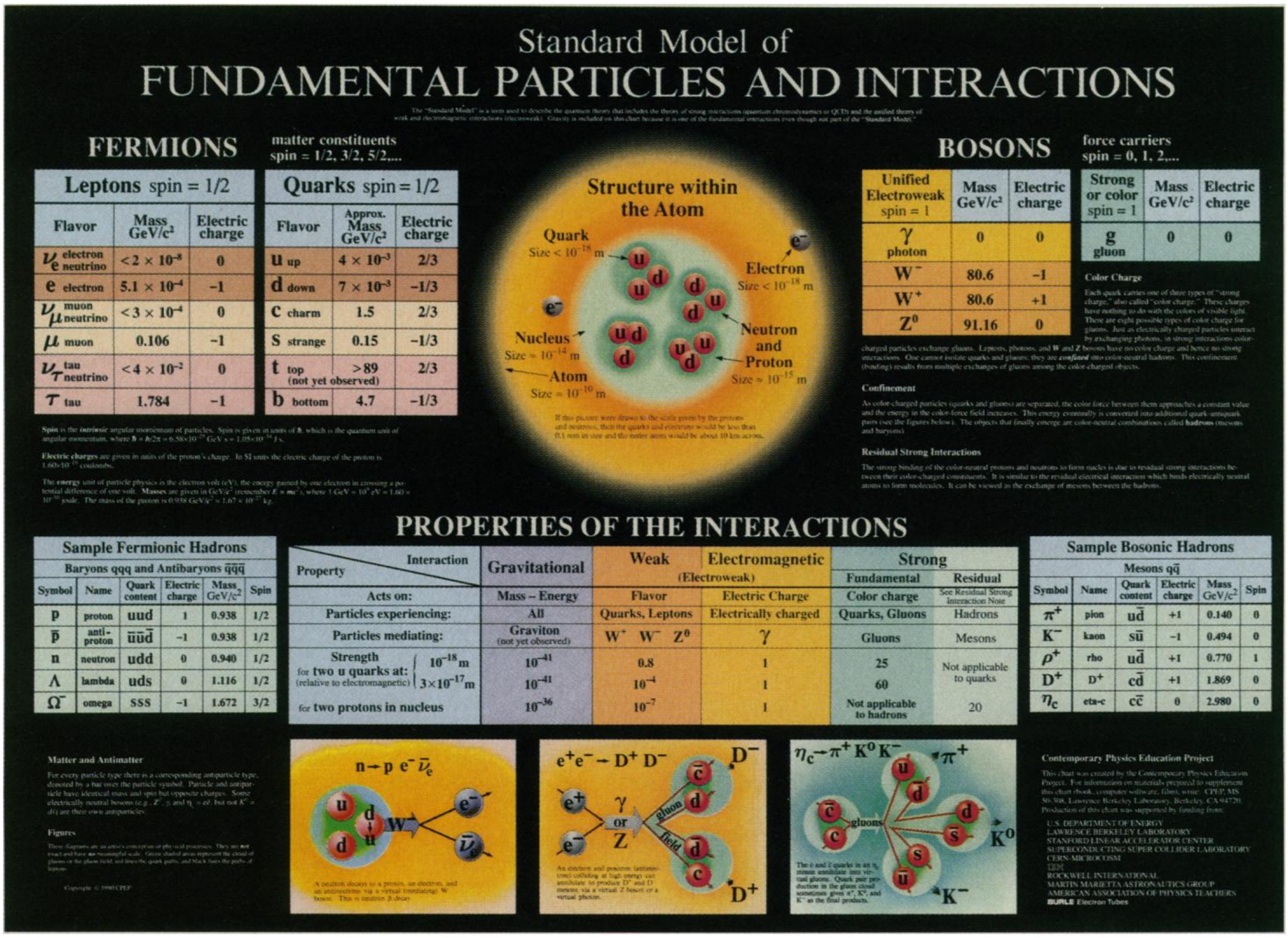

Move Over, Mendeleyev

A group of high school physics teachers is urging colleagues to move beyond bouncing balls on springs and sliding blocks down inclined planes. They are pushing to supplement the standard classroom fare with a taste of something far more modern: muons, gluons, quarks, and the rest of the particles that make up everything and hold it all together.

To help students navigate the intricacies of modern physics, these energetic teachers have teamed up with a group of high-energy physicists to produce and promote a wall chart of the subatomic world, which they hold up as the physicist's answer to the chemist's periodic table of the elements. "Just as you learn about the atom, you should learn about what's inside the atom," says Helen Quinn, a physicist at the Stanford Linear Accelerator Center who is cochair of the 18-member group of physicists and physics teachers behind the effort, dubbed the Contemporary Physics Education Project (CPEP).

The chart and supplemental material mark the debut of the group, founded 4 years ago with the goal of bringing high school physics up to speed on current research. "Most of what's in high school textbooks is not contemporary," says Quinn. "The real point is you can't turn students on to physics by teaching them mechanics. You've got to teach them the things physicists get excited about," says Lawrence Berkeley Laboratory physicist Michael Barnett, another leader of the group.

By teaming up teachers with physicists, CPEP's organizers hope to inject the excitement of the latest physics into classroom teaching. "This is a rather unique collaboration. Physicists work on the content," Barnett says, "and the teachers make sure the level is right."

Following the chart, the group will publish a timely physics book that Barnett says is short on math and long on people and history. Also in the works: a packet of teaching materials that includes, among other things, a card game designed to help students learn allowed quark interactions. The packet even has a puzzle that presents students with a hypothetical group of "discovered" and "undiscovered" objects and asks them to discern relationships between them—the idea being to show high school students what theoretical physicists actually do for a living.

The chart that catalyzed all this first took shape in the mind of Fred Priebe, a physics teacher in Palmyra, Pennsylvania, during a 1986 science and education seminar at Fermilab, near Chicago. Priebe convinced others to help him carry out his idea, and the interested parties eventually coalesced into the formal CPEP group. The group raised the bulk of the $120,000 needed for the project from the Department of Energy and associated laboratories. The rest came from private industry.

Physicists and educators had different reasons for deciding that the time was ripe for Priebe's idea. While teachers such as Priebe see an immediate need in the classroom for a guide to the subatomic world, physicists such as Quinn say the chart is warranted by the current state of knowledge. "The information in this chart is pretty solid now," she says, "but it was in a state of flux just 15 years ago." Thanks to recent discoveries, Quinn says, the basic framework of the chart should endure the way the 100-year-old periodic table has.

It had better: Already more than 1500 requests have come in from schools around the country for the chart and the explanatory software, a hypercard program that allows students to wander around within the material, sampling it through graphics and sound effects.

The image that is beginning to decorate classroom walls is the picture of the structure of the atom, vintage 1991, together with the forces that hold it together—what is known as the standard model. The old solar-system electron orbits have given way to a blurry cloud, and the billiard-ball neutrons and protons of the nucleus have dissolved into fuzzy regions containing three quarks each. Flanking this thoroughly modern atom are tables of particles, with the familiar proton, neutron, and electron taking their places among more exotic and unstable particles only observed in accelerators and cosmic rays.

It all looks a little daunting for high school students, and Priebe says his classes thought so too—but only when they got their first look at the chart. "The students were negative and confused at first," he admits. "But once they got started they found it really interesting."

In fact, teachers can turn out to be a bigger obstacle than students, says Priebe. "Many teachers at the local level are rather stodgy," he says. "While we like to teach others new things, we don't like to be confronted with things we don't know ourselves."

For any teacher who disagrees with Priebe's self-characterization, a copy of the chart is available from CPEP (Mail Stop 50-308, Lawrence Berkeley Laboratory, Berkeley, CA 94720).

P.S.: Some Ph.D.s are decorating their laboratory walls with the chart as well. Barnett says as many requests have come in from physicists as from teachers.

■ FAYE FLAM

Liquid Crystals Meet the Cosmos at APS Meeting

The diversity of physics was much in evidence when 1500 physicists assembled in Washington, D.C., last week for the spring meeting of the American Physical Society (APS). But so was the emergence of unexpected cross-disciplinary links—between computer science and atomic physics, between the behavior of liquid crystals and constructs of theoretical physics such as the Higgs field. To emphasize the relevance of diverse areas to one another, the APS designated the second day of the conference Unity Day.

Atoms for Logic

Vaporized cesium atoms may not seem the obvious material for building something as precise and solid as a computer. But enclose the vapor in glass and replace the electrons that course through a conventional computer with laser light, and you could have an element in a future optical computer, says Randy Knize of the University of Southern California. He underscored the point at the APS meeting by describing how he built a logic element known as a "NOR" gate—a basic computer component—from vaporized atoms.

The NOR gate, which transmits an output signal only when it receives neither one *nor* the other of two possible inputs, enjoys a special status among logic gates: If you can build a NOR gate using a given technology, you can also make any other kind, Knize says. And, "If you can make a NOR gate you can make a computer."

Most of the other researchers competing on designs for optical computers plan to build their logic gates from more conventional, solid materials such as silicon. But a glass cube containing a thimbleful of cesium vapor could perform millions of operations simultaneously, far more than could be packed into an equivalent volume of silicon, Knize says. That's because many different beams of light could play through the cesium vapor at the same time, creating myriad separate circuits—a feature that could be a boon to designers of parallel computers. What's more, according to Knize, making cesium circuits is a breeze compared with the expensive and complex process of etching thousands of minute circuits on a chip. "It's so simple even an undergraduate could build one of these," he says.

The vapor NOR gate opens and closes as the atoms switch between absorbing a main beam of circularly polarized laser light and letting it pass through as output. The gate stays "on," transmitting the beam, as long as neither of two other input beams strikes the cesium. Switching on either one of the inputs increases the absorbing power of the vapor and shuts down the gate.

The paradox on which the gate is founded—more light in equals less light out—is a product of the way the cesium atoms respond to circularly polarized light. When a single beam polarized in one direction strikes the atoms, they absorb a certain amount of it but allow the rest to pass through. Add one or two additional beams that include some light polarized in the opposite direction, though, and some of the atoms flip into a state in which they can absorb the remainder of the original beam. The gate goes from "on" to "off."

Knize's circuit may be ethereal, but he thinks the prospect of a cesium-vapor computer is hardly a will-o'-the-wisp. "We're a long way from a real computer, but at least I think were on the right track with the concept," he says.

■ FAYE FLAM

A Long Look Into a Liquid Crystal Ball

A group of scientists has looked into the shimmering fluid of a liquid crystal and has glimpsed the beginning of time. In the sudden aligning of the crystal's rodlike molecules, the researchers see the abrupt symmetry-breaking that is thought to have differentiated an expanse of indistinguishable mass-energy into distinct particles driven by separate forces during the first split-second of creation. In the flaws that mar the molecules' alignment, they see the grand defects that pulled matter toward some areas of space, allowing it to coalesce into stars, galaxies, planets, and scientists.

At the APS meeting Isaac Chuang and Bernard Yurke, solid-state physicists at AT&T Bell Laboratories, and Neil Turok, a cosmologist at Princeton University, described how they created this microcosm in a layer of the liquid crystal known commercially as 5CB. Their cosmic model—a layer of liquid crystal sandwiched between two