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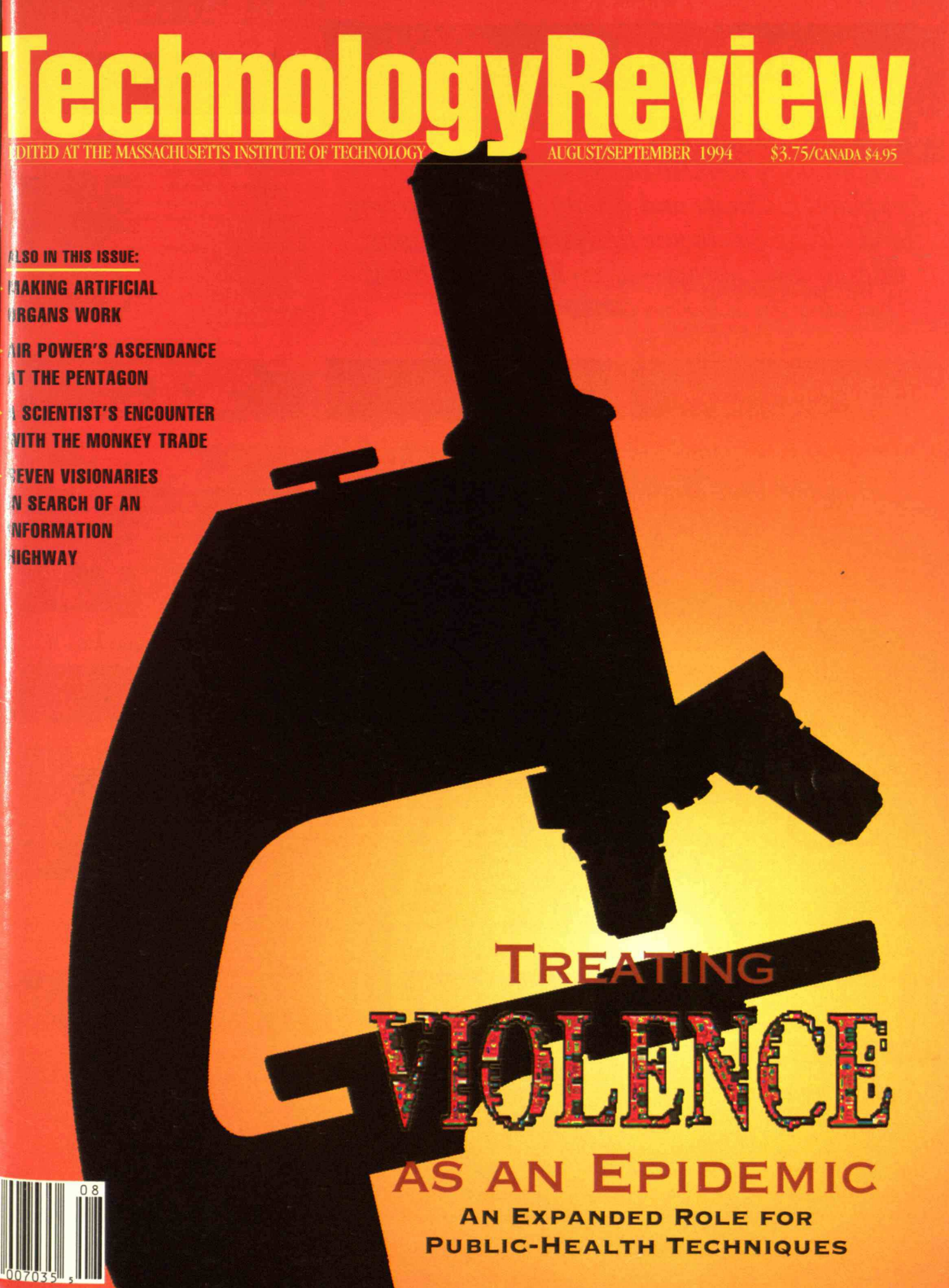

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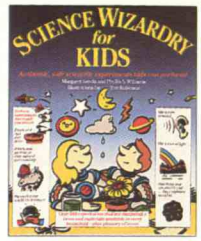

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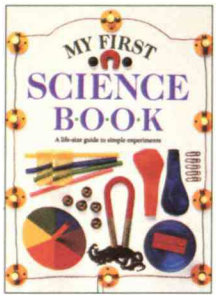

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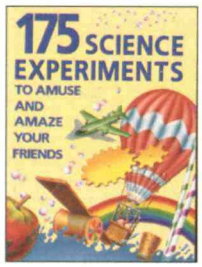

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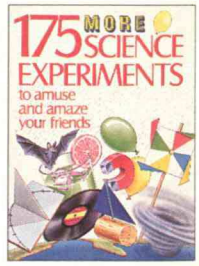

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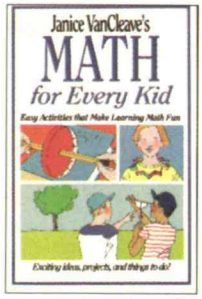

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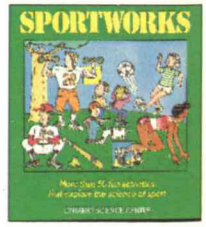

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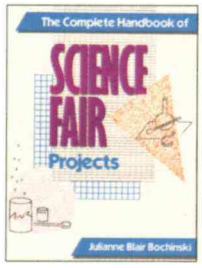

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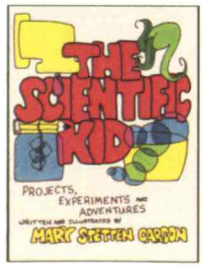

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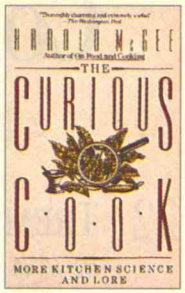

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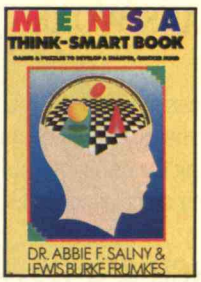

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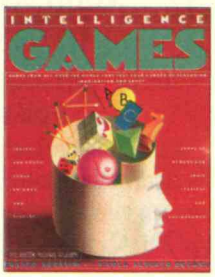

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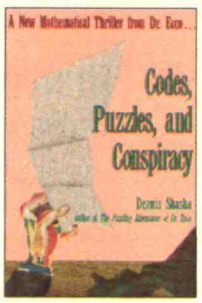

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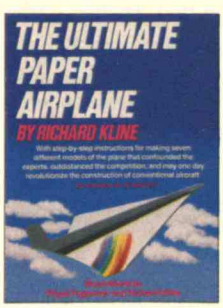

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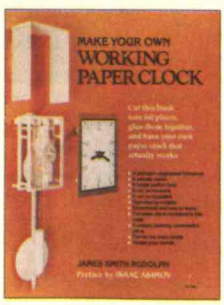

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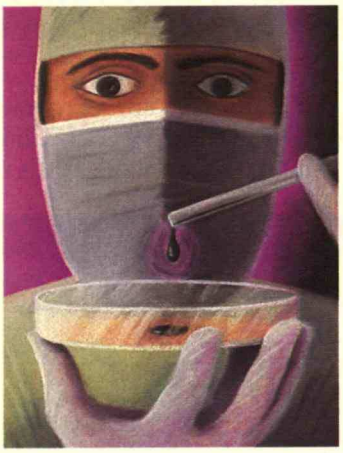
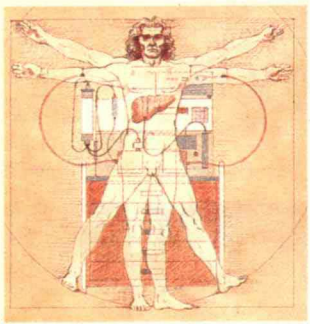
AUGUST/SEPTEMBER 1994

Contents

FEATURES

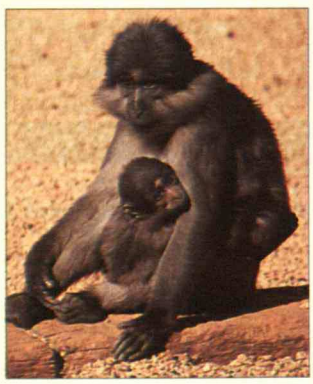


22



32

42



53

COVER: DAVID PERLMAN

TECHNOLOGY REVIEW
VOL. 97/NO. 6

DEPARTMENTS

10

14

76

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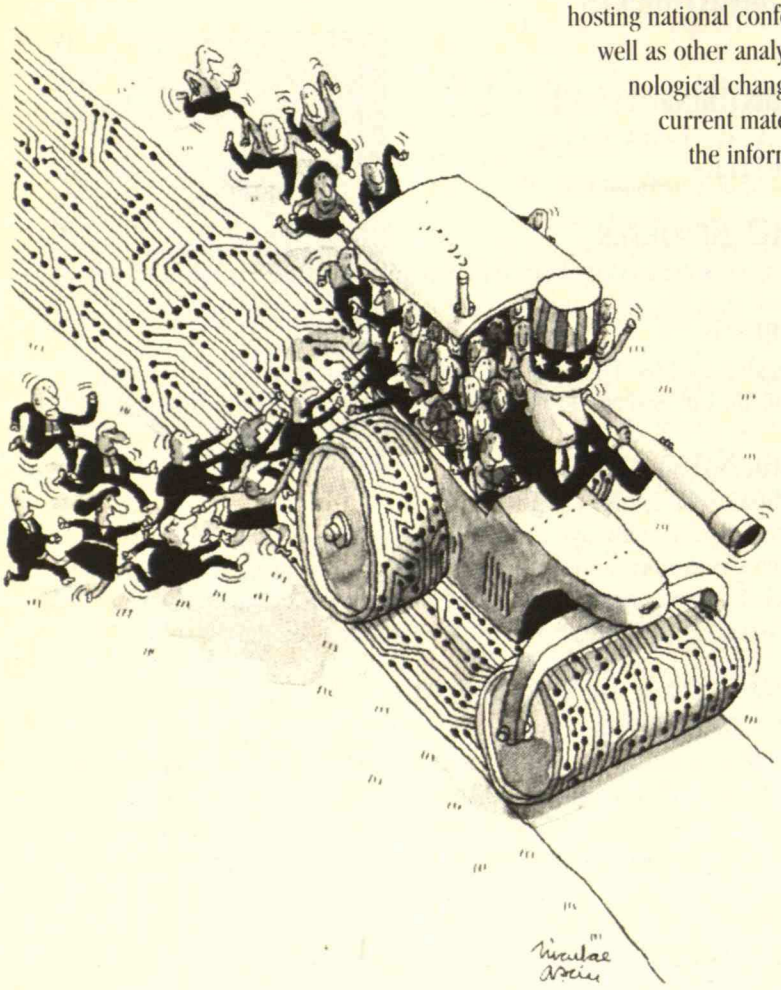

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First Line

Don't Blame the Parent

THE irreverent car buffs Tom and Ray Magliozzi—otherwise known as Click and Clack, the Tappet Brothers—routinely end their weekly *Car Talk* show with some variation on "Though the board of directors hates to admit it when *we're* on the air, this program is a production of National Public Radio." Ever since *Technology Review*'s May/June issue hit the streets with its cover story "Warming Up to Cold Fusion," by Edmund Storms, I've been half expecting MIT to make a similar disavowal with respect to this magazine.

Technology Review's beat embraces some highly controversial issues, and if we're doing our job we'll occasionally make people angry for having allowed an author to present the "wrong" point of view. But reaction to the cold-fusion story marks the first time in my memory that dissenting readers criticized the magazine's editors not only for choosing to run this material—variously describing it as "dreadful," "appalling," "pseudo-scientific," "irresponsible," and "an example of the goggle-eyed approach to science"—but for hurting our institutional parent in the process.

One scientist-reader said that the article "casts disgrace on MIT." Another asserted that it "trashes research at MIT." Yet another wrote that it "embarrasses the Physics Department, MIT, and all graduates of MIT." In a brief news item, *Science* magazine observed that *Technology Review*'s "MIT connections have raised eyebrows rather high, since it was MIT researchers who in 1989, cold fusion's heyday, published some of the most devastating refutations of the claims."

Not all of the reaction was negative. "Thanks for having the guts to print this historical article," said one scientist. "I applaud *Technology Review* for publishing [it]," said another. "I was refreshed to read Storms's open-minded article," said another. One scientist saw major benefit in the affair for the magazine and MIT alike: the public would be reminded that *Technology Review* is an independent publication, in no way a mouthpiece for the Institute; and MIT would be seen as an intellectually rich and multifaceted place, tolerant of diverse points of view.

Of course, that doesn't mean our pages should be open to any and all applicants. *Technology Review*'s editors try to choose authors rigorously—we think of the magazine as a select forum for experts and otherwise credible participants in science- and technology-related debates—and we endeavor to edit these authors with great care so that whatever their arguments, the resulting articles are coherent, accurate, valuable, respectful of the reader's intelligence, and a pleasure to read.

Our base is MIT.
Our beat is the world.

What you see in these pages, however, are the authors' views and no one else's. Except in this First Line editorial space, no editor advocates any particular policy; and as it says beneath our table of contents, "authors' opinions do not represent the official policies of their institutions or those of MIT."

Still, it might appear that we are being a little disingenuous, that *Technology Review* is trying to have it both ways. The above disclaimer notwithstanding, we do after all proudly display "Edited at the Massachusetts Institute of Technology" on our cover. How is it possible, one may ask, for us to capitalize on our affiliation with MIT while simultaneously claiming not to represent the Institute?

There is actually no contradiction at all. Though we are not editorially directed by MIT officials and do not feel compelled to fill all our pages with MIT-based stories, we nevertheless revel in the fact that we are science journalists who work in a kind of science-and-technology heaven. Being in residence here gives us the advantage, shared by no other national science magazine, of seeing a world-class educational and research institution in action while having an excellent view of the whole science enterprise as well.

We serve our readers by trying mighty hard not only to manifest MIT's standards and sophistication but to complement its broad humanitarian mission: making the world a better place through the enlightened use of knowledge and technique, whatever their source. Publishing an independent, globally oriented, occasionally risk-taking enterprise that keeps the general public informed of critical fact, judgment, and opinion is only one of many ways that our parent institution serves society. We cannot directly affect, much less try to "represent," its many other outlets; we do try to respect their methods and hope they will respect ours.

I like to think of *Technology Review* as the rough equivalent of a university department, with my colleagues meriting the kind of respect accorded to conventional faculty. We do not often teach students directly, of course, or perform cutting-edge research, but we do fulfill a major, though academically unusual, educational goal, and we do conduct, in our own way, a relentless search for truth. Sponsoring a magazine like *Technology Review*—unique in American higher education, we believe—is a creative outreach that only a great and far-sighted institution could undertake. We are privileged to live in such a place, and we strive to become among magazines what our parent already is among universities.

Thus if you are one of those who hated the cold-fusion story, don't despair. My distinguished predecessor John Mattill used to say that the magazine is like a pendulum, tracing out its arc fully and evenly, and therefore occasionally visiting the outer limits. And as they say at 3M, a company renowned for innovation and therefore comfortable with taking chances, "You can't stumble unless you're in motion."■

—STEVEN J. MARCUS

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Letters

COLD-FUSION HEAT

In "Warming Up to Cold Fusion" (*TR May/June 1994*), Edmund Storms gives the wrong impression that evidence for cold fusion is on the rise. The reports of cold fusion from hydrolysis using palladium electrodes have been discounted by the nuclear physics community for good reason. The experiments reported in 1989 showing positive results were replete with careless procedures, exaggerated claims, and ignorance of systematic effects. Proponents were uncooperative and even evasive when other scientists questioned their work. A number of careful experiments at U.S. national laboratories and research universities in 1989–90 could not reproduce the cold-fusion effects. A diverse panel of leading nuclear physicists and chemists convened in 1989 by the secretary of energy concluded that "the present evidence for the discovery of a new nuclear process termed cold fusion is not persuasive."

Storms does not present convincing evidence that the situation has changed since this report. He addresses legitimate criticisms by suggesting absurd or miraculous hypotheses that show a limited understanding of the underlying physics. For example, he explains the absence of high-energy gamma rays in the supposed deuterium-deuterium fusion reaction by postulating a "special condition" in the palladium that absorbs the gamma rays. But several inches of lead are needed to completely absorb gamma rays with the 24-million-electron-volt energies that occur in this reaction. It would be astonishing if a few millimeters of palladium could accomplish the same thing. Is the author suggesting that electrons in palladium are different from ordinary electrons? Or does he suppose that palladium has an enormous nuclear resonance at that energy (by sheer coincidence) that is somehow chemically induced?

Storms also describes an experiment in Russia that allegedly observed a tightly focused beam of gamma rays coming from a palladium electrode, and suggests that such beams might arise if the metal had an "unusual, tightly bound electron structure." But this makes no sense because the wavelength of a 24-MeV gamma ray is about one-two-thousandth the size of the palladium atomic radius.

Storms complains of a "catch-22" in which physics journals refuse to accept cold fusion papers and then denounce the field's credibility because no papers are published. The only reason these papers are not accepted is that they do not survive the peer-review process.

FRED E. WIETFELDT
Lawrence Berkeley Laboratory
Berkeley, Calif.

Storms argues correctly and persuasively that many laboratories have accumulated enough evidence of the reality of the cold-fusion effect to justify funding by a government agency. It is true that the field began with scientifically undesirable publicity and polemics, and has engendered much hasty and ill-conceived work. However, there is proof of phenomena that cannot be understood in terms of present chemical or nuclear knowledge, which offer the tantalizing possibility of a new source of energy and therefore should be explored systematically. The current inability of experimentalists to achieve reproducibility in cold fusion echoes past experience in other areas of science and is not enough reason to condemn the work as pathological science.

Although Storms is generally correct, he may be guilty of overstatement. For example, I do not know of any group that can confidently claim to produce excess power routinely. Apparently there are parameters and conditions not yet well enough understood to be specified as proper procedure. Also, the claim by nine laboratories that they have generated excess power through electrolysis of light water (H_20), if true, makes the

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use of H_20 as a control for investigation of excess power from heavy water (D_20) problematic. More important, I have yet to see accounts of experiments with H_20 with enough detail to convince me of the absence of artifacts and errors. I also do not see any justification for asserting that palladium, when reacted with enough deuterium, converts to a special condition of matter in which deuterium-deuterium fusion can occur. As Storms remarks, such fusion would produce neutrons and tritium in a nearly one-to-one ratio, but this is not seen.

Noting these problems does not lessen my desire to join with Storms in his main message, that research on cold fusion should be supported. I would suggest a modest level of annual funding, such as $20 million.

RICHARD A. ORIANI
Professor Emeritus and Director Emeritus
Department of Chemical Engineering and Materials Science
University of Minnesota

The cold fusion story created unwarranted expectations that a cheap environmentally benign energy source is within reach. Such expectations were enhanced by *Technology Review's* association with MIT, an association that engenders any inference of endorsement of cold fusion by, among others, physicists and chemists who are part of the MIT community.

Although a subheadline accurately stated that most scientists reject cold fusion as error or fraud, the story was irresponsible in its poorly supported assertion that "the basis for skepticism is dwindling as reports of energy-releasing nuclear reactions at room temperature pour in from labs about the world." Storms's data are sparse, conveying only bottom-line results—for example, that Pons and Fleischmann "claim that when they applied 37.5 watts to a cell as electric power, it produced 144 watts of excess power as heat." Storms does not show such aspects as power input and output levels as a function of time, or neutron and tritium levels as a function of excess heat.

The author states that experiments conducted at MIT, Caltech, and Harwell did not, as the experimenters claimed, debunk the findings of Pons and Fleischmann (and others) to the effect that a nuclear fusion reaction had occurred in their apparatus. What are the responses of the MIT, Caltech, and Harwell researchers to Storms's dismissal of their conclusions? How do these researchers assess the validity of the experiments upon which Storms based his conclusions?

Overall, the Storms article serves only to help keep alive hopes based on wishful thinking rather than on hard science.

HENRY R. MYERS
Peaks Island, Maine

I applaud *Technology Review* for publishing "Warming Up to Cold Fusion" in the face of the scientific establishment's continuing opposition to this subject. I concur with author Edmund Storms that experiments in which palladium is loaded with large concentrations of deuterium have yielded significant evidence of excess heat, and sometimes of low levels of nuclear products.

One potential explanation for what is going on went unmentioned, however: the possibility that the heat arises from the release of latent chemical energy in the heavy or light water in the cell. I have recently reported quantum-chemical calculations indicating that high loadings of hydrogen in palladium provide a chemical pathway that catalyzes deuterium atoms to continue into molecules of dideuterium ($D+D \rightarrow D_2$). Depending on how long it takes for the dideuterium to diffuse, this process could release 17 to 1,700 watts of latent heat per cubic centimeter of palladium deuteride. This mechanism also explains why excess heat can be generated in light-water cells only when nickel, rather than palladium, is used as the electrode: the surface of nickel is better able than palladium to catalyze the recombination reaction of ordinary hydrogen.

Although the heat is chemical in origin, very low levels of deuterium-deuterium fusion probably do occur in palladium that is highly loaded with deuterium. This fusion is responsible for the nuclear products that have been observed in some experiments.

If this scenario proves correct, "cold fusion" researchers will have uncovered an important supply of energy, even if it isn't really fusion. Ten gallons of water contain about 80 megajoules of latent heat, or 76,000 BTUs. An electrochemical cell containing about 150 grams of palladium could release this heat in about an hour, for an average power of 22 kilowatts; this approaches the heating capacity of a modest-sized household furnace. A power of 22 kilowatts corresponds to 30 horsepower, suggesting the possibility of a "water engine" electrochemically generating both heat and hydrogen for a fuel cell, which could be used to power an automobile.

KEITH H. JOHNSON
Professor of Materials Science and Engineering
MIT

As a physicist who does not subscribe to the conventional wisdom that cold fusion is hogwash because it does not mesh with established theories, I was refreshed to read Storms's open-minded article. The massive opposition to the idea of chemically assisted nuclear reactions is based more on social and psychological factors than on any clear-cut scientific arguments. After all, how is it possible to rule out cold fusion—which, by definition, may involve unknown physical principles—with the argument that the phenomenon does not fit the scheme of known effects? The reality is that any tangible progress in cold fusion

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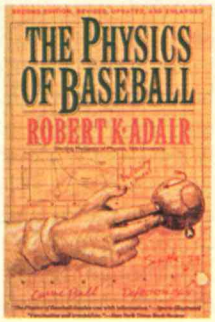

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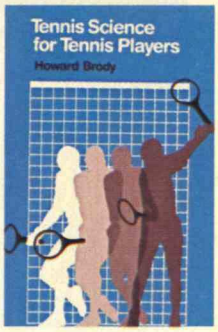

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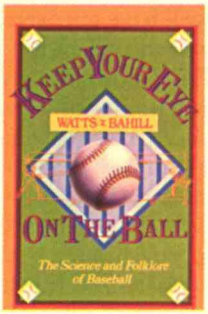

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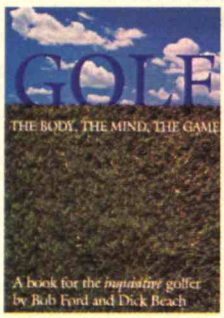

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will call into question research on "hot" fusion—a field in which thousands of scientists around the world have invested their careers.

ALEXANDER A. BEREZIN
Associate Professor of Engineering Physics
McMaster University, Hamilton, Ontario

"Warming Up to Cold Fusion" is an opinion piece posing as an objective overview. The author chooses some results that support cold fusion while giving short shrift to the much larger body of negative results. Worse, the article is riddled with false and misleading statements—for example, that the tritium produced in conventional fusion can fuse with deuterium to produce neutrons and helium-3 nuclei. In fact, the deuterium-tritium fusion reaction produces a helium-4 nucleus, *not* helium-3. Production of helium-3 would imply conversion of an entire mass unit to energy, and as such would yield over 900 million electron volts (MeV) of energy, as compared with less than 20 MeV for production of a neutron plus helium-4. I know of no reports of 900 MeV-particles produced in any kind of fusion. In addition, conventional fusion reactions do not produce tritium directly. Rather, it is bred by the capture of fusion-produced neutrons in a lithium blanket surrounding the fusion chamber. The resulting tritium atom is nowhere near any deuterium atom to fuse with.

I would be delighted if cold fusion really existed, especially if it could produce commercial amounts of power. Nuclear engineering would prosper. Unfortunately, the evidence remains strongly against cold fusion.

KENNETH C. RUSSELL
Professor of Nuclear Engineering
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MIT

ALTERNATIVE ENGINES

In "Fuel-Cell Vehicles: The Clean Machine" (*TR April 1994*), Robert H. Williams writes enthusiastically about what fuel-cell powered cars, fueled by hydrogen, could do for many of our transportation-generated problems a decade