Frances Hellman's kitchen is her laboratory where she delights in cooking up experiments on magnetic materials composed of exotic and rare ingredients.

By Eric Niiler

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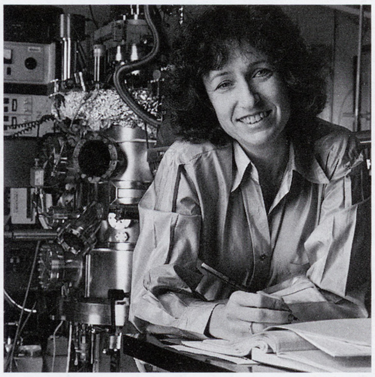
THE JOY OF PHYSICS



Frances Hellman

Frances Hellman's enthusiasm for doing science—and for sharing it with others—is as powerful as the magnets that pulse in her Mayer Hall physics laboratory. They both exhibit a strong attractive force.

"I do love the sense of putting things together and figuring things out," Hellman, an associate professor of physics at the University of California, San Diego, said in a recent interview. "The most fun of all is when you have an idea, you can test it and see if it works."

Hellman is an expert on magnetism, the fundamental force that makes compasses point north, keeps postcards and report cards stuck to refrigerator doors and allows us to hear music on mini-disc style CDs cassettes and even—back in the dark ages—eight-track tapes.

Magnetism is at the heart of the high-stakes world of information storage, a competitive field that has academic and industrial laboratories around the world racing to cram more and more information into tiny magnetic bits and, at the same time, improve our access to it.

The payoff for magnetic research is in new and improved consumer products—such as personal computers and CD players—and in super-sensitive magnetic sensors such as those found inside library books and at supermarket checkouts today and which may be used to detect forces as delicate as brain-wave activity some time in the future.

In addition to studying new kinds of magnetic materials—alloys of cobalt and platinum or terbium and iron, for example—this 42-year-old professor is also an inventor.

Five years ago, Hellman designed a microcalorimeter, a device that can measure the tiny amounts of heat given off by metals at temperatures several hundred degrees below zero. "It tells you what's going on in the material and how many ways energy can get stored," she said.

UCSD medical researchers have found another use for the device: They think it can be used to measure the very specific but tiny amount of heat given off in a chemical reaction as when, for instance, a therapeutic drug begins to take effect in the human body. The device has already been tested in vitro, and its biological possibilities are being tested by Palmer Taylor, who chairs the Department of Pharmacology at the UCSD School of Medicine, and David Lieberman, a graduate student.

Rabid Padres fan

As quickly becomes clear during an afternoon with Hellman, her research interests are widespread—ranging beyond her Department of Physics lab to the School of Medicine and the Center for Magnetic Recording Research, of which she is also a faculty member. She directs or collaborates on several projects at the same time, but she's no lab-coated geek.

This former nationally ranked ski racer

Frances Hellman
THE JOY OF PHYSICS

Pictured in her Sample Preparation Lab, Frances Hellman with postdoctoral associate Alexander Kuprin (left front) and graduate materials science student Barry Zink (right front). In the background are undergrad physics major Daniel Queen (left) and graduate physics student Brian Maranville (right).

plays soccer three or four days a week for two different San Diego city league teams. A rabid Padres fan and season-ticket holder, she fills in the scorecard at each game.

And to give back a little of her education to others, she became involved with the Elementary Institute of Science in San Diego, a program that provides after-school, weekend and summer science-education opportunities for several hundred children age 8-13 from a low-income part of town. "She's an advocate for kids and science," Doris Anderson, the institute's executive director, said. "She works behind the scenes to see that kids have an opportunity."

Growing up in Brooklyn, N.Y., physics seemed about as far away as another planet for Hellman, whose father was a financier and whose mother was a professional ballet dancer.

Winter vacations in New England as a young girl turned into a passion for ski racing. She attended the prestigious Stratton Mountain School, was good enough to be invited to join the U.S. national junior team, and taught and coached ski racing at Green Mountain Academy in Vermont. But during her freshman year at Dartmouth College, the rigors of academics and sports collided and she did neither as well as she wanted.

Hellman remembers the encouragement she received from her academic advisor, encouragement that she tries to offer undergraduates today. "He said he thought I had the understanding and talent to become a good physicist," Hellman said. "I really valued that."

Hellman dropped ski racing (but still buckles up during winter family holidays), completed her studies in physics, moved west to Stanford University and, in 1985, graduated with a doctorate—one of just two women in a class of 30.

It wasn't the first time that she found being a woman in a male-dominated field a mixture of pluses and minuses. "You stand out as a woman and people notice you more," she said. "The downside is that there are still prejudices around."

Outstanding physicist

At Stanford Hellman studied superconductivity, a property peculiar to some metals and alloys that have a negligible resistance to an electrical current at extremely low temperatures.

In 1987, after a two-year postdoctoral fellowship at AT&T Bell Laboratories, in Murray Hill, N.J., Hellman was appointed an assistant professor at UCSD, where her research has attracted a significant amount of peer recognition. She was elected a fellow of the American Physical Society, and became chair of the society's Division of Materials Physics last year.

The appointment "recognizes her as an outstanding and important leader of that community," Thomas O'Neil, a universally respected plasma physicist and chair of the UCSD Department of Physics said. "This is quite unusual for someone who is so young."

Hellman's drive and intensity is obvious to anyone meeting her for the first time. It's even more apparent to someone who knows her very well: her husband, UCSD chancellor and physics professor Robert Dynes. "She's a very critical scientist," Dynes said.

Dynes' specialty is also materials physics and he has collaborated with Hellman on numerous research projects in the past eight years. "I'll come in with an idea and she'll just tear it apart, even if it's right," he said. "Then we'll fight and sort of work through it. Then we come back a day later or so and the ideas are much better in both cases."

This sort of intense verbal jousting and truth-seeking cemented the friendship between Dynes and Hellman, who met as colleagues in 1991. Romance blossomed a few years later and the pair were married in May 1998.

Dynes said the ability to discuss, argue, compromise and learn are helpful for a successful scientific collaboration—and a marriage. "Scientific collaborations are tricky issues," he said. "They are often quite emotional and you get into heated arguments. I got to know her as a scientist first."

A lot like cooking

Research in materials science is a lot like cooking, Hellman said. Costly exotic ingredients are measured, combined and subjected to heat or cooling. The results, hopefully, are worthwhile. "The difference," Hellman said, " is that with cooking, you get to see the results right away."

There is one other important difference: Instead of common kitchen-cabinet ingredients, Hellman often uses rare earth elements, the name given to a group of metallic elements such as cerium, terbium and gadolinium that may be widely distributed around the world, but are nearly always in short supply. Partly because they are normally found in conjunction with each other and partly because they are so similar—chemically—to one another, scientists did not realize for a long time that they were, in fact separate elements. Magnetically, however, these elements can be very different, Hellman said.

Like the head chef at a busy restaurant, Hellman watches over a lab where there's a large stainless-steel canister that has a clear plexiglass porthole in the front and within which rare earth elements are heated to more than 1,000 degrees Fahrenheit. They vaporize at these temperatures and condense onto thin silicon wafers, in layers as thin as 10-1,000 layers of individual atoms.

Then the wafers are subjected to various magnetic fields at temperatures ranging from near zero degrees Kelvin (–460 F.) to 1,000 degrees Kelvin (1,350 F.) and their responses noted.

Hellman is especially excited about a relatively new material made from gadolinium—a rare earth element that is highly magnetic when cooled to low temperatures—and silicon. What's interesting is that sometimes the gadolinium-silicon mixture behaves like a metal (conducts electricity) and sometimes it behaves like glass (insulates electricity) at this super-cooled state. "It's right at the edge," Hellman said. "You can tip it either way."

This change of conductivity states means that it can change its ability to carry a current by 20 orders of magnitude (10^{20}). "It changes from something that is incredibly insulating (such as glass)," she said, "to something that is as conductive as metal (but not quite as good as copper)."

It also becomes extremely sensitive to relatively weak magnetic fields, the kind given off by biological activity, for example in our brain.

Hellman and her colleagues are trying to describe the properties of this gadolinium-silicon mixture. The next step is to make it work without cooling it to .15 degrees Kelvin. "Right now it's a good sensor at a useless temperature," she said.

Hellman says it's curiosity and the thrill of discovery that keeps her interest alive in a field that may not be as glamorous as bioengineering, genetics or neuroscience, whose breakthroughs tend to make headlines more often.

It's the mixture of fundamental science and technology," she said. "It's both fun to do and one hopes it has some impact on society at large."

> "It's the mixture of fundamental SCIENCE AND TECHNOLOGY"

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