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Moore Lab

Walking the Moore Walk

On Gordon Moore's philanthropic legacy and how it changed the landscape of Caltech.

By Andrew Moseman

Carver Mead (BS '56, MS '57, PhD '60) was just starting a decades-long career as a professor at Caltech in 1959 when his future entered his office carrying a briefcase full of spare parts. The unannounced visitor to the Eudora Hull Spalding Laboratory of Engineering introduced himself as Caltech alumnus Gordon Moore (PhD '54), then working for a new company called Fairchild Semiconductor and keen to meet the man running the Institute's electronics teaching lab.

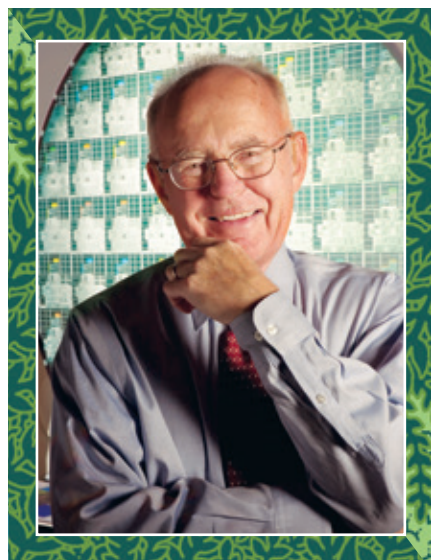
"He asked, 'Are you using transistors?'" Mead remembers. "I said, 'Yes.' He said, 'Would you like some transistors to use in your class?' And I said, 'I sure would.' So, he opened his briefcase—it was an old-fashioned one, a clamshell—and he pulled out bulging manila envelopes."

Mead recognized the contents: the envelopes swelled with then-state-of-the-art transistors, the 2N697 and 2N706, the latter of which Mead calls "a beautiful little transistor, just perfect for teaching classes." The meeting marked the beginning of a lifelong partnership in which Moore collaborated with the professor as Mead pioneered very large-scale integration, the cornerstone of modern computing; and Mead helped Moore define his namesake law that states that the number of transistors that fit on an integrated circuit will double every two years.

For Moore, who in 1968 went on to co-found the iconic chipmaker Intel Corporation (a company now valued at more than \$140 billion), those little transistors offered to a young professor also launched his towering legacy of philanthropy to Caltech. Among those contributions was a 2001 gift in which he and his wife, Betty, personally committed \$300 million to Caltech and contributed another \$300 million through the Gordon and Betty Moore Foundation. The combined \$600 million represented the largest philanthropic donation to an institution of higher learning up to that point.

The Moores also provided two unrestricted gifts during Caltech's *Break Through* campaign: \$100 million that the Institute used to match graduate fellowships, which provide individual graduate students with the freedom and flexibility to fully pursue their educational and research interests, and a further \$37 million to support student scholarships. Moore believed deeply that this kind of unrestricted funding was the best way for him to support Caltech's signature brand of high-risk, high-reward ideas, especially those that crossed academic divisions or were at too early a stage and too far removed from commercial realization to garner federal funding.

"Those within the Institute have a much better view of what the highest priorities are than we could have," he



Gordon E. Moore, co-founder of Intel Corporation and the Gordon and Betty Moore Foundation, in 2005.

said at the time of the \$100 million gift. "We'd rather turn the job of deciding where to use resources over to Caltech than try to dictate it from outside."

There are few corners of Caltech the Moores have not touched. The Gordon and Betty Moore Laboratory of Engineering, home to Caltech's electrical engineering department, was dedicated in 1996. Moore Walk, which had its finishing touches completed this year, was named in

his honor in 2002. A long list of graduate and postdoctoral fellowships, undergraduate scholarships, and Caltech professorships have benefited from support by the Moores or their foundation, especially when this philanthropy amplified other donors' gifts by providing matching funds. Moore endowed the professorship now held by his old friend Mead, a fellow Distinguished Alumni Award winner who is now the Gordon and Betty Moore Professor of Engineering and Applied Science, Emeritus.

Even after his retirement as Intel's CEO, Moore served as chair of Caltech's Board of Trustees from 1993 to 2000, the year in which he and his wife established the Gordon and Betty Moore Foundation, a private and competitive grant-making organization that continues to expand upon Moore's philanthropic legacy. Moore's son, Kenneth Moore, now serves as a trustee on Caltech's board.

"Gordon Moore is an inspiration for Caltech students, alumni, and leaders," Caltech's Board of Trustees chair David W. Thompson (MS '78) said in a tribute to Moore, who passed away on March 24, 2023, at age 94 (see page 39). "With ambition, ingenuity, and magnanimity, he changed the world and positioned the Institute's scholars to pursue equally transformative goals."

"Gordon and Betty's philanthropy, both personal and through the Moore Foundation, continues to expand the universe of knowledge and will continue to enrich the lives of young scholars for generation after generation," says Caltech president Thomas F. Rosenbaum, the Sonja and William Davidow Presidential Chair and professor of physics. "Gordon's innate curiosity, thirst for discovery, humility, and love for Caltech always shone brightly."

Overall, the Moores' personal commitments totaled nearly \$440 million, making them Caltech's most generous alumni donors. The foundation has given another \$469 million to the Institute, between the initial Caltech commitment of \$300 million and other funding dispersed

through competitive programs and grants. The Institute has used the Moores' unrestricted gifts to foster bold new ideas and support one of Caltech's most important resources: its people. To do so, Caltech created a matching program that has had a multiplier effect by amplifying other donors' impacts and, in turn, leveraging additional support. This has led to the creation or continued funding of approximately 100 graduate fellowships, 12 new undergraduate scholarships, and seven leadership chairs that provide unrestricted funding for the holders' discretionary use.

"From his time as a student through his service as chair of the Caltech Board of Trustees, Gordon understood the power and promise of Caltech as a leader in science, engineering, and higher education," says Harvey Fineberg, M.D., president of the Gordon and Betty Moore Foundation. "Through the foundation and in his personal philanthropy, Gordon remained a staunch supporter of Caltech throughout his life."

Idea Accelerator

A few years ago, David Van Valen (PhD '11) had an idea: he wanted to explore a new way to study how single cells process information. But the Caltech assistant professor of biology and biological engineering thought it was too risky to pursue—until he read about the Moore Inventor Fellowships in a departmental email and wondered if his research project, a concept that sits at the interface of technology, biology, and computation, might be exactly what the program is intended to encourage. Still, he had convinced himself the idea was too raw to solicit funding until a nudge from Richard Murray (BS '85), the William K. Bowes Jr. Leadership Chair for the Division of Biology and Biological Engineering, persuaded him to proceed.

In 2021, Van Valen was named a Moore Inventor fellow, and he says that the support has been transformative for his project. The Moore Foundation gives each fellow a total of \$675,000 over three years to pursue their concept. The idea for the fellowship was inspired by the 50th anniversary of Moore's Law and in honor of its creator's penchant for invention. Van Valen's group wanted to advance a new technique, a kind of optical barcoding in which combinations of spatial and color patterns can assist researchers as they delineate how individual cells respond to specific types of stimuli and which genes prompt those behaviors.

"Without support from the Gordon and Betty Moore Foundation, this story ends here, where it's a cool idea but it's not an actual technology," Van Valen says. "We just didn't have the resources to pursue this risky concept. But the foundation gave us what we needed to go down that path." The foundation supported not only necessary technology and tools but also lab managers and students, including a Summer Undergraduate Research Fellowship

(SURF) student who worked in Van Valen's lab. "It's a night-and-day story," Van Valen adds. "Now we have projects. The technology that we set out to build has been built, and it works."

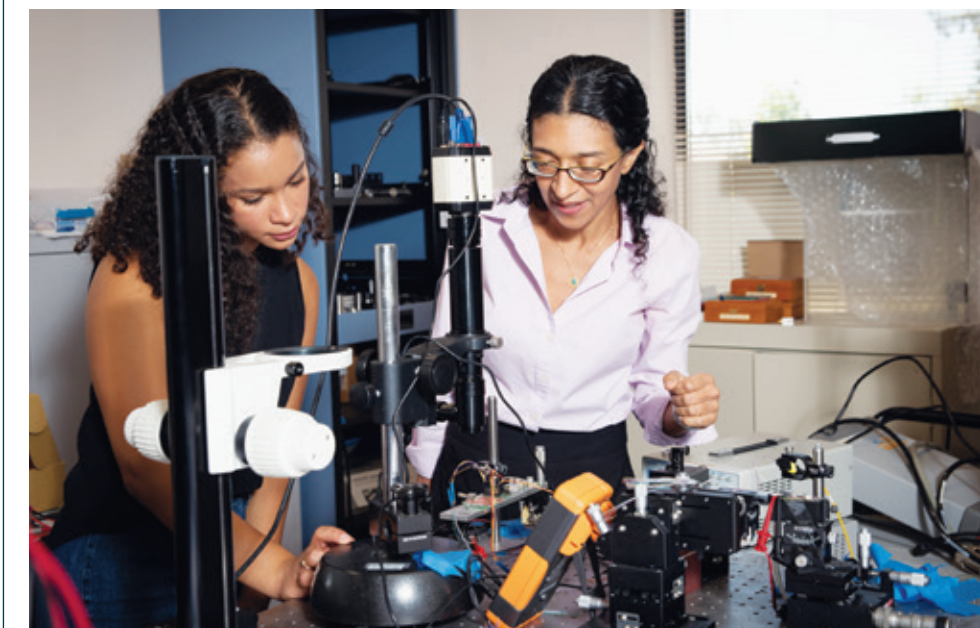
Faculty Benefactor

When Azita Emami, the Andrew and Peggy Cherng Professor of Electrical Engineering and Medical Engineering, joined the Caltech faculty in 2007, she was able to set up her lab, in part, as a result of support from a 2003 Moore Foundation grant. "The startup packages are a marvelous support as we launch our careers, take new directions, and have the freedom at the beginning to define what we want to do," she says.

Emami—whose lab is in the Moore Laboratory, which sits on Moore Walk—says the early financial support meant she could begin her work immediately and did not have to dedicate her first year to seeking grants to support graduate students or purchase equipment for her research: "In my field, because I work on very high-speed data communication systems and optical communication systems, I needed very expensive equipment. So, startup funding helps junior faculty buy those kinds of very specialized instruments and equipment that they need."

Moore's legacy impacted her career in several other ways as well, Emami says. His work at Intel pushed the boundaries of computing power and speed, creating new opportunities in her field. The Moore match funded numerous graduate students who have worked in her lab. And his stature has encouraged many other donors to support the Institute.

Professor Azita Emami (right) with 2021 WAVE student Liliana Edmonds.



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“The name Gordon Moore by itself brings a lot of prestige, and donors appreciate that someone like him is matching the funds,” Emami says.

And Everything in Between

Mead notes that, although Moore came from a chemistry background, he was eager to invest in big ideas, especially the interdisciplinary ones so common at Caltech. Moore provided matching funds to support not only professorships, fellowships, and scholarships, but also leadership chairs that provide the holders with discretionary funding to jumpstart new initiatives.

One such initiative that was supported with discretionary funding from a leadership chair is the Center for Science, Society, and Public Policy (CSSPP), which was established in 2023 in the Division of the Humanities and Social Sciences. The center, led by professors Michael Alvarez and Frederick Eberhardt, was conceived to provide a forum for research and discussion of issues at the intersection of science, ethics, and public policy.

CSSPP recently welcomed incoming postdoctoral scholars Cong Cao and Ozan Gurcan. Cao's research focuses on the intersection of biology, economics, and artificial intelligence (AI). One of her projects, on climate change and public health, leverages AI models of how pollution spreads under different temperatures, car traffic patterns,

and weather trends to predict the locations of outsized respiratory and cardiovascular problems among the people who live and work in the most impacted areas. Gurcan explores questions of moral and political philosophy regarding genetic technologies and hopes to help society think through the ethical dimensions of genetic discrimination.

Through its 2001 commitment, the Moore Foundation also supported the Thirty Meter Telescope, Kavli Nanoscience Institute at Caltech, Center for Analysis of Higher Brain Function, Moore Center for Theoretical Cosmology and Physics, Institute for Quantum Information and Matter, Caltech Tectonics Observatory, Center for Catalysis and Chemical Synthesis, and more.

Beyond the Moores' direct contributions, the foundation's investments in science have yielded numerous grants to leading-edge initiatives at Caltech. These include the Marine Microbiology Initiative, an interdisciplinary effort to better understand the diversity and behavior of marine microbial communities, which received nearly \$5 million to support the advancement of research by Victoria Orphan, the James Irvine Professor of Environmental Science and Geobiology and the Allen V. C. Davis and Lenabelle Davis Leadership Chair for the Center for Environmental Microbial Interactions.

Through its competitive grant programs, the foundation has also funded physicist Jamie Bock's BICEP Array project, which seeks to measure the cosmic microwave

In Memoriam

Read more about their lives at magazine.caltech.edu/post/in-memoriam



Gordon E. Moore (1929–2023)

Gordon E. Moore (PhD '54), a Caltech Board of Trustees chair emeritus, visionary philanthropist, and pioneer of the modern electronics industry, passed away on March 24, 2023, at age 94. In 1968, Moore and his colleague Robert Noyce co-founded chipmaker Intel Corporation. Moore served as executive vice president of the company until 1975 and as CEO from 1975 to 1987. In 1965, Moore predicted the number of transistors that can fit on a chip would double every year, a trend he forecasted would continue through 1975, at which point he updated his prediction to once every two years. This principle, now known as Moore's Law, has become the guiding principle for the industry. Named a Caltech Distinguished Alumnus in 1975, Moore became a Caltech trustee in 1983, a senior trustee in 2001, and a life member of the Caltech community in 2009. He served as Caltech Board chair from 1993 to 2000, the year he and his wife established the nonprofit Gordon and Betty Moore Foundation.

background of the universe; seismologist Zhongwen Zhan's (PhD '14) fiber-optic seismology project, which uses old telecommunications infrastructure to detect earthquakes; research toward the ShakeAlert Earthquake Early Warning system; and the Institute's First-Year Success Research Institute (see page 30).

While the Moores' philanthropy buoyed promising ideas and inspired a great many people, it also sparked a change in the Institute's culture, Emami says.

“Caltech realized how transformative it is to have this type of support,” she says. “It allows us to take risks, it allows us to have more freedom and do what we believe in rather than trying to convince others that it's a good idea, and it allows new projects by new faculty members to take shape. Moore was the person who really changed that paradigm for Caltech.”

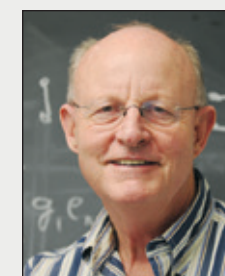
Fundamentally, Mead says, Moore loved to support Caltech because he saw it as a place that shared his values, especially his commitments to efficiency, drive, and accomplishment.

“Gordon understood that Caltech was a special place because he had been here; he earned his degree here,” Mead says. “He realized that Caltech is about getting things done, getting things figured out. It's about excellence, and about the frontier of knowledge. These were values that Gordon fully adopted as part of his being.”



Stanley Deser (1931–2023)

Stanley Deser, a theoretical physicist known for his achievements in general relativity, quantum field theory, and high-energy physics, passed away on April 21, 2023, at age 92. After Deser retired from Brandeis University in 2005, he moved to Pasadena and secured a research appointment at Caltech. At the time of his passing, he served as a visiting associate in theoretical physics at Caltech and was the Ansell Professor of Physics, Emeritus, at Brandeis. Deser and his colleagues Charles Misner and Richard Arnowitt conceived a mathematical description of energy and mass in the context of Albert Einstein's general theory of relativity, which they called ADM formalism (ADM refers to the first initials of the researchers' last names). This, together with Deser's work on supergravity, influenced the development of theories of quantum gravity.



David B. Wales (1939–2023)

David B. Wales, who spent more than 50 years as a Caltech faculty member and administrator, passed away on July 17, 2023, at age 83. In addition to serving on the faculty in the Division of Physics, Mathematics and Astronomy, he was also Caltech's associate dean of students from 1976 to 1980, dean of students from 1980 to 1984, executive officer for mathematics from 1985 to 1991, and master of student houses from 1991 to 1997. Wales retired in 2008 but remained active in math research. An expert in group theory, algebraic combinatorics, and representation theory, he spent the most time on finite group theory, searching for and studying simple groups. In the same way prime numbers can be thought of as the building blocks of integers, simple groups are the building blocks of finite groups, which are groups with a finite number of elements.

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