Applications office—and direct contacts with researchers. Indeed, Kurlander was so committed to Comic Chat that he had himself transferred to a product group to see it through. Myhrvold adds that the proximity of research and product divisions on the same campus has helped produce a culture that encourages researchers to ponder the possible commercial applications of their work, no matter how abstract it may seem.

Yet researchers at Microsoft say they face few restrictions on their freedom to publish results. Unlike many other companies, including IBM and Xerox, Microsoft has no review process for papers and no intellectual property department. Researchers are simply expected to file their own patents when necessary. The benefits of this nonpolicy, in Myhrvold's view, are the automatic quality control that comes from peer review and the freedom to exchange ideas with outside researchers. The Theory Group, for example, plans to host regular visitors from academia for periods of anywhere from 1 day to 12 months. And Microsoft researchers often serve as de facto advisers for graduate students at the University of Washington. "People worry, 'That means we're going to lose some ideas,'" says Myhrvold. "Well, I've found that people who are too afraid of losing ideas are people that don't have very many."

Research leaders elsewhere might not be that sanguine. But Microsoft does not seem to be alone in its strategy of keeping the research focused on a problem relevant to the business—such as creating a computer with a completely intuitive interface—while letting people take any approach to it they want. Andrea Califano, the manager of computational biology at IBM Research, says the atmosphere there has changed "quite significantly" since the company's financial crisis in the early '90s, from a pseudoacademic environment where publishing papers was the only requirement to a more technology-driven model. Still, Califano says, "at least 50% to 60% of the work that we do would be very basic science." Michael Garey, director of mathematical research at Lucent Technologies Bell Laboratories, complains about the "misperception" that his company now does only applied research. "It hasn't gotten any less fundamental. We think in terms of building an intellectual foundation for a technological area we see as important to the company down the road."

Now that Microsoft is a convert to that notion, Myhrvold says it's time for other technology companies to take a longer view as well. "Most have lots of what I call 'r&D'—little r, big D. Or even no r, in the sense that they do no pure research."

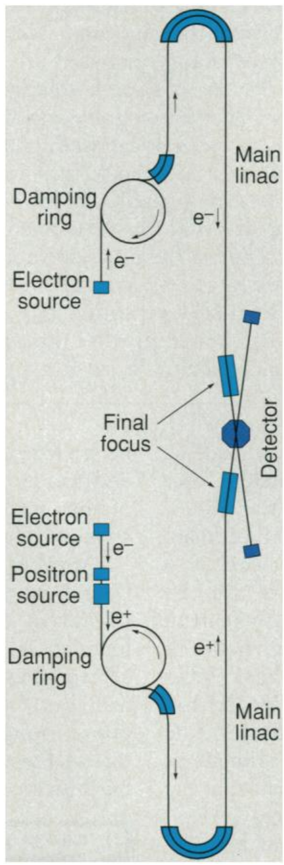
–**Dana Mackenzie**

Dana Mackenzie is a mathematics and science writer in Santa Cruz, California.

PHYSICS

Reports Call for New Super-Accelerator

Physicists in the United States have been understandably timid about asking for a major new accelerator. The debacle of the Superconducting Super Collider (SSC), which Congress canceled in 1993 when it was already under construction, is still fresh in their minds. And it took years of negotiation to arrange a consolation prize: U.S. participation in what will be the highest energy collider ever built, the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland. But the message was clear in two U.S. reports on the state of particle physics released last week: Another collider will be needed if physicists are to assemble a complete picture of the particles and forces that constitute the world.



Object of desire. A concept for a future electron collider, tens of kilometers long.

SOURCE: SLAC

Plans for some kind of successor or companion to the LHC—which hurls protons against protons—have been in the works since the mid-1980s. But in a once-a-decade review of the field prepared by the National Research Council (NRC) and a draft report to the Department of Energy's (DOE's) influential High Energy Physics Advisory Panel (HEPAP), physicists have made their most public plea yet for a new machine. "The LHC is set, so the stage is now open for the next [machine]," says Columbia University physicist William Willis, a member of the HEPAP panel.

On the wish list are three very different devices: a scaled-up LHC, called a Very Large Hadron Collider; a 30- to 50-kilometer-long Next Linear Collider (NLC) that would smash electrons together; or an even more fanciful device that would collide muons—the electron's short-lived, heavy brothers (*Science*, 9 January, p. 169). Physicists have been exploring all three possibilities, and some portions of the NLC have even been benchtested. Any of the three options will cost over a billion dollars and take a decade or more to plan and build.

But such a behemoth will be essential for moving beyond the existing picture of the subatomic world, says University of Chicago physicist Bruce Winstein, who chaired the NRC committee. The missing piece of the decades-old theory called the Standard Model is an account of how particles get mass. Most physicists think a hypothetical particle called the Higgs boson works behind the scenes to confer mass. Although physicists expect the Higgs to tumble out of the collisions in the LHC, sightings are expected to be rare at the energies the accelerator can achieve. And occasional glimpses won't be enough, because the Higgs is expected to lead the way beyond the Standard Model to an even more fundamental theory of particles and forces.

Finding out which, if any, of several candidate theories is right will take a more detailed investigation of the Higgs—and any other particles that turn up—than will be possible at the LHC, the reports say. The electron and muon colliders would give physicists a cleaner environment for studying the new particles, as these collisions produce less debris than do the proton collisions of the LHC. And a supersized LHC would generate higher energy collisions, allowing physicists to search for still more particles.

But the specter of the failed SSC clearly darkens the pages of both reports. The SSC cost rose billions of dollars over initial estimates, to nearly $12 billion just before its demise, and the project came up short in attracting funding from other countries. The SSC "cannot happen again," says Cornell physicist Persis Drell, who helped draft the NRC report. "If nothing else, that is branded on our foreheads."

The key to success, physicists hope, will be an affordable price tag and a global effort. Building even the NLC (the furthest along of the three options) will be "damn difficult and very, very expensive," says Donald Shapero, director of the NRC board on physics and astronomy. "This is going to be an international game from now on. No one country is going to be able to contemplate doing it alone."

Yet the NLC camp is already divided,

members of the NRC committee note. While physicists at the Stanford Linear Accelerator Center (SLAC) and Japan's KEK laboratory have been working in close concert on a design that uses conventional radio-frequency cavities to accelerate the electrons, Germany's DESY lab is hard at work on a plan that uses superconducting technology. That's a bad omen for future collaboration, some say. "Each lab gets committed to its own technology," explains Michael Riordan, assistant to the director at SLAC. "You have this kind of technological inertia."

Overcoming that inertia, and bringing all the labs together, may take the creation of a "world HEPAP," says Peter Rosen, DOE's associate director for high-energy and nuclear physics. It may have to come soon. Already, DESY director Bjorn Wiik has made the rounds at towns near Hamburg to build support for an underground tunnel that could house the NLC. Wiik says he is simply preparing the ground for DESY's proposal. But many say that raising the issue of the NLC's site at this early stage is risky, because each lab is likely to want the new accelerator in its own backyard. "I have to say, quite frankly, it's not good for international collaboration," says Rosen.

–David Kestenbaum

GLOBAL MATH-SCIENCE TEST

Northern Europe Tops in High School

The Winter Olympics are over, but this week many of the countries at the top of the medals chart could claim another victory in worldwide competition: Their high school students were the top performers in the latest results from the Third International Mathematics and Science Study (TIMSS). Unfortunately for the United States, its solid standing in Nagano was not replicated on TIMSS. Instead, U.S. high school seniors performed near the bottom in general science literacy, were second to last in advanced mathematics, and brought up the rear in advanced physics. The results "debunk the myth that our best and brightest are still the best in the world," says Larry Suter of the U.S. National Science Foundation's education directorate. "There is no evidence here that any of that is true."

The new results are the third in a series of international assessments of student performance in mathematics and science. The first showed Singapore, Japan, Korea, and the Czech Republic at the top of the heap among seventh- and eighth-grade students (*Science*, 22 November 1996, p. 1296). The second test, for third- and fourth-graders, featured the same countries, plus strong showings by Hong Kong in mathematics and the United States in science (*Science*, 13 June 1997, p. 1642). Asian countries did not participate in the latest assessment, however, citing the intense pressure on their students in the senior year to prepare for college entrance exams. "We naturally were disappointed," says TIMSS international study director Albert Beaton of Boston College. "My guess is they would have done very well."

The latest report includes the results of three tests. An assessment of general mathematics and science literacy—given to students from both academic and vocational tracks—included questions on basic algebra, proportionality, estimation, life science, physical science, and earth science. A second test assessed students in advanced mathematics courses [those in precalculus, calculus, or advanced placement (AP) calculus in the United States]. And a third assessed students taking advanced physics (either physics or AP physics in the United States). The Netherlands and Sweden scored highest on the general literacy exam, while France and the Russian Federation outpaced 14 other countries on the advanced mathematics test. Norway, Sweden, and the Russian Federation had the highest scores among the 16 countries whose students took the advanced physics exam.

MATHEMATICS AND SCIENCE LITERACY

Country	Mean score	
The Netherlands	559	Significantly above
Sweden	555	
Iceland	541	
Norway	536	
Switzerland	531	
Denmark	528	
Canada	526	
New Zealand	525	
Austria	519	
Australia	525	Average
Slovenia	514	
France	505	
Germany	496	
Czech Republic	476	
Hungary	477	Significantly below
Russian Fed.	476	
Italy	475	
United States	471	
Lithuania	465	
Cyprus	447	
South Africa	352	
Average	**500**	

SOURCE: IEA/TIMSS, 1995–96

Northern highlights. Scandinavia dominates general literacy test, with the U.S. well below average and Asia not participating.

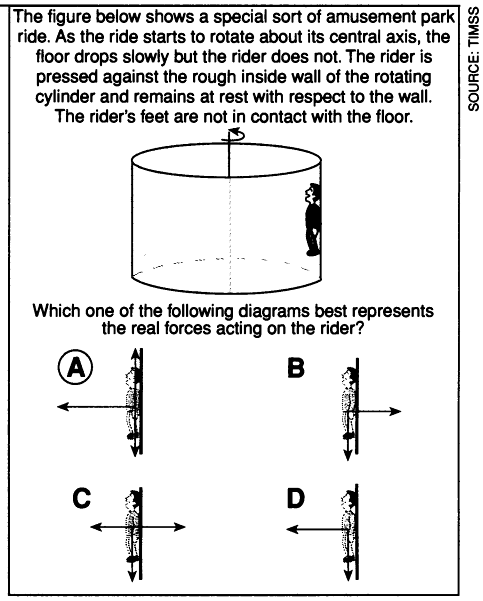
Although educators praise the latest findings, they provide few simple answers about why some countries do better than others. As with the other exams, top scores did not correlate directly with any of the factors commonly associated with student performance. Students in high- and low-scoring countries spent about the same amount of time in math and science classes, had similar amounts of homework, and watched about the same amount of television. "The study just doesn't have a lot of new insights into why," Suter says.

The new test also found that, once again, boys scored better than girls did. The differences were not consistent in all countries, however, ranging from 17 points in the United States to 57 points in Norway. That result "will make an uproar in this country," says Svein Lie, a science education professor at Oslo University and head of Norway's TIMSS project.

Pressed for possible factors contributing to his country's high ranking, Lie notes that Scandinavian students typically start school a year later than most of the rest of the world and are a year older when they graduate. Barbara Wennerholm of the National Agency for Education in Stockholm, Sweden, points to the homogeneity of the Swedish system, in which students on vocational tracks have the same science teachers as those on academic tracks.

For U.S. officials, the results reinforce the unhappy lessons of the earlier tests. A recent analysis of the elementary and middle-school results shows that U.S. students decline in almost all subject areas between the fourth and eighth grades. As a result, says William Schmidt of Michigan State University in East Lansing, "you have to do remarkable work at the high school level to make up for that."

–Gretchen Vogel



Feeling the pressure. Only 20% of advanced physics students gave the correct answer.

* The full report, including sample problems, is available at http://wwwcsteep.bc.edu/timss