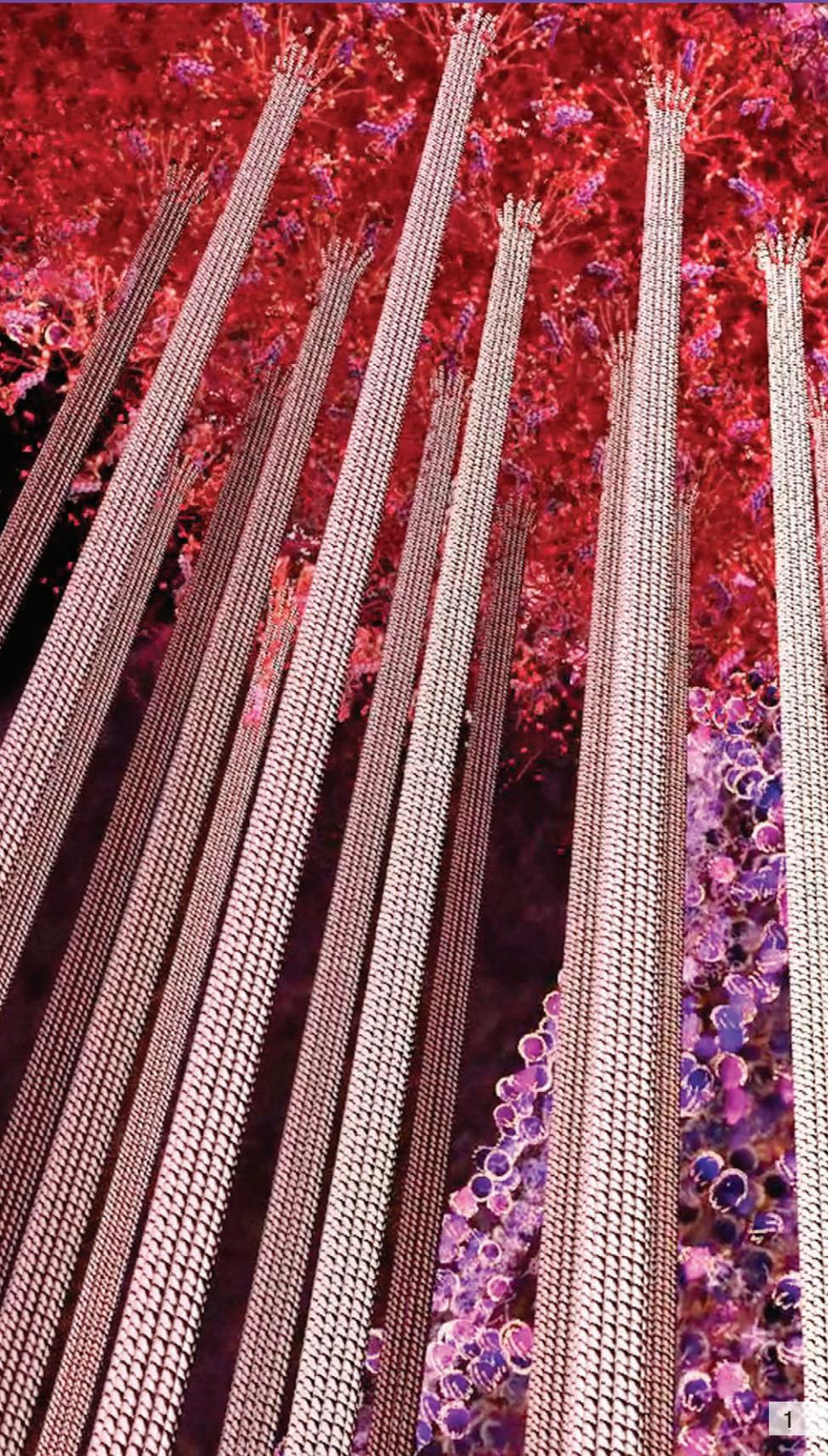


Fun with Dick at TEDx

By Douglas L. Smith



Richard P. Feynman, Caltech's Renaissance man—visionary, artist, teacher, showman, safecracker, raconteur, bongo drummer, and winner of some award for physics that they hand out every year in Stockholm—was the subject of Caltech's first independently organized TED event. *Feynman's Vision: The Next 50 Years* drew 1,035 people to Caltech's Beckman Auditorium on Friday, January 14, for a daylong amalgam of science, music, and some just plain silliness. The (un)dignified professor himself, who died of cancer in 1988, made numerous appearances in video clips, giving those of us who had never had the opportunity to meet him a glimpse into the mind of a very curious character indeed. TEDxCaltech also marked the 50th anniversary—more or less—of Feynman's prescient "There's Plenty of Room at the Bottom," an exploration of the possibilities of nanotechnology published in these very pages in February 1960; and of the 1961–1963 *Lectures on Physics*, his classic introductory physics course released in 1964 as a set of iconic red textbooks.

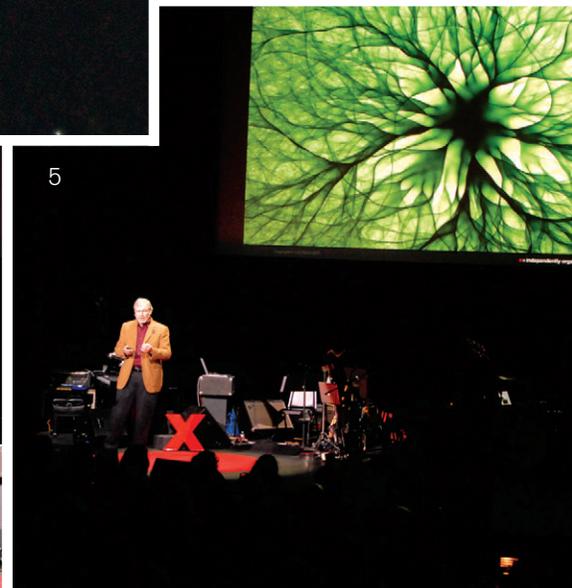
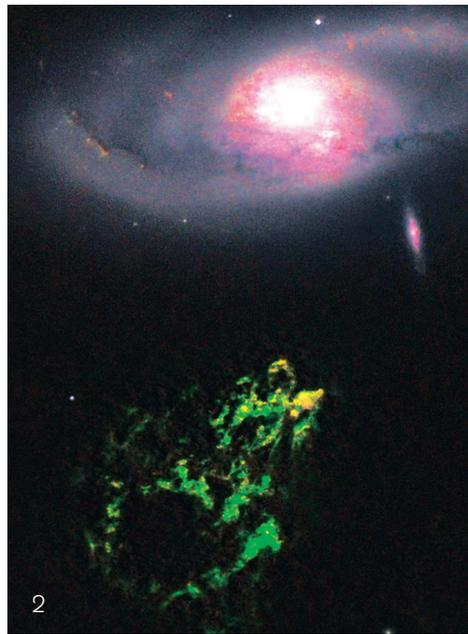
Emceed by Rives, who cohosts the annual TEDActive conference in Palm Springs, the day was divided into three sessions. The first focused on taking the world from another point of view, as it were. The second session revolved around strange theories of light and matter, from quantum computing to cosmology. And the third revisited the room at the bottom, showcasing the coming intersection of nanoscience and biology. Here are some highlights.

Session One: Conceptualization and Visualization in Science

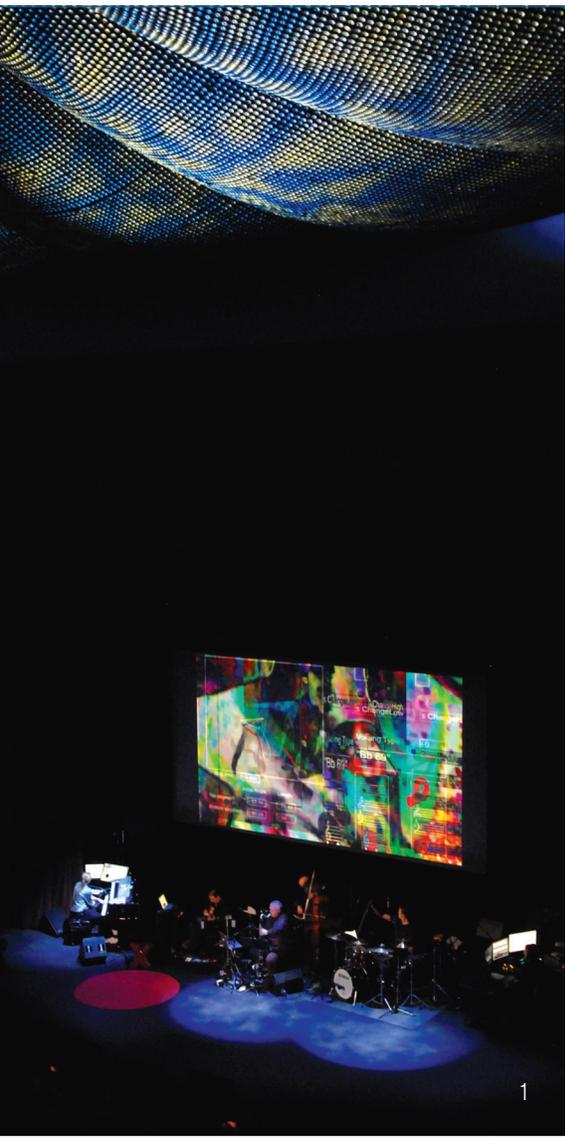
After an introduction by Feynman's daughter Michelle and Feynman documentarian Christopher Sykes, the session settled into talks on making sense from complexity and communicating with clarity: Caltech biologist Pamela Björkman's presentation featured a long-armed cartoon Elmo to demonstrate how a successful HIV antibody has to grasp widely spaced marker molecules on a virus's surface—an insight made possible by accurate 3-D renderings of the proteins involved. "When the imaging is good enough, solving some problems in biology becomes, 'Hey, just look at this!'"

Microsoft's Curtis Wong demoed the World Wide Telescope, an interactive atlas of the universe downloadable to a browser near you. Caltech astronomer George Djorgovski noted that scientists are migrating into cyberspace, where data, literature, and computational tools are just mouse clicks away. Humanity and society coevolve with science and technology, he said. "The rapid pace of technological change may accelerate our evolution as a species."

But for now, we still have to learn the old-fashioned way. Shuki Bruck, the 2009 winner of the Feynman Prize for Excellence in Teaching, talked about engaging students' curiosity. Adam Cochran, Caltech's intellectual-property counsel, previewed the electronic *Lectures on Physics*, where users can not only zoom in on any equation, but see photos of Feynman's actual blackboards or hear a recording of him giving the lecture. (In tribute to the master practical joker, the audio—which had worked fine at rehearsal—refused to play.) A surprise announcement followed: The Ralph M. Parsons Foundation is underwriting the renovation of 201 East Bridge, the venue for said lectures, to be renamed the Richard P. Feynman Lecture Hall. [ess](#)



1. Drew Berry showed three-dimensional digital animations derived from scientific data—"a whole semester of biology in only three minutes." Here the white pillars are the microtubules that connect a pair of chromosomes as they detach from each other during cell division. The red region is a megacomplex made of thousands of proteins on the chromosome that senses the degree of tension in the microtubules and gives the go-ahead for separation to proceed.
2. With large data sets easily accessible on the 'Net, average folks can make discoveries almost as a hobby. In July 2007, Johns Hopkins astronomer Alex Szalay helped launch the Galaxy Zoo, a website where volunteers could classify the million or so galaxies photographed by the Sloan Digital Sky Survey. In the first three days the site had 300,000 users, and within a month a Dutch schoolteacher named Hanny van Arkel found this bizarre blob known as Hanny's Voorwerp—a part of a streamer of gas encircling galaxy IC 2497 that has been made visible by the searchlight beam of its central quasar.
3. MIT's Sanjoy Mahajan (PhD '98) demonstrated how to solve complex problems with educated guesses—a skill for which Feynman was famous. Here he drops two coffee filters of different diameters to estimate the force of aerodynamic drag en route to approximating the fuel efficiency of a 747.
4. Feynman himself made an appearance, as channeled by JPL attitude-control engineer and veteran Theater Arts at Caltech performer Steve Collins, dressed in the Ladakhi monk's robe and hat that Gweneth Feynman sewed for her husband to wear to a costume party.
5. Harvard's Eric (Rick) Heller creates simulations of the paths of electrons through a semiconductor—which he likens to tracing light rays through "a drawerful of bad lenses"—and turns them into works of fine art. Heller followed grad student Dennis Callahan, a two-time winner of Caltech's Art of Science competition, who showed microscope images from various labs around campus.

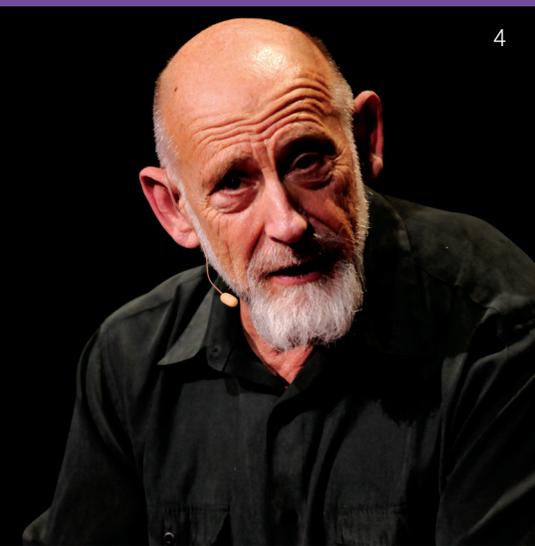


Session Two: Frontiers of Physics

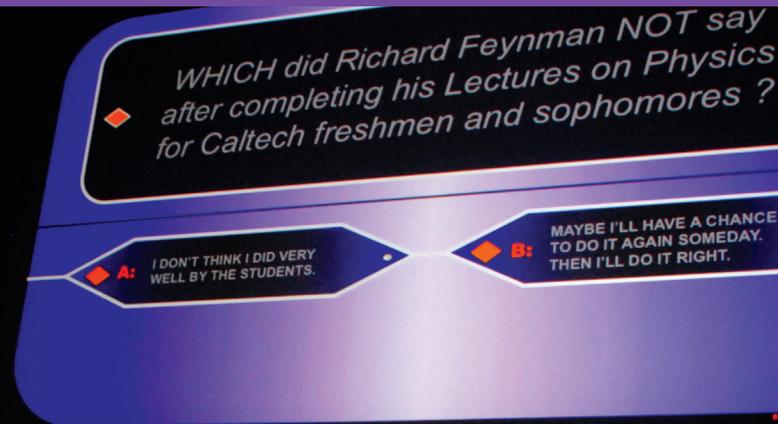
With the exceptions of cosmologist Sean Carroll's exploration of the universe's increasing entropy, and an excursion to Mars with grad student Jeff Marlow, the frontiers in question tended to be quantum. Simon Fölling of the Max Planck Institute for Quantum Optics talked about building the hardware for quantum computers, which are widely expected to be the Next Big Thing. However, as UCLA's Zvi Bern remarked in his talk about Feynman diagrams, "A good idea will always kick the pants off of a supercomputer." Scott Aaronson, a designer of quantum-computing algorithms from MIT, asked rhetorically, "Is there *anything* we can discover in the 21st century that would not have been deeply obvious to this man? We might as well quit physics and take up bongo drumming. . . . Oh, never mind—he had that covered, too." Aaronson compared the state of quantum computing today to Charles Babbage's hand-cranked difference engines of the 1830s. Feynman, he noted, did not have much respect for pure mathematics (or pure mathematicians?), possibly because "quantum mechanics is incredibly easy once you take the physics out."

The physics was leavened by the TEDx Jam Band, led by Lyle Mays, 11-time Grammy-winning keyboardist and longtime creative partner of Pat Metheny. The ensemble also included bassist Tom Warrington, saxophonist Andrew Pask, drummer Jimmy Branly, and guitarist / synthesizer programmer Bob Rice. Sound engineer (and holder of a double fistful of Grammys) Rich Breen handled the mix, and the music was backed by a wall-sized mash-up of live camera feeds, assorted Feynmanalia, and trippy video effects created in real time by digital artist Jon 9. **ESS**





4



5



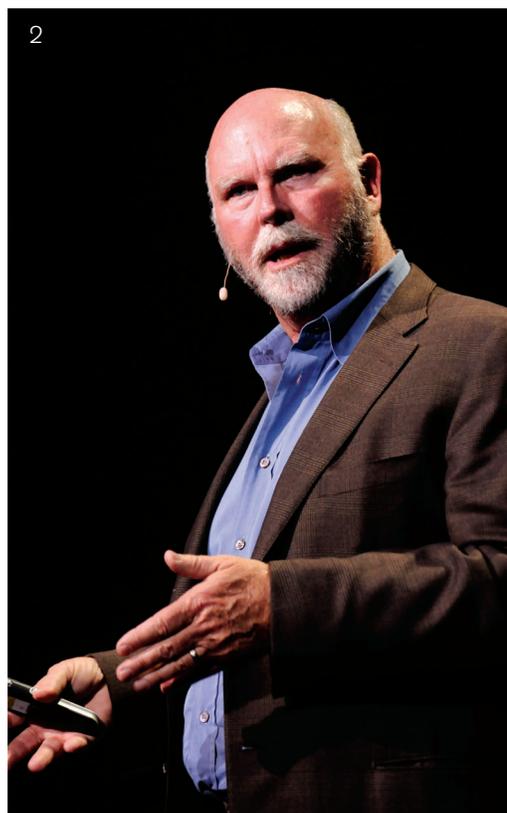
6

1. The multimedia jam session before the lunch break explored the connections between nonlinear dynamics, jazz, and visual perception in a full-on sound and light show that evoked the sixties on steroids.
2. The line to get in stretched past Beckman Behavioral Biology and all the way out San Pasqual Walk almost to Wilson Avenue.
3. Feynman was fascinated by the central Asian nation of Tannu Tuva, whose distinctive triangular postage stamps he'd collected as a child. While he never made it there, his interest has allowed several Tuvans to visit here, including throat singer Kongar-Ol Ondar. Throat singing is a folk art in which the singer produces two or more pitches simultaneously to create strange, mesmerizing harmonics.
4. Stanford physicist Leonard Susskind told stories about Feynman the showman and Feynman the gamesman. "He had a kind of macho one-upsmanship. He loved intellectual battle. . . . And he loved to win. But when he lost, he laughed and seemed to have just as much fun as if he had won." On one occasion, Susskind actually got the last word: Feynman loved to tell the story of a bunch of undergrads taking him to a local eatery featuring sandwiches named for celebrities. By arrangement, all the students went off-menu, ordering "Feynman sandwiches." Susskind wondered what a Susskind sandwich might be like, and Feynman cracked that it would be about the same as a Feynman sandwich, but with "a lot more ham," as in a bad actor. Well, I happened to have been very quick that day, and I said, 'Yeah, but a lot less baloney.' The truth of the matter is that a Feynman sandwich had a *load* of ham, but absolutely no baloney. What Feynman hated worse than anything else was intellectual pretense."
5. Saying, "Feynman didn't just dress differently; he thought differently," Microsoft's Tony Hey showed this 1969 photo of, from left, Carl Anderson (a 1936 Nobelist), Murray Gell-Mann (1969), Max Delbrück (1969), Feynman (1965), and George Beadle (1958), which he said the *California Tech* once ran under the headline "Four Kings and a Joker."
6. The game show *Finding Things Out—Ordinary Genius Edition* featured (at left) Kid Throne (Kip Thorne, BS '62, the Feynman Professor of Theoretical Physics, Emeritus) and (center) Jot Pretzel (John Preskill, the Feynman Professor of Theoretical Physics) answering Feynman trivia questions to win an answering-machine greeting recorded by Stephen Hawking: "Nobody's home . . . dude." Hawking himself made a surprise appearance, rolling into the auditorium in response to the "Phone a Friend" lifeline.

Session Three: Nanoscience and Future Biology

There's still plenty of room at the bottom, but the real estate is getting parceled out. Don Eigler of the Almaden Research Center was among the first to plant a flag there, using a scanning tunneling microscope back in 1989 to push xenon atoms around on a nickel surface to form the letters *IBM*. Afterward, he said, he was rereading Feynman's "Plenty of Room" late one night, "and the hair on the back of my neck went up. . . this is the ghost of Feynman! And if he's here, what would he say? 'What took you so long, kid?'" Harvard's Charlie Marcus and UC Santa Barbara's David Awschalom continued to carry the torch for quantum computation. Steve Quake, now at Stanford, talked about the microfluidic circuits he began developing here at Caltech. (See "Rubber Layered Micropumpers," *E&S* 2003, No. 2.) These circuits essentially shunt cells or even proteins around a silicon chip as if they were electrons, using tiny fluid-filled channels in lieu of wires. Beyond making an entire set of blood tests as disposable as the syringe that draws the sample, this technology opens up what conference co-organizer Michael Roukes called "plenty of room in the middle"—fluid-based integrated circuits whose performance will be measured in "GBOPS: billions of biological operations per second."

The day's final speaker, Danny Hillis, made it all personal. Hillis, cofounder of Thinking Machines and a longtime friend of Feynman's, recalled a walk in the San Gabriels in the summer of 1987, when the toll the cancer had taken suddenly became obvious. Feynman was philosophical, saying, "By the time you get to be my age, a lot of what's good about you has rubbed off on other people." **E&S**





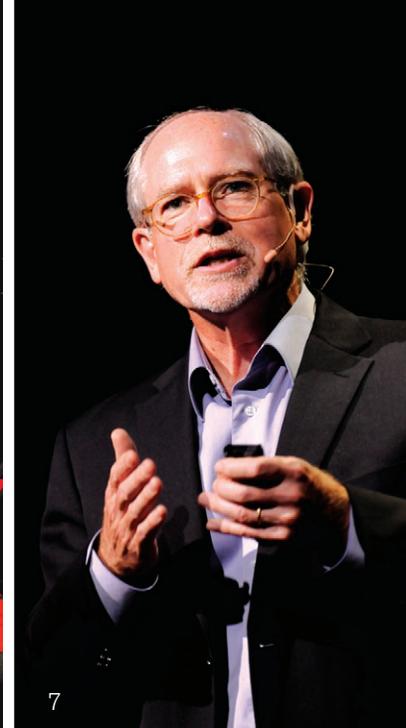
4



5



6



7

1. Rives (right) wrapped it up by rapping with Ondar and the band before calling TEDx co-organizer Roukes to the stage to thank the folks who made it happen. Rives's riffs were "curated" from the speakers' words, ending with the thrice-repeated tag "People lose a lot of pleasure / Who find science dull." Nobody found this day dull.

2. Biologist J. Craig Venter's eponymous Institute recently assembled the first "synthetic" organism by inserting cobbled-together bits of bacterial DNA into an enucleated cell, which happily "booted up" and reproduced itself. When the news broke, "We got an immediate response from both the pope and the president—a first. And I was not invited to a barbecue, so I was very happy about that."

3. At the dinner that evening, Caltech president Jean-Lou Chameau (at right) presented Fred Kavli of the Kavli Foundation and Caltech's Kavli Nanoscience Institute with a facsimile of Feynman's notes for a lecture—jotted on a place mat from Gianonni's, a topless restaurant near Feynman's house where he sketched the girls and doodled about physics.

4. Caltech grad student Nadine Dabby showed off a nanorobot made from DNA. A collaborative project with researchers at Arizona State, the University of Michigan, and Columbia, the 'bot crawls along a sinuous strand of DNA bewhiskered with little wisps of DNA that it grabs and releases—"a robotic lawnmower propelled by uncut grass."

5. And grad student Pete Trautman showed off his somewhat larger robot, which is capable of threading its way through crowds of people. (See "Automata In Our Midst," page 7.)

6. Junior chemistry major Jordan Theriot wowed the crowd with "The Pleasure of Finding Things Out"—an enthusiastic recounting of her 2010 Summer Undergraduate Research Fellowship (underwritten by Caltech's Office of Development and Institute Relations, of which *E&S* is a part), which has inspired her to pursue a career in academia after graduation.

7. Caltech chemist Mark Davis updated the audience on his cancer-fighting nanoparticles (see "Sweet Revenge," *E&S* 2007, No. 1), which are now in Phase II clinical trials. In the last year, Davis has adapted the particles to carry interfering RNA molecules, which will in principle allow the selective shutdown of any specified gene in the cancer cell.

8. MacArthur "genius" Angela Belcher, a materials chemist and bioengineer, has programmed a brace of viruses to assemble carbon-nanotube electrodes into a high-output lithium-ion battery in a Petri dish. "My dream is to drive a virus-powered car." More broadly, she noted that biomaterials contain exquisitely designed nanostructures, but only make use of a few elements, such as iron and calcium. "I would like to convince biology to work with the rest of the periodic table. . . . What if we could convince [viruses] to build a solar cell for us?" In her freshman classes every year she passes out laminated, wallet-sized periodic tables that say, "Welcome to MIT, now you're in your element." When President Obama toured her lab last summer, she offered him one. He replied, "Thank you. I'll look at it periodically." Which he did, pulling it out later during a speech on clean energy.



8