

Moore looks beyond the law

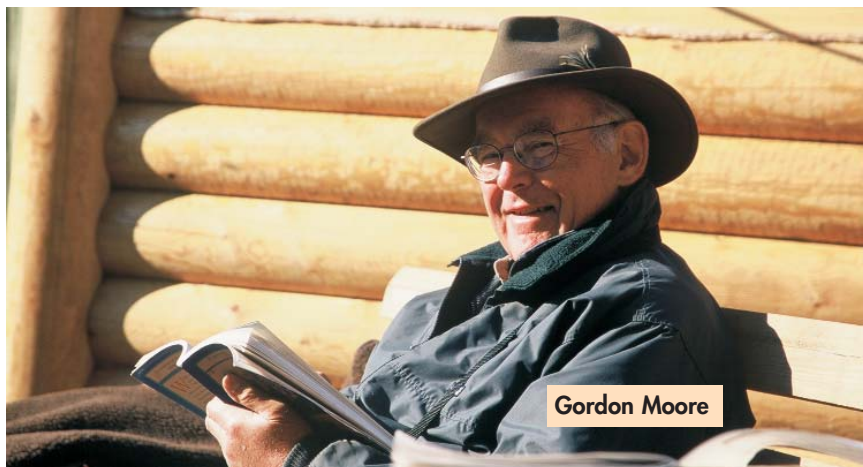
Intel cofounder, author of Moore's law, and self-titled "accidental entrepreneur" is a benefactor of the Thirty Meter Telescope and other scientific research and education efforts.

Gordon Moore does not bear the mantle of Nobel laureate like his former boss William Shockley, nor does he share the patent for the invention of the integrated circuit with his business partner Robert Noyce, with whom he cofounded Intel Corp. Rather, he is best known for Moore's law—his prediction in the 1970s that transistor density on a chip would double roughly every two years—a pace the semiconductor industry still pushes to stay ahead of. Moore finds it "ridiculous" that his legacy should be defined by that prediction. "I think the success of Intel has to be the high point of my career," he says.

In December 2007 the Gordon and Betty Moore Foundation committed \$200 million to the Thirty Meter Telescope, one of several ground-based optical and IR projects that would be more than twice the size of existing telescopes. The TMT would probe planetary formation, dark matter, and galaxy evolution, among other things (see *PHYSICS TODAY*, August 2003, page 22). Caltech and the University of California system, managing partners in the project, have also pledged \$50 million each. The site choice, expected in May, is down to locations in Chile and Hawaii. It remains to be seen where the funds for the rest of the roughly billion-dollar project will come from. Richard Ellis, a Caltech astronomer on the telescope's board of directors, sees the Moore gift as "a turning point in making the TMT a reality."

Moore began his career as a research scientist at the Johns Hopkins University Applied Physics Laboratory in 1953 after finishing his PhD in chemistry and physics at Caltech. He then returned to his native California and established himself as a leader of the movement that produced Silicon Valley.

Although no longer an Intel insider, Moore still has an office at the company's headquarters in Santa Clara, California. The semiconductor industry "is a business where if you step away from it for a year or two, you become so obsolete, you're useless," he says, so these days he spends most of his time in Hawaii, where he lives with his wife.



Gordon Moore

MOORE FOUNDATION

Moore recently spoke with *PHYSICS TODAY* about science funding, developments in the semiconductor industry, and his foundation's interest in astronomy and education.

PT: What is it about telescope projects and the TMT in particular that excites you?

MOORE: Well, some of the biggest questions that we've discovered and might be discovering the answers to are coming through astronomy. The dark matter and dark energy kinds of things are fascinating. The fact that we see only a few percent of the universe is absolutely amazing. I think that a very likely path to finding out the origin of these things is going to be through astronomical observation.

We [the Moore Foundation] have been supporting [astronomy] programs principally at Caltech. We supported [the University of California] and Caltech together for a fairly significant investment in the design phase of the TMT. It then seemed to be competing with similar projects like the [Giant Magellan Telescope] led by Carnegie [Institution of Washington]. The government doesn't act well in cases like that, so we thought that by making an initial significant commitment, we could get all the efforts behind a single program.

PT: What is your view of the role of public-private partnerships in funding science research?

MOORE: I think they are very impor-

tant. The government funds people but doesn't fund equipment much anymore. It's been surprising to me how difficult it is for scientists to get funding for enabling instrumentation. Our foundation has worked with Caltech on a big improvement of a beamline on Stanford University's synchrotron to do structures of proteins. We supplied Caltech with the big magnets for their active-brain imaging program, cryo-electron microscopes... that kind of stuff. [Research institutions] have the personnel that can make the scientific breakthroughs, but they've got to have the equipment also.

PT: Congress reneged on some funding increases for the physical sciences at the end of 2007. [See *PHYSICS TODAY*, February 2008, page 20.] What is your reaction to those cuts?

MOORE: I think it is a damned disaster. This is Washington politics at its worst. They are playing with the national competitiveness for short-term political gain.

PT: What are the fundamental challenges that Moore's law faces, now that the semiconductor industry has solved the power dissipation issues related to shrinking transistors? [See *PHYSICS TODAY*, February 2008, page 25.]

MOORE: We are now very close to the atomic limit, which is going to slow down the rate of progress. It will eventually end our ability to make things smaller and still have them work. I've been amazed that we haven't yet been



The Thirty Meter Telescope got a \$200 million boost from the Moore Foundation. Construction on the telescope may begin as soon as 2009 and be completed by 2016. Meanwhile, the project is seeking funds from Canada, Japan, and the US, among others. (Artist's depiction courtesy of the TMT Observatory Corp.)

bit by something at the current [dimensions]. It seems to me that the statistical fluctuations and the number of impurity atoms in the active parts of the microprocessor device would be enough to be a problem. But I think that in the next two or three generations of shrinking, we will find some fundamental problems that we won't be able to get around that easily.

PT: How has collaboration and competitiveness changed since the birth of the semiconductor industry in the 1960s?

MOORE: The industry is kind of incestuous I guess. I remember in the early days of Intel when we considered Texas Instruments one of our principal competitors. At the same time, we were one of their 10 largest customers and they were one of our 10 largest customers. Nobody made the complete spectrum of what was needed. That's been the model all along.

PT: Semiconductor development no longer seems to be dominated by US research labs. How much of that do you attribute to the low science literacy in the US, especially at the precollege level?

MOORE: I'd be hard pressed to make a correlation. We [the US] did educate a lot of foreign students, and many of them returned to their countries of origin and have taken a lot of the technology with them. The technology is not as mysterious as it used to be. When I got into the semiconductor business, there were no universities that had a course for it. When I worked for Shockley [Semiconductor Laboratory], Stanford hired James Gibbons, who eventually became the head of the electrical

engineering department. Gibbons was sent to Shockley part-time to learn something about semiconductor technology so he could get a program started at Stanford. Now all of the major universities have extensive training. The technology has gotten diffused around the world. In the manufacturing area, for example, Japan was really ahead of us in the 1980s, and it took a while for the US industry to get turned around and learn how to compete successfully.

PT: What should be done to ensure that US companies can recruit the scientific talent that they need?

MOORE: We have to at least have a fraction of youth appreciate how exciting science and technology can be. The US K-12 situation is an extremely difficult one, and a lot of money has been thrown at it. We [the Moore Foundation] couldn't see what we could do to make a difference so we avoided jumping into it. I don't have what I would consider a viable alternative.

PT: Your foundation has contributed to science museums in the San Francisco Bay area. What role do they play in addressing the concerns about science literacy?

MOORE: One of the problems that we have in our educational system is that the people teaching science in the K-12 system often don't know anything about it themselves. The science museums, at least in the Bay Area, have pretty strong programs that bring in science teachers and help them understand what the basic ideas of science are. For a relatively small investment, we hope we can help.

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