

say, however, that the state cannot afford complete "redundancy"—that is, offering every degree on every campus. Sgro told us that she will not get involved in the details of the JMU restructuring because physics is not being removed from the curriculum. "I'd have a major heartburn if they did that," she said.

Squabbles and protests

The JMU administration initially stated that the physics graduation rate over the last two years had averaged five degrees per year, but department chairman Moore said his figure of seven holds true for both two- and five-year averages. This discrepancy over what should be a simple datum illustrates the relationship between the department and the administration.

The administration has issued statements about making a "good-faith effort" to reassign as many of the ten faculty members as possible. Moore saw little evidence of good faith immediately after the original announcement, but was more hopeful four weeks later, after Oberst had met with all physics faculty members individually.

Charges and countercharges were part of the intense debate throughout the university. On 18 January the faculty of the biology department

gave its unanimous opposition to the administration decision. On 30 January the mathematics faculty joined them in opposition, also unanimously.

On 23 January faculty members voted 305 to 197 for "no confidence" in president Ronald Carrier's ability to lead the university, and more than 3600 students (of a total population of about 11 000) reportedly signed a petition in favor of restoring the physics department. As of this writing, the administration has stood firm, and Robert LaRose, the rector of JMU's governing Board of Visitors, said that the board "fully supported" the administration

and was not planning to reverse the decisions.

Sgro, Oberst and Moore all told PHYSICS TODAY they believed publicity about the difficulty that physics PhDs are having getting jobs influences decisions like the one at JMU—indeed, Oberst called it a "direct result." But Sgro also made a more general comment, independent of the situation at JMU, that perhaps exemplifies the times: "Decisions have to be made about priorities. It's a tough thing to do in education—as well as everywhere else."

►DENIS F. CIOFFI

STAT OF THE MONTH

About 450 new physics faculty (not postdocs) were hired at the 747 US physics departments for the 1993–94 academic year. Departments that offer the bachelor's as their highest degree hired about 200 new faculty, as did those who grant PhDs. In the late 1970s, there were nearly twice as many young (under 35) faculty in PhD departments as there were in 1993–94.

Some traits of new faculty, 1993–94	Highest physics degree offered		
	PhD	Master's	Bachelor's
Migrated from other US academic jobs	58%	59%	50%
Migrated from US nonacademic jobs	24%	12%	12%
Earned PhD in US since 1990	27%	50%	60%
Earned PhD within one year of job	8%	25%	35%
Earned PhD outside US (any year)	22%	13%	5%

Source: AIP Education & Employment Statistics division (stats@aip.org).

Inventions Born of Necessity Offer New Tools for the Blind to Study and Do Science

At its heart, science is about observation: looking at things, measuring them, analyzing their properties, figuring out how they work. How then does one proceed when nature's most basic and powerful tool for observing—that of sight—is missing?

To be sure, the blind are not without tools of their own. Speech synthesizers interfaced to personal computers can read text aloud; a blind person can send and receive e-mail and access the Internet with nearly the same ease as a sighted person.

And then there's Braille, the tactile alphabet developed in the 1800s by Louis Braille, in which each letter is represented by a pattern of raised dots. But Braille code, like the more modern computer tools, works best when the material being conveyed is simple—that is, plain text. A not-too-tricky equation can bring even the most clever talking computer to its knees. And even though in principle there's a way to write math in Braille, in practice it's unwieldy for higher math.

That's a situation John A. Gard-

New ways of rendering advanced mathematics are removing a major barrier to the pursuit of science by the blind.

ner, a professor at Oregon State University, knows well. His career in solid-state physics was already well established when, in 1988, he became blind. Adding to the difficulties of adjusting to this loss of sight was having to figure out a way to continue with his work. "If I wanted to read the *Physical Review*," Gardner says, "I couldn't get it in Braille. I could get second-grade textbooks or maybe even a high school algebra book, but nothing that I was interested in." An imperfect solution was to have his assistant, Mark Pretty, either tape-record or type journal articles and other reading material into a computer. The neater solution was to build a better Braille code—or two.

Solving Braille's problems

"Present Braille is very peculiar,"

Gardner says, explaining some of what he encountered while learning to "read" at age 48. "Blind students have to learn to use one Braille system for math, another for literary things and another for computers."

The existing math Braille code—also known as the Nemeth code, for its creator, Abraham Nemeth—has been around for about 40 years, and in its time it revolutionized how the blind did math. Still, it is cumbersome, and many blind scientists ended up devising their own private notation schemes, which worked just fine until it came time to publish.

"A complicated equation has two-dimensional structures, and those dimensions carry a lot of information," Gardner says. But Braille is linear; a single equation can go on for lines before the equals sign is even reached. Representing numbers is also tough. "Louis Braille made a serious mistake in that regard," Gardner notes. Each number is preceded by a number sign followed by letters. So, for example, "# A C C B" means 1332. "It's very difficult to do algebra that way."

Gardner decided to create a better math Braille. The result, called Dots Plus, renders equations the way they would appear to sighted people. Mathematical symbols—integrals, summations and the like—are exactly the same as in regular type, just bigger (by a factor of about 2.5) and, of course, raised. Letters and numbers are done in regular Braille.

In collaboration with Norberto Salinas, a University of Kansas mathematician who is blind, Gardner is also at work on an "eight dot" Braille code, which has unique characters, or cells, defined for numbers and certain symbols, such as plus signs. Standard "six dot" Braille, in which the dots are laid out in a 2×3 matrix, allows only 63 permutations (plus a blank space), too few to represent all of the special characters used in scientific notation. (The six-dot Braille is itself being reworked by an international committee to eliminate confusing "dialects" and other problems.)

Among those who've tried Dots Plus and liked it is Kent Cullers, a PhD physicist who works as a signal detection scientist at NASA Ames Research Center. In his work, "it's vital to have a compact way to symbolize mathematics, the same way that sighted people do," Cullers says. In his opinion, Gardner's code is "absolutely the best one that's come along. It's as important to mathematics as the Nemeth code itself. It may change the way that the blind are able to think about mathematics."

Speaking math and Shakespeare

When Gardner first began working on Dots Plus, "it was my opinion that voice is just not the right way to read mathematics. Of course, Raman proved me wrong."

"Raman" is T. V. Raman, who as a graduate student at Cornell University invented a computer system that takes electronic documents written in TeX and converts them into audio format using a speech synthesizer. Named for his guide dog, Aster, the program was developed for Raman's PhD dissertation in applied mathematics, which he received in January 1994.

Now working at Digital Equipment Corporation in Cambridge, Massachusetts, Raman recalls how AsTeR got its start: "In TeX you write your article or your textbook with embedded commands that tell the system how to typeset it. Three or four years ago I looked at TeX and I realized that if all that information is there and the computer is smart enough to process it and print it, then it could be possible to develop another system that takes the same information and proc-

esses it in such a way that it can be spoken." AsTeR does just that. After reading in a TeX file, it "audio formats" it, building an internal representation for the document that conveys its structure: where the various sections lie, where the equations (if any) are, and what each equation is. This in turn affords the listener "multiple views" of the document, be that a journal article, a complete textbook or a play by Shakespeare.

The resulting audio rendering goes far beyond the traditional books-on-tape approach. "Suppose I give you a textbook and you record it for me onto a cassette tape," Raman says. "I'm now restricted to listening to it the way you read it. I can rewind it, I can forward it, but I cannot change it." AsTeR turns listening into an active process, allowing the user to browse through the document's headings, skim or skip over sections, or mark a passage for later perusal.

Reading equations is also done interactively. "Typically with complicated math, you don't always read left to right, top to bottom," Raman explains. "If it doesn't make sense forwards, you read it backwards. Basically, equations are to be read and reread until you understand them." And so the simple expression $(AB)^T$ could be read as "transpose of A times B" or "A transpose times B transpose" or "the product of the transposes of A and B." The listener chooses how AsTeR says the equation. If desired, the user can replace an equation's number with a name, which can then be cross-referenced. AsTeR's synthesized voice uses a higher pitch to indicate superscripts and a lower pitch for subscripts.

This use of varying sounds, tones and pitches to display information is known as sonification—the auditory analog of visualization. Researchers at the Santa Fe Institute and Bolt Beranek and Newman, among others, are studying ways to render graphical data through sound; for example, cer-

tain medical and seismographic monitors have been found to be more effective when they give auditory rather than visual readings.

At Oregon State, Gardner and his crew (which includes two research assistant professors, William A. Berry and Randy Lundquist, both physicists) are now reformulating Raman's program, with the goal of "porting it" to a personal computer. In its present form, AsTeR requires a full Unix-based workstation. Likewise, the technology to produce Dots Plus easily and cheaply does not yet exist, although several companies are now developing tactile computer printers. Gardner relies on something called swell paper, which when heated expands wherever it's been printed on; at \$1 per page, it's too expensive for widespread use.

It's hoped that eventually a single electronic file could be used to generate both audio and Braille. Someday blind students may get newly released science books at the same time as their sighted peers do.

Crossing hurdles

How many people could benefit from the new Braille codes and AsTeR? In the US there are 20 000 to 30 000 pre-college students who are blind or severely visually impaired, according to Lawrence Scadden, who directs the NSF program for persons with disabilities within the education and human resources directorate, which is funding work on Dots Plus and AsTeR. Many of those students will be steered toward fields requiring little or no math or science, and there is a corresponding underrepresentation of the blind in the sciences. It doesn't have to be that way, Scadden says. "The theoretical part of science is not that much harder for someone who is blind, because you're mostly dealing with symbols that can be easily handled with the right computer. As for experimentation, where there may be a lot of apparatus to be manipulated,

For Further Information

▷The American Association for the Advancement of Science, through its Project on Science, Technology and Disability, maintains a resource directory of scientists and engineers with disabilities. The third edition is now being assembled; contact AAAS, 1333 H Street NW, Washington DC 20005; phone, 202-326-6670.

▷The NSF makes grants for innovative interventions designed to help disabled students pursue science study and careers. Contact: Programs for Persons with Disabilities, Division of Human Resource Development, Education and Human Resources Directorate, NSF, 4201 Wilson Boulevard, Suite 815, Arlington VA 22230; phone, 703-306-1636

▷Those with access to the Internet's World Wide Web can try out an interactive demo of T. V. Raman's AsTeR program. The universal record locator is <http://www.research.digital.com/CRL/personal/raman/raman.html>.

▷John Gardner's Science Access Project also has a Web site, which includes a picture of Dots Plus. The URL is <http://dots.physics.orst.edu>.

that can typically be done by working in groups." In studying and doing science, he says, "the primary hurdles that a blind person faces are the attitudes of others."

Changing those attitudes will be made easier when blind students are less reliant on sighted people—hence the attractiveness of Dots Plus and AsTeR. "Both projects are still experimental, under development and under evaluation," cautions Scadden. But it

is both his hope and his expectation that these innovations will be widely adopted in the future. Blind scientists, engineers and mathematicians in the US and elsewhere have already tested Dots Plus and AsTeR, Scadden says, and "there seems to be almost total unanimity that they have great potential for improving mathematics notation for the blind."

►JEAN KUMAGAI

Congressional Fellows Add Their Expertise to the Political Process

The Congressional Fellows program, organized by the American Association for the Advancement of Science, sends scientists to Washington, where they lend their personalities and their technical knowledge to the legislative process. In the 104th Congress, fellows sponsored by the American Institute of Physics and two of its member societies are now at work. AIP sponsors Laura Philips in the office of Senator Joseph Lieberman, a Democrat from Connecticut. The American Geophysical Union fellow, J. David Applegate, assists the Senate Energy and Natural Resources Committee. John Morgan, sponsored by the American Physical Society, works in the office of California Representative Dana Rohrabacher, a Republican who heads the House subcommittee on energy and environment.

The five fellows profiled last year (see PHYSICS TODAY, May 1994, page 65) have completed their terms. The APS sponsored Duncan Moore, who was able to extend his appointment by several months so that he could continue to assist West Virginia Senator Jay Rockefeller IV, a Democrat, with three bills, on technological competitiveness, reauthorizing the National Science Foundation and commercialization of technology. Moore, a participant in this month's PHYSICS TODAY Roundtable discussion (see page 42), came to the program with about 20 years of experience in science and technology. He saw this background as a great advantage: He had had direct involvement with many of the topics that interest Rockefeller. Moore urged senior scientists from industry and academe to participate in the fellowship program. He helped to provide another opportunity to do so by convincing the Optical Society of America to sponsor its fellowship in tandem with the Materials Research Society.

Sponsored by AIP, AGU and APS, physicists help to develop and review legislation on issues ranging from nuclear waste to patent law. Past participants in the program report a gratifying experience.

Ruth Howes, who was a AAAS fellow, spent a sabbatical year away from Ball State University in Muncie, Indiana, in the education office of the Senate Committee on Labor and Human Resources, which was headed by Democrat Edward Kennedy of Massachusetts. She worked on general science policy and funding issues in higher education (for example, student loans). Howes enjoyed the work, but she noted that in contrast with the pace of university life, there was rarely the "luxury of foresight" in her experience on Capitol Hill. Howes has taken a second sabbatical year to work as a program director of physics in the division of undergraduate education at the National Science Foundation.

Carmina Londoño has returned to her position as a principal engineer in optics with Polaroid in Cambridge, Massachusetts, after completing her fellowship on the House subcommittee on technology and competitiveness. This subcommittee of the Science, Space and Technology Committee was known for its many hearings, and Londoño organized several: on the GATT subsidies code and its impact on research and development, on export controls and their impact on high-technology industries, and on international standards.

Londoño said that "putting on a hearing is like putting on a small conference." She explained that by building a public record and establishing authority, hearings are critical to getting a bill passed—a kind of "hearing or perish." For Londoño, who completed her fellowship in December, the experience reinforced the importance of

"accommodating other people's viewpoints."

Effects of an earthquake

One of last year's APS fellows, Philip (Bo) Hammer, spent his year on Congressman George Brown's subcommittee on science when Brown, a Democrat from California, headed the House science committee. Hammer, a native Californian, worked on issues of earthquake and fire safety—referred to by the committee, he said, as "shake and bake." In November 1993 Brown thought that the National Earthquake Hazards Reduction Program needed better direction, but he could get no support. Two months later the Northridge earthquake hit Southern California, and Hammer was asked to help plan the "lessons learned" hearing. He is now the assistant to AIP Executive Director Marc Brodsky.

Elizabeth Cohen, a fellow with the National Economic Council, has returned to her business, Cohen Acoustical Inc, and her earthquake-stricken home in Los Angeles. Cohen was sponsored by the Acoustical Society of America.

She is proud that she was able to do some "very, very practical things" in telecommuting that helped people in the Los Angeles area after the Northridge earthquake. Her experience as an acoustician—which she describes as being at the interface between technology and the arts—also prepared her well to help draft "white papers" on accessibility for people with disabilities and on arts and humanities on the National Information Infrastructure.

During much of Winston Tao's AGU fellowship year in Congressman Brown's office, he dealt with issues of low-level radioactive waste. He also studied the Clinton Administration's clean-car initiative from many different angles. Tao said he was exposed to a tremendous amount of new science and technology as a fellow—"more in one year than in the last five." He also said that perhaps the main reward was the repeated demonstration that "there are multiple points of view in a rapidly changing world."

Tao remains in Washington at the Office of Technology Assessment, where he is an "in-house contractor" hired specifically for research on "earthquakes hazard mitigation in the US." Eventually he would like to return to academe and teach undergraduate courses in environment, technology and policy.

1995: Geology, patents and technology

Applegate, this year's AGU fellow, received his BS in geology and geophys-