michael L. Wong.
11. See caption 2.
12. See caption 2.
13. Caltech Geology field trip. 1940s. Photo: Caltech Archive.
14. A close up of a geological sample being examined during a field trip for “Fundamentals of Planetary Surfaces” (Ge 151). Fall 2013. Photo: Michael L. Wong.

# Informal Learning

This group of images explores the many informal interactions, spaces, and moments of teaching and learning that have helped define Caltech’s history and character.

On the very informal end of the spectrum, we find striking images related to Ditch Day and other outlandish and delightful episodes—students in bubbles, playing marbles, dancing, and playing the now-forgotten game of “push ball,” invented in the 1890s. While significant enjoyment comes through in the photographs, a fascination with the technical aspects of the activities is also apparent, as Caltech students undertake practical investigations of the opposing forces at play while dancing the tango, the mechanics of rolling and inelastic collisions in various games, and the ins and outs of air pressure in human-scale inflatable objects.

Students also engage intently with guest speakers in these images. In 1966, they lean in for a conversation with Roy Wilkins, awarded the Presidential Medal of Freedom the following year for his contributions to major civil rights victories. In 2015, they gesture and pose questions in response to comedian and educator Chris Duffy at a workshop on infusing joy into teaching. In 1967, they listen attentively to US Senator Charles Percy speak.

The audience shown at Percy’s talk, about a dozen students, appears to include one woman. A few years later, in 1970, a gathering of faculty and women graduate students at the home of Caltech president Harold Brown included Jenijoy La Belle, Caltech’s first female professor, whose 1975 landmark tenure case and Equal Employment Opportunity Commission ruling helped bring attention to gender discrimination in faculty hiring. While women graduate students had been earning PhDs in small numbers since the mid-1950s, Caltech’s first admitted women undergraduates arrived in 1970, after Brown’s insistence that the institute not wait to build new housing but act immediately on the institute’s 1969 decision. The proportion of women undergraduates remained near 10% until the early 1990s, when, according to dean Robert Huttenback (shown here at an outdoor “Deans’ Office Annex” gathering in 1970), a concerted effort was made, and it increased to approximately 30%. Recently, the percentage of women in the incoming undergraduate class has risen to as high as 46%, though the overall percentage, including graduate students, remains in the mid-30s—quite a contrast in gender composition, though not in exuberance, to the all-women class of 1907 of Caltech’s predecessor, Throop Polytechnic Institute.

While modern-day images are more diverse in terms of student race and ethnicity, few sources exist documenting these changes. Black graduate students attended Caltech sporadically since the 1930s and a small number of black undergraduates were present in the 1960s. Caltech enrollment by Asian, Hispanic, and Latino students has also increased, though their stories are difficult to find. Today, underrepresented minorities comprise about 16% of undergraduates and 5% of graduate students.

Notably, faculty are present throughout these informal moments—offering support, inspiration, humor, and company. Professors Harry Gray, Gerald Wasserburg, and Murray Gell-Mann share a light-hearted moment at a Caltech Y event dedicated to exploring the creative process (see “Acts of Writing” in this exhibit for additional information and manuscripts from Wasserburg and Gell-Mann). Professors Ray Owen and Harry Gray take part in a frosh workshop in Dabney Garden—both noted for their dedication to teaching and recognized with various awards.

**Captions:**

1. Caltech Y Panel Discussion entitled “The Creative Process: What Is it,” featuring Harry Gray, Arnold O. Beckman Professor of Chemistry and founding director of the Beckman Institute, Gerald Wasserburg, John D. MacArthur Professor of Geology and Geophysics, and Murray Gell-Mann, Robert Andrews Millikan Professor of Theoretical Physics. 1980s. Photo: Caltech Archives.
2. Graduate students and postdoctoral scholars at a workshop on “Bringing Joy into Your Teaching” by comedian and educator Chris Duffy. October 20, 2015. Photo: Martin Springborg.
3. Frosh workshop in Dabney Garden, with Caltech faculty members Ray Owen, Professor of Biology (seated on bench), and Harry Gray (center of back row) looking on. April 1971. Photo: Caltech Archives.
4. Roy Wilkins, NAACP Executive Director, meets with students at a Caltech Y event. February 1966. Photo: Caltech Archives, Caltech Y Papers.
5. L. Winchester (Winch) Jones with students; Jones held many roles at Caltech between 1925 and his retirement in 1968, including director and dean of admissions, professor of English, registrar, assistant dean of upperclassmen, and director of undergraduate scholarships. Date unknown. Photo: Caltech Archives, by Stuart W. Bowen, Pasadena.
6. A student participating in a “stack” (a challenge or puzzle) during Ditch Day, a Caltech tradition in which seniors set up challenges to occupy lower year students while the upperclass students leave campus. May 22, 2015. Photo: Jenny Somerville.
7. Students in large air balloon on the west lawn of the Athenaeum. ca. 1970s. Photo: Caltech Archives, by Floyd Clark.
8. Faculty members, including Jenijoy La Belle, Professor of English (end from right, seated), and women graduate students at home of Harold Brown, Caltech President. March 1970. Photo: Caltech Archives, by Floyd Clark.
9. Robert Huttenback, then dean of students, with students at the outdoor “Dean’s Office Annex.” 1970. Photo: Caltech Archives, by Floyd Clark.
10. Students listening to a talk by US Senator Charles Percy, formerly president of the Bell and Howell Corporation. May 1967. Photo: Caltech Archives, by Karel Bauer.

Note: “Informal Learning” images continue on the elevator wall.

1. Student Dance. ca. 1933-1935. Photo: Caltech Archives, C. W. Lindsay Collection.
2. Caltech Tango Club class in Winnett Center. October 2015. Photo: Martin Springborg.
3. Students with push ball. ca. 1933-1935. Photo: Caltech Archives, C. W. Lindsay Collection.
4. Students playing marbles. ca. 1933-1935. Photo: Caltech Archives, The C. W. Lindsay Collection.
5. Throop Polytechnic Institute class of 1907. ca. 1907. Photo: Caltech Archives.

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# Thinking at the Board

Little else matches the iconic place that chalkboards—typically full of equations, sometimes reaching from wall to wall and nearly floor to ceiling—hold in Caltech’s collective culture.

Indeed, chalkboards and blackboards, and now whiteboards (opinions vary), are one form of educational technology that endures. In part, such large, writable surfaces afford students, faculty, and TAs advantages that have been difficult to improve upon, while maintaining reasonable cost and ease of use. They allow instructors and students to view and collaborate on swaths of shared representation, to build and cross-reference sequences of ideas or steps, and to easily revise and augment their shared thinking—or erase it altogether and start with a clean slate.

Beyond the aesthetic enjoyment of a well-executed chalk/white board, these images capture the intensity, collaboration, and thinking that seems prevalent across Caltech’s various eras. Students and instructors gather at the board to master well-known subjects and to sort out new ones. They pause, gesture, and back up to take in the bigger picture. They listen, contribute, and add to each other’s work. Who gets to write, think, and learn at the board also changes over time, though not uniformly, to include students, women, and people of color. The form of the board is also changing. Instead of one wall with a writable surface that belongs to the instructor, some classes now use desktop whiteboards or rooms with boards on all walls—enough for all students to use them simultaneously. These changes can facilitate student collaboration and equitable access to the benefits of thinking at the board.

President Lee DuBridge is shown here at a chalkboard in 1962, charting a course to the planet Venus. In 1956, while presiding over Caltech’s student population of almost all men (the first woman to receive a PhD from the institute, Dorothy Ann Semenow, graduated in 1955), DuBridge wrote in *Science*, “We have almost completely failed in the physical sciences and engineering to make use of the talents and services of women.” Caltech would admit its first undergraduate women nearly a decade later, in 1970.

**Captions:**

1. Jesse DuMond (BS ‘16, PhD ‘29), Professor of Physics, with students in the classroom discussing the Compton Effect, a phenomenon about which DuMond made crucial research discoveries in the 1920s and 30s. Date unknown. Photo: Caltech Archives.
2. Arthur Erdelyi, Professor of Mathematics, with student, T. Ryan, discussing mathematics. Date unknown (C. 1950s). Photos: Caltech Archives.
3. Richard Feynman, Richard C. Tolman Professor of Theoretical Physics, lecturing at blackboard; the lecture title was “Motion of the Planets around the Sun,” and was originally given in the Feynman Lectures on Physics series, but was not published. March 13, 1964. Photo: Caltech Archives.
4. Richard Feynman lecturing at blackboard. Mid-1970s. Photo: Caltech Archives.
5. See caption 2.
6. Richard Feynman in classroom with students; the lecture title was “The Hamiltonian Matrix,” part of the Feynman Lectures on Physics series. May 2, 1963. Photo: Caltech Archives.
7. Teaching assistant for a course taught by Dianne Newman, Gordon M. Binder/Amgen Professor of Biology and Geobiology, “Principles of Biology” (Bi 1), working together to plan their approach to recitations. 2013. Photos: Martin Springborg.
8. See caption 2.
9. Joann Stock, Professor of Geology and Geophysics, at the board, explaining the three-dimensional system used in her demonstration about fault planes (see Demonstrations section of this exhibit). October 20, 2015. Photo: Martin Springborg.
10. Students work together and with Mike Brown, Richard and Barbara Rosenberg Professor of Planetary Astronomy, on in-class problems in “Applications of Physics to the Earth Sciences” (Ge 108)—a flipped class where students watch lectures online before class to prepare them for active problem-solving. October 22, 2015. Photo: Martin Springborg.
11. Theo Agapie, Professor of Chemistry, at the board, early and later in his class, “Inorganic Chemistry” (Ch 112). October 20, 2015. Photo: Martin Springborg.
12. See caption 11.
13. See caption 10.
14. See caption 10.
15. Students in a course taught by Antonio Rangel, Bing Professor of Neuroscience, Behavioral Biology and Economics, “Principles of Economics” (Ec 11), working together to solve problems using table-top whiteboards. 2017. Photo: Cassandra Horii
16. Students in Physics 1a work together at floor-to-ceiling chalkboards on the top floor of Lauritsen, solving problems in Newtonian Mechanics, with guidance from TAs. 2015. Photos: Martin Springborg.
17. See caption 10.
18. Lee DuBridge, President (1946-1969) and Professor of Physics, lecturing at a blackboard. October 5, 1962. Photo: J. Loengard.
19. See caption 10.
20. See caption 16.
21. See caption 10.
22. See caption 16.
23. See caption 10.

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# Classes

What comes to mind when you hear the phrase “Caltech class”? Do you picture students, professors, and teaching assistants holding discussions in Millikan Pond, gathered around tables in Avery Dining Hall, clustered in groups in Noyes 147, or working on problems on all four sides of the room in South Mudd? Or does some other scene come to mind? Classrooms, and what we do in them, are both fixed and constantly changing—sometimes changing through instructors’ efforts to overcome their fixed attributes with creative approaches.

Upending our expectations of old and new teaching approaches, these images reveal dynamic moments and connections in classrooms and lecture halls from the earliest days of the Institute, along with a visual narrative of Caltech’s changing student population. In its years as Throop Polytechnic Institute (1893-1912), students included men and women, from elementary grades through college, in subjects ranging from clay modeling (shown), to other manual skills like wood shop, drawing, and cooking, alongside mathematics, biology, chemistry, physics, history, civics, and ancient and modern languages. Later, as the California Institute of Technology sought to become a preeminent engineering institution, enrollment was limited to men, and classroom spaces still in use today were born. Professor Earnest Watson oversaw the construction of Bridge Laboratory in 1922, creating 201 E. Bridge—the site for the Feynman Lectures on Physics in the 1960s, where we see moments of levity and connection, and the home of the Physics 1 course series today, which nearly every Caltech undergraduate takes in their first year.

While lectures are not going away, we also see examples breaking out of the mold. In some cases, Caltech professors, such as Paul Asimow in “Earth and Environment” (Ge 1) and Theo Agapie in “Inorganic Chemistry” (Ch 112) have students working with samples, models, or in groups—regardless of the fixed seating arrangements in their lecture halls. In other cases, such as Howard Lucas’s intimate discussion with his organic chemistry students in the late 1940s, and Mike Brown’s guided problem solving in recent offerings of “Applications of Physics to the Earth Sciences” (Ge 108), the qualities of engagement and connection are readily apparent. Some, like Jenijoy La Belle (1970) and Antonio Rangel (2017) have temporarily escaped the formal classroom altogether to try teaching in unconventional settings—Millikan Pond and Avery Dining Hall, respectively.

What happens in Caltech classrooms has been recognized through awards and prizes, given by the Institute and by outside societies and organizations. Building on Feynman’s dedication to teaching, the Richard P. Feynman Prize for Excellence in Teaching has been awarded to Caltech professors since 1993, including those given to Paul Asimow in 2012, Mike Brown in 2007, and others across the academic divisions. Howard Lucas was honored in 1953 with the American Chemical Society’s Scientific Apparatus Makers Award in Chemical Education, and Theo Agapie was named a 2013 Cottrell Scholar, an award dedicated to the nation’s very best early career teacher-scholars in chemistry, physics, and astronomy.

**Captions:**

1. Richard Feynman and Robert Leighton, William L. Valentine Professor of Physics, with students in 201 E. Bridge, at the first lecture of the Feynman Lectures on Physics series, entitled “Atoms in Motion.” September 26, 1961. Photo: Caltech Archives.
2. Antonio Rangel, Bing Professor of Neuroscience, Behavioral Biology and Economics, working with students in “Principles of Economics” (Ec 11), in Avery Dining Hall, turned in to an active learning classroom for a day. 2017. Photo: Cassandra Volpe Horii.
3. Melany Hunt, Dotty and Dick Hayman Professor of Mechanical Engineering, teaching “Thermal Science” (E 11a), with students, their notes, and a sign-in for TeachWeek Open Classes in the foreground. 2015. Photo: Martin Springborg.
4. Jenijoy La Belle, Professor of English, teaching her class in the Millikan Library reflecting pool; the caption in Engineering and Science (March 1971) read, “When the weather gets really hot, you’re liable to find almost anything in the water.” 1970. Photo: Caltech Archives, attributed to Caltech photographer.
5. Howard Lucas, Professor of Organic Chemistry, with a group of chemistry students. In 1953, Lucas was honored with the American Chemical Society’s Scientific Apparatus Makers Award in Chemical Education—a $1000 award; he oversaw Caltech’s undergraduate courses in organic chemistry for 38 years. 1948. Photo: Caltech Archives.
6. Clay modeling class, Throop Polytechnic Institute. 1900. Photo: Caltech Archives.
7. Students examine and share geological samples in a course taught by Paul Asimow (MS ‘93, PhD ‘97), Eleanor and John R. McMillan Professor of Geology and Geochemistry, “Earth and Environment” (Ge 1). 2013. Photo: Martin Springborg.
8. See caption 7.
9. Richard Feynman, Richard C. Tolman Professor of Theoretical Physics, teaching Physics X to a relaxed group of students. 1976. Photo: Floyd Clark, Physics.
10. Paul Asimow with students in “Earth and Environment” (Ge 1). 2013. Photo: Martin Springborg.
11. Student groups discuss problems with the professor and teaching assistants in a course taught by Theo Agapie, Professor of Chemistry, “Inorganic Chemistry” (Ch 112). 2015. Photos: Martin Springborg.
12. See caption 10.
13. See caption 11.
14. Students in 201 E. Bridge during Physics 1a, an introductory course in Newtonian Mechanics. 2015. Photo: Martin Springborg.
15. Students of Mike Brown, Richard and Barbara Rosenberg Professor of Planetary Astronomy, in “Applications of Physics to the Earth Sciences” (Ge 108) spend class time working at whiteboards, discussing problems, and getting feedback; TeachWeek visitors observe. 2015. Photo: Martin Springborg.

# Demonstrations

From Caltech’s earliest days to the present, hands-on demos of scientific concepts and phenomena have been a mainstay. While we now know more about maximizing the depth and clarity of students’ learning from demonstrations (e.g., by making predictions before observing the demo and following up to articulate and correct the reasoning), the importance and immediacy of bringing demos into the classroom and other learning settings is enduring.

Strikingly, we see devices like the Sterling Engine used by mechanical engineering professor Melany Hunt to bring thermodynamics to life in “Thermal Science” (ME 11a). Props and objects used in demonstrations may be relatively simple and low-tech, too: a hamster ball, a bowling ball, a bicycle wheel, the students themselves. Here, we see these objects in use by Caltech professors in their undergraduate classes, including Joann Stock’s freshman seminar on Earthquakes (FS 16) and Ryan Patterson’s class on Newtonian Mechanics (Ph 1a). Several Science Night demonstrations by Caltech graduate students at local elementary schools also make appearances, with the added delight of potentially inspiring future scientists and engineers.

The Caltech tradition of employing demonstrations both to advance our students’ high-level understanding, and to enliven science for younger students and the public, has origins dating back to Caltech professor Earnest Watson’s work in the 1920s. On the 75th anniversary of the Watson Lecture series, Caltech noted that Watson began his “weekly demonstration lectures at Caltech because he felt the school’s course in physics problems was dull.” These demonstrations began in 1919 for the campus community, and after 201 E. Bridge was finished, were opened up to the public in 1922. Here we see two views of Watson’s renown “liquid air” demonstration, which he performed regularly on campus, took on the road to high schools, and conducted in 1964 at the opening of Beckman Auditorium—where Watson Lectures continue to be held today.

**Captions:**(Note: Caption numbers continue from “Classes,” which is on the same wall in the exhibit.)

1. Joann Stock, Professor of Geology and Geophysics, and students use various props (hamster ball, coasters, an overhead projector) to explore fault planes and focal mechanisms in “Earthquakes” (Freshman Seminar 16). 2015. Photo: Martin Springborg.
2. See caption 16.
3. Earnest Watson, Professor of Physics, giving his “liquid air” demonstration in 201 E. Bridge, which he did regularly on campus as well as for high schools in the area and the public. Date unknown (ca. 1940s). Photo: Caltech Archives, Watson Papers.
4. See caption 16.
5. See caption 16.
6. Graduate student Arian Jadbabaie gives a lesson on angular momentum to a student at the Eliot Arts Middle School Science Night. 2018. Photo: Kitty Cahalan.
7. Ryan Patterson, Professor of Physics, demonstrating principles of kinetic and potential energy in E. Bridge 201 during Physics 1a, Caltech’s introductory course in Newtonian Mechanics. 2015. Photo: Martin Springborg
8. Arie Haagen-Smit, Professor of Bio-organic Chemistry, conducting a demonstration on the formation of smog. ca.1950s. Photo: Caltech Archives.
9. See caption 22.
10. Melany Hunt, Dotty and Dick Hayman Professor of Mechanical Engineering, demonstrates principles of thermodynamics in “Thermal Science” (E 11a). 2015. Photo: Martin Springborg.
11. Fifth graders from Los Angeles 68th Street Elementary school learn about curvature of space-time with LIGO's stretchy universe demonstration. 2018. Photo: Kitty Cahalan.
12. See caption 25.
13. Earnest Watson giving a demonstration in 201 E. Bridge. Date unknown (ca. 1940s). Photo: Caltech Archives, by C. B. Mitchell, Watson Papers.
14. A student dashes up the stairs in 201 E. Bridge during a demonstration in Ryan Patterson’s Physics 1a course. 2015. Photo: Martin Springborg.

# Acts of Writing

Acts of writing are fundamental to the work of teaching and learning. This selection of texts and images from Caltech’s past and present illustrates a dynamic ecosystem of writing related to student learning.

Scientific journal articles are seen here displayed proudly in the hallway of Richard M. Murray's lab, celebrating the culmination of years of learning and research. If we take a closer look at professional scientific writing, we can see the importance of learning-through-writing, as exemplified in a page from Caltech professor Murray Gell-Mann’s revision of notes from a presentation. Gell-Mann’s draft dramatizes that the work of writing is not merely an act of typing up known information—rather, revision is a mode of active thought in which ideas are developed, revised, and sometimes discarded. Gell-Mann was working on this paper in 1969, the same year he received the Nobel Prize for Physics for his work in quantum field theory.

The texts that scientists publish are then often brought into the classroom as documents for teaching, as we can see from graduate student Donald A. Glaser’s class notes on Leonard I. Schiff’s article “Production of Particle Energies beyond 200 Mev” (1946) in his course notebook. Schiff’s article appears to have been assigned by Charles Christian Lauritsen during his “Atomic and Nuclear Physics” course at Caltech. Glaser's careful notes remind us of the ways research writing directly informs teaching and learning. Glaser went on to a distinguished career in physics, publishing his own work on techniques for studying physics, among other things. He won the Nobel Prize in Physics in 1960 for his invention of the bubble chamber, a device used for experiments in high energy physics.

Much of the work of teaching also involves composing texts, as shown by professor Gerald J. Wasserburg's working and final drafts of a problem set—titled, cheekily, “Unsolicited Problem Set No. 7”—for his graduate course, “Advanced Petrology.” Students rarely see all the documents that go into the work of teaching, many of which are behind-the-scenes or reworked extensively before they are shared with students. We get some sense of the variety and importance such texts by looking at Susanne Hall’s table in the classroom of her “Writing about Science” (Wr/En 84) course. It overflows with the documents she uses to teach—lesson plans, assigned readings, notes on the readings, texts written by students, and handouts for activities to be undertaken in class.

Classrooms and labs, then, are full of writing by both professors and students. Students through the ages have taken notes during lectures, a practice that is still going strong, as is clear in the recent images from Paul Asimow’s “Earth and Environment” (Ge 1) course. Carefully written lab instructions guide the work of students in their “Biomolecular Engineering Laboratory” course (ChE 130), taught by David Tirrell and Michael Vicic.

In examining these images and texts, it becomes clear that the journal article, a capstone of successful research, can only be written after hundreds of other acts of writing, revision, and critical reading—by both professors and students—that contribute to learning and the development of ideas.

**Captions:**

1. Revision notes on a talk being reworked for publication, "Symmetry Violation in Hadron Physics,” by Murray Gell-Mann, Robert Andrews Millikan Professor of Theoretical Physics. 1969. Caltech Archives, Murray Gell-Mann Papers.
2. Published papers from the Richard M. Murray lab are proudly displayed in a hallway. 2013. Photo: Martin Springborg.
3. Carefully written lab instructions guide students toward successful experiments in “Biomolecular Engineering Laboratory” (ChE 130). 2013. Photo: Martin Springborg.
4. Paul Asimow (MS ‘93, PhD ‘97), Eleanor and John R. McMillan Professor of Geology and Geochemistry, teaches "Earth and Environment" (Ge 1) as students take notes. 2013. Photos: Martin Springborg.
5. See caption 4.
6. Graduate student Donald Glaser's notes on an article by Leonard I. Schiff that was assigned reading in a course on “Atomic Physics” taught by Charles Christian Lauritsen (PhD ’29), Professor of Physics. 1940s. Courtesy of Caltech Archives, Donald A. Glaser Papers.
7. The working and revised draft of "Unsolicited Problem Set No. 7" for an “Advanced Petrology” course by Gerald J. Wasserburg, John D. MacArthur Professor of Geology and Geophysics. Late 1950s or 1960s. Caltech Archives, Gerald J. Wasserburg Papers.
8. The table of Susanne Hall, Campus Writing Coordinator in the Hixon Writing Center and Lecturer in Writing, overflows with texts of various kinds during a class meeting of "Writing about Science," a course focused on teaching students to communicate scientific knowledge to non-experts. 2013. Photo: Martin Springborg.
9. See caption 7.

# References

Bix, Sue. *Girls Coming to Tech!: A History of American Engineering Education for Women*. MIT Press, 2013.

Boehm, Felix. “Jesse W. M. DuMond, 1892-1976: A Tribute*.*” *Engineering and Science,* March-April 1977, pp. 35-36, calteches.library.caltech.edu/367/1/dumond.pdf.

Brown Harold. *Interview with Harold Brown (b. 1927) by Alice Stone*. March 19, 1990, resolver.caltech.edu/CaltechOH:OH\_Brown\_H.

Burnton, Simon. “The forgotten story of…pushball, a game for giants that bewitched Britain.” *The Guardian*, June 1, 2017, www.theguardian.com/sport/blog/2017/jun/01/the-forgotten-story-of-pushball-a-game-for-giants-that-bewitched-britain.

Caltech Archives. *Fast Facts About Caltech History*. archives.caltech.edu/about/fastfacts.html.

“Clark to staff Alumni Fund.” *Caltech News*, 1978 12(2), p. 3, caltechcampuspubs.library.
caltech.edu/2356/1/1978\_03\_12\_02.pdf

Collins, Sibrina Nichelle. “Unsung: James Ellis LuValle. *Undark: Truth, Beauty, Science*, August 165, 2016, undark.org/article/unsung-james-ellis-luvalle-olympics/.

Craven, Wesley Frank, and James Lea Cate, editors. *The Army Air Forces in World War II, Volume Six: Men and Planes*. New Imprint by the Office of Air Force History, 1983.

Division of Engineering and Applied Sciences. “Professor Atwater Receives James King Award.” May 24, 2016, eas.caltech.edu/news/855.

Gally, Sid. “Past on Parade: Throop cooking classes began Caltech tradition.” *Los Angeles Daily News*, October 3, 2010, www.dailynews.com/2010/10/03/past-on-parade-throop-cooking-classes-began-caltech-tradition/.

Gell-Mann, Murray. “Symmetry Violation In Hadron Physics” In *Hawaii Topical Conference In Particle Physics, Vol. 1*, edited by S. Pakvasa and S. F. Tuan, 161-188. Caltech, 1983.

Goins, Edray Herber. *The History of Caltech's Underrepresented Students*. Accessed April 14, 2018. http://www.math.purdue.edu/~egoins/notes/caltechs\_minorities.pdf.

Goodstein, Judith R., and Alice Stone. *Caltech's Throop Hall*. Friends of Caltech Libraries, 1981, authors.library.caltech.edu/25055/1/CaltechBOOK\_throop.pdf.

Goodstein, Judith R. *Millikan's School: a History of the California Institute of Technology*. Norton, 2006.

Greenstein, Jesse L. *Lee Alvin DuBridge, 1901-1994: A Biographical Memoir*. National Academies Press, 1997, www.nasonline.org/publications/biographical-memoirs/memoir-pdfs/dubridge-la.pdf.

Hill, Judy. “2018 Feynman Teaching Prize is Awarded to Harry Gray.” California Institute of Technology, February 19, 2018, www.cce.caltech.edu/content/2018-feynman-teaching-prize-awarded-harry-gray.

Huttenback, Robert A. *Interview with Robert A. Huttenback (1928-2012) by Shirley K. Cohen*. September 14 and November 6, 1995, resolver.caltech.edu/CaltechOH:OH\_Huttenback\_R.

Jones, Winchester. “Winchester Jones—How It Was: Oral History.” *Engineering and Science*, September-October 1979, pp. 23-27, 32. calteches.library.caltech.edu/3244/1/jones.pdf.

La Belle, Jenijoy. *Interview with Jenijoy La Belle (b. 1943) by Heidi Aspaturian*. February – May 2008, April 2009, resolver.caltech.edu/CaltechOH:OH\_LaBelle\_J.

NAACP. “NAACP History: Roy Wilkins.” www.naacp.org/oldest-and-boldest/naacp-history-roy-wilkins/.

Office of the Provost. “Richard P. Feynman Prize for Excellence in Teaching.” California Institute of Technology, provost.caltech.edu/FeynmanTeachingPrize.

Registrar. “Fall Enrollment 2017-18.”  Caltech Office of the Registrar, www.registrar.caltech.edu/academics/enrollment.

“Roy Wilkins, of the NAACP, chats with Caltech students, during visit arranged by Caltech Y.” *Independent Star News, Pasadena*, February 13, 1966, p. 83, www.newspapers.com/newspage/31752710/

Schiff, L. I. “Production of Particle Energies beyond 200 Mev.” *Review of Scientific Instruments* 17, 6, 1946.

Shapin, Steven. *The Scientific Life: A Moral History of a Late Modern Vocation*. University of Chicago Press, 2009.

Sharp, Robert. *Interview with Robert P. Sharp (I), 1911-2004, by Graham Berry*. December 18, 1979 – January 9, 1980. resolver.caltech.edu/CaltechOH:OH\_Sharp\_1.

Smith, Douglas. “Fifty Years of Clearing the Skies: A Milestone in Environmental Science. California Institute of Technology, April 25, 2013, www.caltech.edu/news/fifty-years-clearing-skies-39248.

Staff. “Faculty Portrait: Howard J. Lucas.” *Engineering and Science*, 1953, 16 (6), pp. 21–22, calteches.library.caltech.edu/1360/1/Lucas.pdf.

Staff. “Earnest Watson--1892-1970*.*” *Engineering and Science,* 1971, 34 (24). pp. 26-10, resolver.caltech.edu/CaltechES:34.24.watson.

Svitil, Kathy. “Remembering Ray D. Owen (1915-2014).” California Institute of Technology, September 23, 2014. www.bbe.caltech.edu/content/remembering-ray-d-owen-1915-2014

Tindol, Robert. “Watson Lectures To Celebrate 75th Anniversary.” Caltech Media Relations, 1997, www.caltech.edu/news/watson-lectures-celebrate-75th-anniversary-211.

Watson, Earnest C. *Interview with Earnest C. Watson by Larry Shirley.* January 20, 1969, resolver.caltech.edu/CaltechOH:OH\_Watson\_E