found, for example, that a CFTR with mutations in the presumed R-binding region opens at about the same rate as the normal CFTR but, once open, closes much faster. This, "of course, reduces the total amount of chloride ions" a cell can shuttle in and out, Kirk says.

In the past, the CFTR tail had attracted little attention, but that is now likely to change. "The tail is a new player in the game, and this suggests a new way of regulating the gating of CFTR which may involve other proteins that can bind to the tail," says William Guggino, a cell physiologist at the Johns Hopkins School of Medicine in Baltimore. One of these other proteins is likely syntaxin 1A, which may keep the tail from interacting with the R domain until activating signals somehow disrupt syntaxin binding and release the tail to capture the R domain.

What's more, says Richard Boucher, a physiologist at the University of North Carolina, Chapel Hill, the newfound tête-à-tête between the tail and the R domain "gives you a clear-cut target" for drugs against cholera or for drugs to treat the 10% to 20% of cystic fibrosis patients whose CFTR makes it to the cell surface but is crippled by mutations. And though it's unclear whether such compounds will work, specific CFTR blockers, for instance, should help clarify the intricate workings of the CFTR, which even today—10 years after its discovery—still holds many secrets.

–**MICHAEL HAGMANN**

MATERIALS SCIENCE

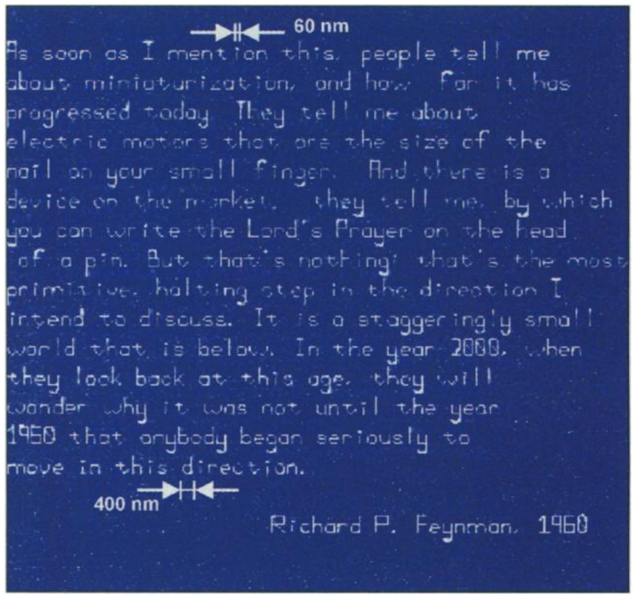
Words Writ—Very—Small by a Nanopen

In 1959, physicist Richard Feynman gave a speech that inspired later generations of scientists. Titled "Plenty of Room at the Bottom," the talk foreshadowed one of today's hottest trends in material sciences: nanotechnology, assembling chosen molecules into tiny materials that can be used for everything from fluorescent dyes to solar cells. He did take some seemingly wild flights of fantasy, however, such as wondering whether crafty researchers would one day find a way to write an encyclopedia on the head of a pin. Now, chemists at Northwestern University have memorialized a paragraph of Feynman's speech in a most appropriate way: They've used a nanoscale pen and ink set to write it in an area just one-thousandth the size of a pinhead.

The work, performed by postdoc Seunghun Hong and graduate student Jin Zhu along with group leader Chad Mirkin, is described on page 523. It isn't the first example of nanoscale writing, but it is the first time researchers have accomplished the job with multiple "inks" that line up with one another to produce features as small as 5 nanometers.

More than just a gimmick, the achievement could pave the way for applications, ranging from testing novel catalysts to creating nanoscale electronic devices, that might reveal whether the dream of making electronic devices with the dimensions of molecules could ever succeed. "It seems like a real enabler" of nanotechnology, says Clifford Kubiak, a chemist and nanotechnology expert at the University of California, San Diego.

Previously, researchers have used either electron beam lithography or, more recently, the tiny styluslike arm of an atomic force microscope (AFM) to create nanometer-sized features on a surface. But these techniques can damage the surface, particularly if it's already been patterned with an organic ink, or leave behind molecular contaminants, making it hard to add new, pristine layers that line up in perfect registry with the ones below, a typical requirement for making electronic devices.



Tiny tribute. Text from a speech by physicist Richard Feynman, which was first delivered in 1959 and published in 1960, now comes nanosized.

To get around these problems, Mirkin and his colleagues came up with a technique called dip pen nanolithography (*Science*, 29 January, p. 661). It takes advantage of another problem encountered by researchers trying to write features with a conventional AFM: water from the air that condenses between the tip and sample, interfering with the tip's motion and thereby the resolution of the image. Rather than being stymied by this problem, Mirkin's team used the water layer to transport organic ink on the AFM tip to a surface. Thus, dragging the tip over the surface produces well-defined lines.

With just one ink, they could write simple structures, including letters. But making an electronically active nanostructure requires positioning different organic conductors, insulators, and semiconductors in different regions. The Mirkin team hasn't yet accomplished that, but it has taken a step in that direction by figuring out how to align a second set of ink marks with the first.

They began by coating one AFM tip with an ink consisting of 16-mercaptohexadecanoic acid (MHA), an organic molecule capped with a water-attracting carboxylic acid group. They then used this ink, along with their computer-controlled AFM, to write a set of parallel lines 70 nanometers apart. Because they feared that their second AFM pass would damage these lines if they used it to locate them directly, they also put in cross-shaped alignment marks, which sit 2 micrometers on either side of the lines.

Next, the researchers changed their AFM tip to one dipped in a second ink called 1-octadecanethiol (ODT), which is capped with a water-repelling methyl group, and scanned this tip across the surface to find the alignment marks. The computer then positioned the tip near the original set of parallel lines and wrote another set alongside the first. Alternatively, the researchers simply use the second ink to fill in the space around the first set of features, because the two inks they chose don't mix.

Finally, to view the patterns they created, the team switched to an uncoated AFM tip, which they used to scan the entire surface. Since the tip encountered higher friction with the MHA than with the ODT, it could tell the two materials apart and create an image of the pattern.

All this tip-changing sounds slow and tedious, but the team has recently automated the procedure, enabling them to write letters reasonably quickly. Indeed, the 115-word paragraph from Feynman's speech took 10 minutes—"about the same amount of time it took us to print it out on our color printer," says Mirkin.

While nanowriting could generate some interest among spies, Kubiak believes its real value will be in making numerous nanoscale electronic devices in a highly reproducible fashion. That would benefit researchers trying to understand how well such small devices operate. Mirkin adds that the technique could also be used by researchers trying to understand catalyst behavior, since it would enable them to place catalysts and reactants in precise locations, just a few nanometers apart, and

CREDIT: S. HONG, L. ZHU, AND C. MIRKIN/NORTHWESTERN UNIV.

then to watch to see how they react over time. But, as with most enabling technologies, the best use is probably not yet even a glimmer in anyone's eye. —ROBERT F. SERVICE

POLICING OF SCIENCE

A Misconduct Definition That Finally Sticks?

A White House panel was due this week to unveil the first government-wide definition of improper conduct in scientific research. True to long-circulating rumors, the new definition would narrow research misconduct to three specific acts: fabrication, falsification, and plagiarism (FFP). But officials at the White House's Office of Science and Technology Policy (OSTP) say they've fleshed out these categories to ensure that a variety of serious misdeeds are explicitly included.

The proposed misconduct policy, expected to appear in the *Federal Register* on 14 October, spells out a range of procedural steps for policing misconduct that all federal agencies would be forced to follow. The most controversial issue, however, is the definition, which the scientific community has agonized over for years. Those who have advocated a minimalist definition appear to have won the battle. "I think it is something that we are comfortable with," says David Kaufman, a toxicologist at the University of North Carolina, Chapel Hill, and president of the Federation of American Societies for Experimental Biology (FASEB), who notes nonetheless that his organization had not seen the final phrasing before *Science* went to press.

"I think it is something that we are comfortable with."

—David Kaufman

The misconduct definitions now used by the Department of Health and Human Services (HHS) and the National Science Foundation (NSF) consist of FFP and "other serious deviations" from accepted practice, a clause that has been criticized as too vague. But other attempts to broaden FFP have faltered: A 1995 proposal for an updated HHS definition, from a commission headed by Harvard reproductive biologist Kenneth Ryan, drew fire for being too open-ended and potentially stifling creativity (*Science*, 21 June 1996, p. 1735). In April 1996, an OSTP committee called the National Science and Technology Council (NSTC) set out to craft its own definition of research misconduct.

The NSTC's proposal, obtained by *Science*, starts out much like the existing HHS definition, defining research misconduct as "fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results." The added value of the NSTC wording is that it spells out each of these concepts in a sentence to ensure that they encompass misdeeds that may have fallen through the cracks. In addition, to make it clear that destroying a colleague's research data is considered misconduct, the NSTC definition added "manipulating research equipment" to the falsification category. The definition also explicitly covers plagiarism during peer review.

Included in the proposed policy is the statement that a misconduct finding must amount to a "a significant departure from accepted practices of the scientific community." NSF had argued in favor of such wording, which echoes its own misconduct definition. The agency has invoked a similar clause in at least one case—to discipline a professor who sexually harassed several students. Although "there's no flexibility to go beyond research misconduct more broadly than it's defined in this policy," an OSTP official says, agencies and universities are free to investigate and prosecute other transgressions during the course of research.

Parties now have 60 days to comment on the definition; the Office of Research Integrity and the National Academy of Sciences are planning a meeting on 17 November with FASEB, journal editors, and other groups to vet the proposal. Judging from the subdued reaction so far, it appears the agencies have reached the end of a long road toward a standard definition of research misconduct. —JOCELYN KAISER

DIPLOMACY

Gibbons Joins Effort to Boost Science at State

The State Department now has a 12-step self-help plan for producing science-savvy diplomats. A National Academy of Sciences (NAS) panel last week sent Secretary of State Madeleine Albright a dozen recommendations for rebuilding her department's depleted expertise in science, technology, and health. But while top diplomats welcome the ideas—and have asked former White House science advisor Jack Gibbons to help put them into practice—they say a budget crunch could slow the progress. "The problem is not one of will but of resources," says Ken Brill, acting head of the agency's Bureau of Oceans and International Environmental and Scientific Affairs.

The new report,* which Albright requested in April 1998, is a fleshed-out version of a preliminary study the panel released late last year (*Science*, 25 September 1998, p. 1937). It concludes that science-based issues—from trade in genetically modified crops to global climate change—are moving "to the forefront of the international diplomatic agenda" just as the State Department is losing technically trained staff. The number of full-time science counselors at embassies, for instance, has slipped from 22 in the 1980s to about 10 today. The panel also found it "striking and alarming" that foreign service officers assigned to the agency's roughly 300 science-related posts, many of them part-time, had "weak" academic credentials. "Ironically, as the world becomes more technologically interdependent, the trend at the State Department has been to downplay science and technical expertise," says panel chair Robert Frosch, a research fellow at Harvard University in Cambridge, Massachusetts.

To reverse that trend, Frosch's committee goes straight to the top. Albright, the panel says, "should articulate and implement a policy that calls for greater attention to [science] dimensions of foreign policy throughout the department" and should appoint a high-ranking aide to make sure that technical advice is injected into policy discussions. The panel also recommends setting up an external advisory committee, training all diplomats on technical issues, strengthening the department's ties with research-oriented agencies, and assigning 25 new full-time science counselors to key outposts abroad. But the department shouldn't pick and choose among the recommendations, Frosch says. "We want it to be a package and not a menu."

Speaking for science. Gibbons will advise State Department.

State Department officials won't say if they'll go that far. Albright plans to meet with NAS president Bruce Alberts "as soon as their schedules permit." But Brill notes that State Department officials have already asked Gibbons, who left the White House last year, to help a committee review the report and draw up a game plan by next spring. Gibbons will also help develop the science advisor's post and aid ongoing efforts to strengthen training, increase dialogue with scientists, and recruit more academics to serve stints as science fellows within several departments. Brill warns, however, that all that may be tough to do on a budget that has shrunk by 15% since 1993. —DAVID MALAKOFF

* "The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of Science" (www.nap.edu)

CREDIT: RICK KOZAK