LAB OF IDEAS

By Herb Brody

Photography By Bill Burkhart

Though she came late to the field, Jennifer Chayes ’79 now runs one of the top computer science labs in the world—a hothouse of creativity that could profoundly alter life, work, and health for all of us.

The next time you’re bumped from an airline flight, don’t think of it as bad luck. You’re just the victim of a poorly worked out constraint satisfaction problem. A flight booking system has to evaluate many variables and then negotiate a fine line between, on the one end, empty planes, and on the other, overbooked ones. The first option loses the airline money. The second angers passengers, which will hurt the airline’s business. The airline reservation system, in effect, passes through a “phase transition”—a qualitative change akin to what happens when water freezes into ice, or boils into steam. The characteristics that describe one phase do not describe the other, and ignoring the difference leads to wrong answers about what will happen. Finding the happy medium turns out to be a tricky problem.

The study of such sharply defined transformations launched a Wesleyan alumna who had minimal exposure to computer science while at the university onto an unlikely path. Jennifer Chayes ’79 now runs one of the world’s best-known computer science laboratories, which is distinguished by its multidisciplinary approach to the field. By bringing computer scientists, economists, anthropologists, mathematicians, physicists, and other experts together under one roof, she is forging a new kind of research lab.

The first thing you see when you walk past the huge glass doors into Microsoft Research New England is not a reception desk but a giant staff lounge—a meeting place overlooking the Charles River in Cambridge. A visitor to this space might overhear intense young scientists natter on about how understanding of self-organizing networks could lead to more effective cancer treatments. Or the urgency of transparent privacy policies on Facebook. Or the optimal way to sell online advertising.

Ever since coming here in 2008 as the lab’s first leader (her title is managing director), Chayes has worked to create a research institution that boasts the intellectual rigor of a university and emphasizes the spanning of disciplinary boundaries in ways not often found in academe. “One of the very nice things here is that we don’t have the silo structure of a university,” she explains.

This is the lab that Chayes is building.

Chayes might seem an unlikely leader of a computer science research lab. While at Wesleyan in the mid-1970s, she had other interests. “I knew very little about computer science,” she says. “I took one C.S. class at Wesleyan. I think it was one semester of Fortran and Pascal in my freshman year.”

Although she had not yet discovered computers, Chayes was most definitely walking on the science side of academia. After growing up in the suburbs of New York as the child of Iranian immigrants, she blazed through both a physics and a biology major. Plus, she recalls, she was “a couple of courses shy of a chemistry major and a couple of courses shy of a math major.” Wesleyan gave her freedom, she says, that “allowed me to take more science than I would have taken at MIT.”

Wesleyan also gave Chayes her first glimpse of working in a research laboratory—and convinced her that she was not cut out to be an experimentalist. She spent a year in a cell biology lab, studying the cell cycle of tetrahymena, a single-celled organism that has not one but two nuclei. Her research involved introducing into the cells the DNA base pair thymidine tagged with tritium (a radioactive isotope of hydrogen), which allowed her to trace the cell’s growth and reproduction cycle.

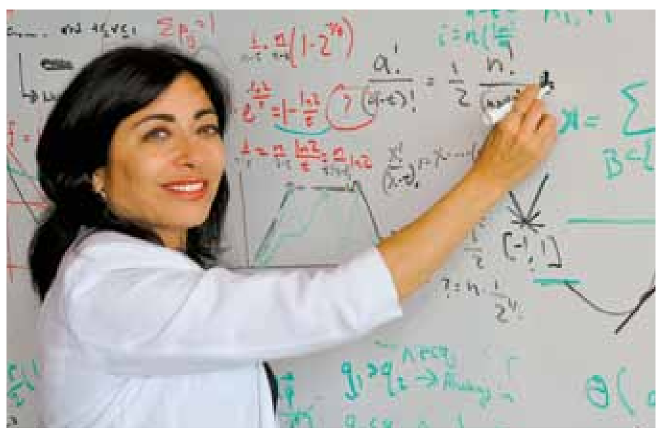
“I tend to think very theoretically,” she says. “I can spend years thinking about a math problem, or a theoretical physics problem, or a computer science problem. I’m fine with that. But when things are slow in a lab, my mind wanders.” Just such a lapse in attention led to a turning point in her scientific work when her adviser caught her distractedly jeopardizing her own safety. “He said, ‘What are you mouth-pipetting?’ Well, I was mouth-pipetting tritiated thymidine. If I had gotten a mouthful of that, I would have had radioactive DNA. I realized that I really should do theoretical work rather than experimental work.”

Her passion for theoretical, hands-off science led her to leave biology behind and pursue a graduate degree in mathematical physics at Princeton—“far away from thymidine. Or tritium,” she laughs.

She joined the mathematics faculty at the University of California, Los Angeles, where her research focused on a specific kind of network in which connections appear and disappear seemingly at random. Such behavior describes, for example, the way oil works its way through stone, always seeking cracks for the path of least resistance, and where “either there’s a passageway for the oil or there isn’t one—and it’s apparently at random,” she says.

This turns out to be an uncannily accurate description of another phenomenon that was rapidly emerging as a world-changing technology. “The Internet, the World Wide Web, and social networks like Facebook have many characteristics of random networks,” she says. “They’re not engineered. There’s no overriding authority telling you what to link to on a web page, or dictating what path an Internet signal travels through the maze of computer routers and telecommunications lines. It’s a self-engineered system.”

Chayes’s work on these random networks brought her to the unlikely next step in her career. While on sabbatical at the Princeton Institute for Advanced Studies, she had set up a program aimed at bringing computer scientists, mathematicians, and physicists together to work on problems such as phase transitions and constraint satisfaction. One of the members of the board of the Institute was Nathan Myhrvold, the chief technology officer of Microsoft—and a former grad school physics classmate of Chayes at Princeton.



MICROSOFT RESEARCH NEW ENGLAND MAY BE THE ONLY LAB OF ITS STATURE WITH A WOMAN AT THE HELM.

Myhrvold had been given a long leash by Microsoft founder and CEO Bill Gates to put together a team of scientists who would not simply be tweaking the next versions of Windows but rather laying the scientific underpinnings for developments that might take years, even decades, to reach fruition. To pursue these studies, Myhrvold had founded Microsoft Research, a quasi-academic arm of the software giant, located near corporate headquarters in Redmond, Wash.

“We needed some mathematicians to do theoretical work, and Jennifer was doing spectacular work,” recalls Myhrvold, now CEO and founder of a company called Intellectual Ventures, which seeks to fund and nurture the enterprise of invention. “The kinds of skills Jennifer had in math and physics are very relevant to developing advanced computer algorithms”—techniques that are at the heart of encryption, for example. Despite Chayes’s slight background in computing, Myhrvold says she was his “first choice” to bring aboard Microsoft’s nascent research theory group.

Chayes herself was far from confident that leaving academia for the world’s dominant software company made sense.

“I thought it was a bizarre idea,” she says. “I didn’t know any computer science! I had taken a Fortran class in 1975. I didn’t know how to program. I didn’t have a Windows machine. I had a Macintosh and a SPARCstation.” The last place she saw herself going was a corporate computing research lab. Nevertheless, Myhrvold convinced both Chayes and her husband, Christian Borgs, a professor of physics at the University of Leipzig in Germany, to come to Microsoft Research and start a group focusing on theory. “I had confidence that they could do something that would be both great theory and relevant to our business,” Myhrvold says. “They got the theory group going and were very successful.”

For his decision to hire her, Myhrvold says he’s still patting himself on the back. “She’s brilliant, vivacious, and energetic. I’m a fan across the board.”

The theory group introduced a new culture into Microsoft. Chayes and Borgs “had a really remarkable vision for bringing math into Microsoft Research,” says Henry Cohn, a mathematician at the New England lab who previously had worked for Chayes and Borgs in Redmond. “They’re really committed to the idea of foundational research. They never tell people, here’s this specific question from a Microsoft product group, now go work on it. They recognize that it’s valuable for the company to be doing research in math and computer science on topics that are very closely connected to Microsoft’s commercial interests, but that are not motivated by immediate commercial application.”

In fact, one of the goals of Microsoft Research all along had been to show that it made sense from a business perspective to do long-range research. For a long time, Myhrvold says, Silicon Valley had been spooked by the experience of Xerox, whose famed Palo Alto Research Center (PARC) had invented a huge amount of what now comprises modern computing—in particular the graphical user interface—but then failed utterly to capitalize on these innovations, allowing companies such as Apple and Microsoft to ascend to the top of the personal computer business. “PARC is, unfortunately, an object lesson in Silicon Valley for why not to do research,” says Myhrvold. “At Microsoft Research, we wanted to refute that—and we have.” Chayes and Borgs were a huge part of that success, Myhrvold says. “From the very early days, the theory group had important insights into Microsoft products,” he says, citing the group’s contributions to search algorithms, among other achievements.

In leading the New England lab, Chayes acknowledges the need to strike a delicate balance. Microsoft’s top corporate management doesn’t control what goes into the research pipeline, she says, but it most definitely wants to monitor the other end. “If there’s something useful coming out the research pipe, we make sure somebody at the company’s product divisions knows about it.”

As part of her drive to break down traditional barriers between disciplines, Chayes has brought to the Microsoft lab a steady stream of researchers who work in fields other than those most commonly associated with computer science. Because much of what is important about today’s advances in computing are in the domain of the social sciences, she has hired, or brought to the lab as visiting researchers, a number of economists from Harvard and MIT. Harvard economist Susan Athey, for example, is studying the dynamics of using auctions to price and sell advertising on search sites. An expert in the design of government auctions, Athey was attracted to the Microsoft lab because she wanted to apply her expertise to the hottest venue of commerce. “Search advertising is an important and growing business for Microsoft, and my research sheds light on how to design and operate these auctions,” she says. The impact could be huge: “Having competing search engines, and competing online advertising platforms, is crucial to the future of the Internet,” she adds.

Chayes also brought on board danah boyd, a young anthropologist who has become a well-known voice on issues arising from the way people relate to one another via social networking sites such as Facebook and Twitter. “I was working on algorithms for a recommendation system” for such social networks, says Chayes. “I can come up with lots of algorithms. But which ones do I want? What will be most helpful to users of these sites? Danah and I and others worked together on this and we’re filing a patent together. My contribution was at the algorithmic level, and hers was an understanding of human relationships, of what people are trying to achieve online.”

The resulting atmosphere is conducive to creative thinking, says senior research staff member Adam Kalai. “If I’m collaborating with an economist, I will need to figure out how to explain what I’m doing so that he or she can understand it. When you’re forced to explain your research to people in other communities, that helps you realize what’s important in a big picture sense.”

Talk to members of Microsoft Research New England, and one theme keeps coming up: they’re here because Chayes drew them here. For example, boyd says she was finishing her PhD dissertation at the University of California, Berkeley, when she met Chayes at a dinner party. Before the encounter with Chayes, the last thing boyd wanted to do was move to Boston. “I loathed it there,” she says. But the encounter with Chayes changed boyd’s mind. “There were immediate sparks. We started talking about networks, in that beautiful academic way. We both talk a mile a minute. Finally, Jennifer said, ‘You have to come with me to Microsoft.’ People in my world, the world of academic anthropology, think I’m crazy to be working here, but it’s been a fantastic experience,” she says.

Chayes’s work on random networks and constraint satisfaction problems has recently brought her back full circle to the biology that she studied at Wesleyan. Only now she wields not a pipette but a theory about how to apply the principles of networking to the analysis of biological systems. Many cancers, she says, are caused by failures of the organism’s gene regulatory network. And these networks have much in common with the random networks she studied previously.

The connection of network theory to disease was something of a surprise to Chayes. “I wasn’t thinking about cancer,” she says. “I was thinking, ‘pretty math!’ But then we started hearing about all these problems in biology”—problems, Chayes says, that her study of random networks fit perfectly. Cancer, she explains, is caused by mis-regulation in the gene regulatory network, and different cancers are caused by different mis-regulation. Two cancers that we think are the same but may be different are caused by different kinds of mis-regulation and so might need to be treated with different classes of drugs. “So if we understand these networks we can understand where the drug targets are,” she says. “We would know what proteins we need to shut off, or turn on in order to stop the growth of that cancer.

“If you look at some very important questions in biology, they boil down to networks,” Chayes observes. “There is a regulatory feedback system in each of your cells that controls it. So what happens is that each gene produces a certain protein. These proteins bind to pieces of the DNA and they either inhibit or enhance the production not just of the same protein, but of other proteins as well. This becomes an extremely complex network.”

Her lab is now working with the Memorial Sloan-Kettering Cancer Center on ways to use this network analysis to determine the best combination of therapies to treat particular cancers, most notably prostate cancer. The researchers at Sloan-Kettering, Chayes says, are “trying to pinpoint several different points at which to try to stop a cancer, and they’re trying to figure out multiple drug targets simultaneously.” The problem is that no existing computer can possibly crunch all the data needed for this kind of analysis. It turns out, though, that the work Chayes has done on non-biological problems could apply beautifully here. “We have a new class of algorithms, which arose by studying phase transitions and constraint satisfaction problems, and it looks like we can apply these to understanding gene regulation problems,” she says.

Chayes portrays herself as in a constant state of excitable curiosity, deeply in love with what she does for a living (her official biography on the Microsoft website says that “in her spare time, she enjoys overworking”). And she can’t suppress how tickled she is that ideas she starting working on 15 or more years ago with little thought of their practical impact now show such enormous promise.

“Six months after I came to Microsoft, in the summer of 1997, I gave a talk to Bill Gates on what I was working on. I told him about phase transitions, about constraint satisfaction. And I told him that I thought that no one would find any use for this for 100 years. And here we are—it’s being used for the study of cancer.”

Microsoft Research New England may be the only lab of its stature with a woman at the helm. “I certainly hope that changes—it should change,” Chayes says. The main barrier to a greater female presence in science generally, in her view, is that girls and young women don’t see science and technology as creative activities. That’s an unfortunate impression, and one that she would love to correct. “I see science as very creative. I see it as a blank slate. I can paint whatever I want to paint.”

As computing becomes identified more and more with social networks, it is moving into a traditionally female-oriented domain. “In social computing,” she says, “girls tend to understand the creativity that’s involved a little more.” Ultimately, it’s her hope that women who are brought into the field by the lure of social networking will find that the nuts and bolts of computer science are also realms where original, nonlinear thinking is of value. But the truth, she says, is that “there’s tremendous creativity in mathematics. When I do math, it’s like I’m just writing poetry in a different language.”

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Do you have an opinion about this topic? Please write us at letters@wesleyan.edu.