Technology Review

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY MAY/JUNE 1994 $3.75

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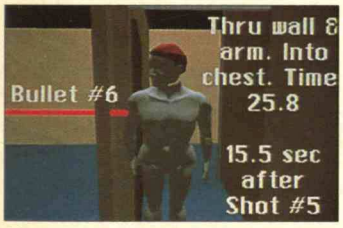
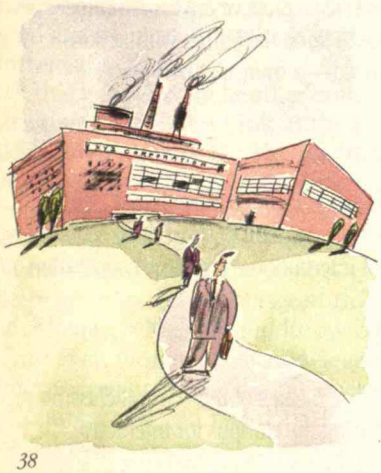
TECHNOLOGY REVIEW
MAY/JUNE 1994

Contents

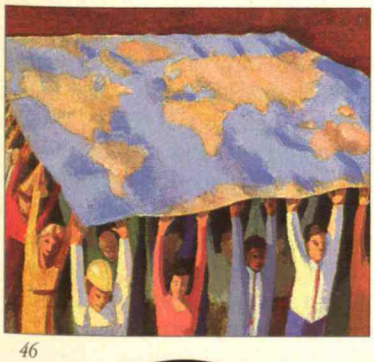
19



30



38



46

56

FEATURES

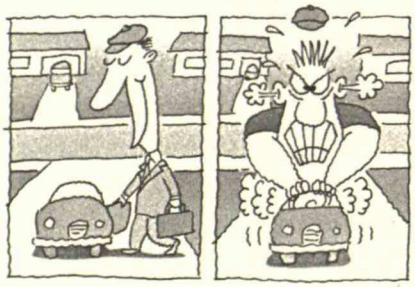
COVER ILLUSTRATION: JOHN PAUL GENZO

TECHNOLOGY REVIEW
VOL. 97/NO. 4

DEPARTMENTS


12


16


62

Technology Review (ISSN 0040-1692), Reg. U.S. Patent Office, is published eight times each year (January, February/March, April, May/June, July, August/September, October, and November/December) by the Association of Alumni and Alumnae of the Massachusetts Institute of Technology. Entire contents ©1994. The editors seek diverse views, and authors' opinions do not represent the official policies of their institutions or those of MIT. We welcome letters to the editor. Please address them to Letters Editor.

Editorial, circulation, and advertising offices: *Technology Review*, Building W59, MIT, Cambridge, MA 02139, (617) 253-8250; FAX (617) 258-7264. Printed by Lane Press, S. Burlington, VT. Second-class postage paid at Boston, MA and additional mailing offices. Postmaster: send address changes to *Technology Review*, MIT, Building W59, Cambridge, MA 02139.

Subscriptions: $30 per year. Canada add $6, other foreign countries add $12. Contact *Technology Review*, P.O. Box 489, Mount Morris, IL 61054, (800) 877-5230 or (815) 734-1116; FAX (815) 734-1127.

Advertising representatives: Mark E. Lynch, Eastern Sales Manager, 9 Salem Drive, Saratoga Springs, NY, (518) 583-6086; The Leadership Network: Kiki Paris, 200 Madison Ave. New York, NY 10016, (212) 686-1734; The Noblehart Group, Charles Hollingsworth, P.O. Box 15478, Washington, DC, (202) 547-8488. Printed in U.S.A.

BPA INTERNATIONAL

First Line

Fostering a Nation of Science Generalists

I was nine when Mrs. Peach, our teacher at the English High School for Boys in Istanbul, taught us "General Knowledge" on Friday afternoons. It was the most memorable class of all my school years. Here were natural history, physical processes, and geography—real knowledge of our world—all rolled into one approach to science so you could see the connections.

Unfortunately, Mrs. Peach's course was an exception to the rest of the curriculum. After age nine, every succeeding school year became a more specialized jumble of individual subjects, each standing on its own as though the others didn't exist.

All this happened in another country at another time. But a look at the pre-college curriculum in the United States today reveals nothing vastly different. Compartmentalization still prevails. We teach youngsters science—indeed, all subjects—one discipline at a time, with little or no connection between them. Our colleges, which should know better, are even worse. Most non-science majors are required to take only one science course, and in a particularly confined subject—concentrating, for example, on chemistry or geology or astronomy—rather than learn about the unity of nature, of scientific research, and of technological thought.

Broad-based science courses like Mrs. Peach's "General Knowledge" may exist here or there. But I never saw one until four colleagues—a cognitive psychologist, an anthropologist, a historian of science, a botanist—and I, an astrophysicist, teamed up to teach undergraduates at Cornell. Immodestly, we called our class "The Course of Science." The intentional double meaning was designed not only to reveal individual disciplines as integral parts of one system, but to stress that this system had been fashioned over time by human thought, each great civilization deeding its legacy to the next.

The compartmentalization of knowledge in our educational system is, if anything, on the rise as a result of our current preoccupation with industrial competitiveness. Specialists point to our loss of international market leadership in some areas of high technology, and correlate that loss with the low science and mathematics scores U.S. students earn in comparison with their counterparts elsewhere. From this they infer that the country must be spurred to produce larger numbers of scientists.

Our "competitiveness problem" stems not from insufficient R&D but from too few citizens able to appreciate and apply its results.

But if our economy, particularly in high-technology areas, is insufficiently competitive, the reason may be not that we teach too little science but rather that education—technical and non-technical alike—has become so narrow. Few scientists know how to mesh their knowledge with other disciplines and the world around them; and few non-scientists, having had only brief, superficial, and one-sided exposure to science, can begin to appreciate and control its power.

Many of our citizens are confused, for example, by press accounts that quote differing scientists—some who are convinced that growing amounts of atmospheric carbon dioxide pose a danger and others who remain skeptical. How can this be, the public asks, when our schools have taught us that the scientific method guarantees immutable truths? Few non-scientists understand that scientific conclusions are often the result of judgment calls based in considerable part on hunches, personal preferences, and idiosyncracies.

The welfare of the nation depends on a shared understanding of what science and engineering entail and what types of problems they are able to solve. We especially need leaders who can formulate a broadly conceived technology policy. But while our country allocates major portions of its budget to areas such as medical research and space programs, no more than half a dozen among the 535 members of Congress can claim even some professional background in science or engineering, or bring their own critical insight to technological issues.

To provide not only our country's future leaders but also general citizens with the cross-disciplinary insights modern society requires, we need to recognize that it is not enough to learn scientific principles or mathematical logic. Driven students will find their way to acquire such knowledge, as they always have, through sheer motivation. But all citizens need to understand the history of science and come to see that science is a human enterprise. It arrives at correct or incorrect conclusions through the accumulation of evidence and consensus. It sometimes leads to new technologies but often does not. It can improve the quality of life or lead to some of the gravest dangers modern society faces. It sometimes is supported by government but occasionally is thwarted with all the power of the law. At times it is considered humanity's highest calling but at other times it is seen as highly immoral, as when it attempts to pursue birth control, genetic engineering, and other activities considered perverse or sinister by some.

Until the majority of our citizens acquire a basic feel for science and its relationship to human affairs, we will lack the general input and broad social support needed for the nation to equitably fund research and development and reap its rewards. In the United States the price tag for R&D now stands at $76 billion dollars a year. That investment and what it will accomplish must be understood and valued by all who are asked to pay for it.■

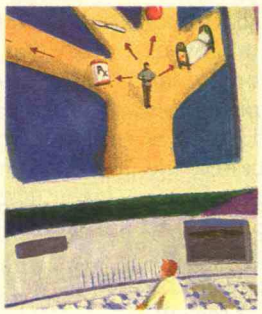
—MARTIN HARWIT

MARTIN HARWIT is director of the National Air and Space Museum in Washington, D.C.

Letters

QUALITY OF MEDICAL CARE

In "Plugged-In Medicine" (*TR January 1994*), Jerome H. Grossman correctly notes that medicine's incentive structure rewards doctors and hospitals for dispensing "units of service" rather than for curing patients. He suggests that the current emphasis on cost control will reduce the tendency to prescribe evermore expensive drugs and perform more tests.



However, the new incentive structure strikes us as being equally off the mark. If a provider receives a fixed amount of money to treat a certain patient, as is the case with Medicare and many health maintenance organizations, then doctors and hospitals will tend to perform fewer tests than necessary—if we assume their goal is to maximize profit—thereby undertreating the patient.

An incentive is required that aligns the natural interest of hospitals and doctors in making money with patients' interest in being cured. Such a scheme might, for example, reward practitioners whose ability to cure certain diseases is above the national average. Under this scheme, patients would pay extra for successful treatment and would receive a refund for unsuccessful treatment.

Such an incentive strategy would encourage the use of appropriate technology and emphasize Grossman's goal of outcome-oriented medicine, thus decreasing costs and improving patient care.

MICHAEL DE LA MAZA
DENIZ YURET
Cambridge, Mass.

In reference to "Plugged-In Medicine": "How well they do" rather than "how much they do" might be a new theme for medical providers.

KEVIN M. KELLY
New Hartford, N.Y.

Despite Jerome H. Grossman's interesting and useful observations on applying information technology to patient care, I was saddened by a subtle theme throughout.

Computer diagnosis, machine-ordered treatment, and home videos teaching how to change bandages are all wonderful, I suppose, but the author omits a vital part of treatment. The late Dr. Norman Vincent Peale called it thinking positively, scientists called it the placebo effect, and to some it's just tender loving care. The preacher Mark Anschutz, of New York, who has spent a great part of his life visiting the sick, confirms: "It is my opinion that most people would get well a lot faster if the doctor would spend more time with his arm around the patient and less time frowning at the charts."

MARK ROLLINSON
Leesburg, Va.

Jerome Grossman makes a strong case for the computerization and networking of medical information, a transition that no doubt will take place with or without national health care reform. However, Grossman neglected to caution readers about the difficulties of protecting privacy in a plugged-in world. Most citizens want to retain some control over the use and dissemination of highly personal medical information. In fact, one of the hospitals at which I consult has posted signs in every elevator that read "Remember Patient Confidentiality." But it is one thing for a couple of interns to discuss some intimate detail in a hospital elevator and quite another for such information to be transmitted across the continent, available to anyone with a modem.

We will do well to design a health information network that can "remember patient confidentiality."

JEFFREY W. KALENAK, MD
Assistant Professor of Ophthalmology
Medical College of Wisconsin, Milwaukee

NUCLEAR POWER FOR DEVELOPING COUNTRIES

In "A New Energy Path for the Third World" (*TR October 1993*), Nicholas Lenssen questions the need for a grow-

ing energy supply in the Third World to expand its industrial base and raise its standard of living. While he also argues for increased attention to energy efficiency, he states that nuclear power is not a viable option for the Third World, citing problems in Argentina, Brazil, and India. Perhaps inadvertently, he does not take note of the very different example of South Korea.

Between 1970 and 1990, South Korea's GNP rose at an annual rate of 8.6 percent, along with a parallel growth in energy consumption of 8 percent per year. Per capita GNP rose 20 times, from $252 to about $5,500, far exceeding the 50 percent per capita GNP growth in the United States in the same period. Through the last three decades, growth in South Korea's electricity generating sector has been particularly impressive, achieving an average annual rate of 15 percent. And significantly, almost 50 percent of the electricity generated in 1990 came from nuclear power. Today nuclear power provides nearly 14 percent of the country's total energy consumption at a lower cost than power from coal- or oil-burning plants.

Several developing countries are capable of handling advanced nuclear technology, and in fact some do so today on a limited scale. I, for one, would like to see more follow the South Korean example. We should encourage efficiency in energy use, but for developing countries there is no substitute for additional energy growth as part of their economic growth.

Furthermore, we should consider the impact of not providing large developing countries such as India and China with the option of nuclear power. As their demand for energy grows, these countries will consume huge amounts of fossil fuels and add millions of tons of potentially harmful emissions to the atmosphere.

MUJID S. KAZIMI
Chair, Department of Nuclear Engineering
MIT

R&D RESCUE UNNEEDED

In "Nurturing Winners with Federal R&D" (*TR November/December 1993*), Don E. Kash and Robert W. Rycroft are of course well-meaning when they conclude that the federal government should invest huge sums in the U.S. auto industry to strengthen its technology and consequently its position in world trade. But the U.S. auto industry hardly needs a federal bailout—it is already making itself competitive through the marketplace by improving its products and lowering costs. That is how our economic system is supposed to work. And it is working: domestic market share of Detroit's Big Three is now 75 percent, while that of Japanese manufacturers is slipping.

Kash and Rycroft should consider the failures of socialism in the former USSR before recommending massive federal intervention in industries that simply don't need fixing. The authors should also think through the implications of an industrial policy that would not only raise serious objections in trade forums such as the General Agreement on Tariffs and Trade, but would also pit Big Three workers in Detroit against employees at Japanese-owned auto manufacturing plants in Marysville, Ohio, and Smyrna, Tenn.

JAMES V. LACY
Laguna Niguel, Calif.

(Lacy was chief counsel for technology in the Department of Commerce during the Bush administration.)

SALUTING THE BOTTOM LINE

"Losing the Cooperative Edge" (*TR November/December 1993*) was an excellent column, though I think Langdon Winner was too polite.

The cutbacks, layoffs, and downsizing fueling America's "jobless recovery" reflect the longest and severest case of U.S. corporate greed since the Roaring Twenties.

For the sake of almighty profit, America's manufacturing base has been exported to cheap labor oysters abroad by multinational corporations that salute no flag except the bottom line. That U.S. workers suffer the consequences is of no importance in this brave-new-global-village economic mentality.

Hard-won U.S. employee reforms

such as the right to collective bargaining, health insurance, and decent wages and hours will have to be regained or initially obtained in dubious battles by workers around the globe as well as in the United States.

If the U.S. economy continues to lose high-paying jobs, the United States cannot continue as the world's greatest importer of goods. A nation of haves and have-nots yields a Banana Republic primarily dedicated to sending its Army, Navy, Air Force, and Marines, composed mainly of its disadvantaged, wherever and whenever American interests abroad feel threatened.

JACK CROWE
Dhahran, Saudi Arabia

BALANCING ENGINEERING WITH FAMILY AND COMMUNITY

I read Samuel C. Florman's "Respecting the Rank and File" (*TR January 1994*) with disappointment and confusion. Although his column is called "The Humane Engineer," I find his comments show a blind spot about the humanity of the rank and file he is discussing, namely that there is probably more to consider about these people's lives than their purely professional contributions. The "underlings, malcontents, independents, and mavericks" Florman cites might actually be individuals who have changed their commitments to include family, children, and community instead of focusing narrowly on technical development and advancement in professional rank.

JEAN RENARD WARD
Arlington, Mass.

FERTILIZING RICE

I was surprised that the otherwise excellent article "Growing Rice the Old-Fashioned Way, with Computer Assist" (*TR January 1994*) asserts: "Green Revolution rice hybrids cannot be grown without fertilizers." The sentence contains two errors. First, the new rices are not hybrids—they are varieties. Second, both new and traditional varieties can be grown without fertilizer. Under conditions of moderate fertility, both the old and the new varieties tend to have about the same yield, but the latter are more responsive to higher levels of fertilizer. This provides an economic incentive to apply higher levels of fertilizer when growing these new varieties.

VERNON W. RUTTAN
Regents Professor, University of Minnesota
St. Paul, Minn.

CREATION CONTROVERSY

In "Life's Grand Design" (TR February/March 1994), Kenneth Miller cogently shows why biologists no longer entertain the notion of "intelligent design" of living things. But as Miller points out, an evolved form of this incorrect theory is being advocated as an alternative to evolution in the high school biology text, *Of Pandas and People*. Although the book has been roundly criticized by teachers and scientists alike, school boards are hearing about it through a grass-roots creationist lobbying campaign.

Pandas suggests that complex problems such as the origin of the first replicating molecule are too difficult to explain as occuring "by chance" and require, like the pocket watch found in the woods, an intelligent designer. Aside from the fact that evolutionists don't rely on "chance" to explain the origin of life, *Pandas* errs in assuming that the *unexplained* (or the difficult to explain) is therefore unexplainable.

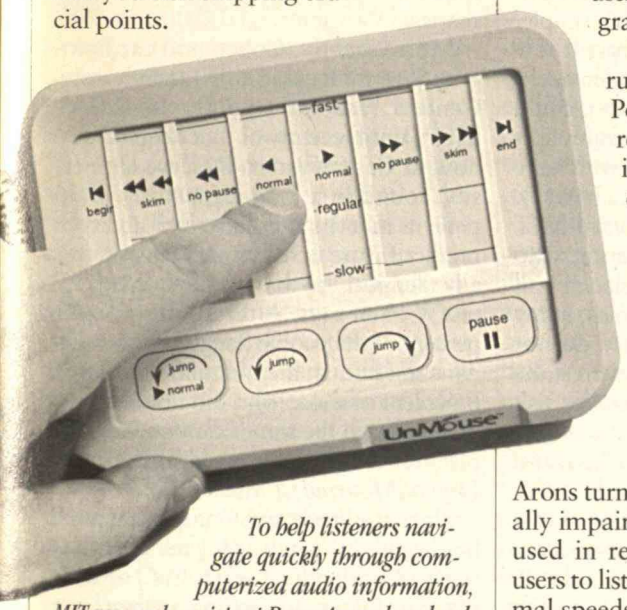
After all, many problems in science are unexplained. We do not know, for example, exactly why the El Niño climate system remained in place for two years and is now waning. This causes no distress to intelligent design theorists, nor does it generate any enthusiasm for explaining the phenomenon by supernatural means. Is it merely coincidence that only those areas of science that have religious implications, such as the origin of humans, are the ones requiring explanation through "intelligent design?"

EUGENIE C. SCOTT
Executive Director
National Center for Science Education
Berkeley, Calif.

MIT Reporter

SPEEDLISTENING

Since our ears can't skim recorded information the way our eyes can skim print, reviewing the tapes of a meeting, lecture, or interview often becomes frustrating. Speed up the tape and you hear Alvin and the Chipmunks instead of familiar human speakers; randomly fast-forward through the tape and you risk skipping crucial points.



To help listeners navigate quickly through computerized audio information, MIT research assistant Barry Arons has developed a touch pad in which eight columns and four buttons control various functions.

SpeechSkimmer, a device being developed by Barry Arons, a graduate student and research assistant in speech research at MIT's Media Lab, helps listeners browse through recorded information. It can zip through a tape at twice the original speed while preserving the speaker's normal voice, or allow a listener to jump from one potentially important segment to another.

The algorithms required for "audio manipulation" have been around for years, but by and large nonmilitary applications have only recently started to appear. That's because personal computers are just now becoming fast and cheap enough to manage these tasks in real time, says J. Robin Rohlicek, a speech-processing specialist at BBN Systems and Technologies in Cambridge, Mass.

Arons's effort has entailed figuring out ways of processing digitized audio information for personal use, determining which off-the-shelf hardware and software could be packaged to perform these tasks, writing other necessary software, and creating a device to let users work with the various programs and hardware.

With Arons's system, which runs on a portable Macintosh PowerBook, a user can directly record a meeting or interview into the computer or play a conventional tape for pickup by the machine's microphone. Arons has outfitted the computer with additional hardware to digitize and store the recording.

To speed up or slow down the computerized recording while preserving the sound of the speaker's voice, Arons turned to technology for the visually impaired. He employed a program used in recording devices that allow users to listen to tapes at faster-than-normal speeds, much as people with sight can set their own pace while reading.

The software chops an audio file into 60 millisecond segments. During playback, it delivers odd-numbered bits to one side of a headphone and even ones to the other. If segment 14 perfectly follows segment 13, and so on, the recording plays back at the original speed. But if the software delivers segment 14 slightly before segment 13 is complete, the playback time compresses. The greater the overlap, the faster the recording flashes by. Though unsettling at first, the brain can adapt to listening this way in only a few minutes.

To further compress an audio file such as a speech or recorded business letter, Arons includes a program that searches for and removes pauses of less than half a second. Such delays rarely convey any meaning; speakers usually insert them to catch their breath. Combining this pause-removal program with the overlap software can reduce listening time 50 percent—the limit at which most people can process audio information—or more.

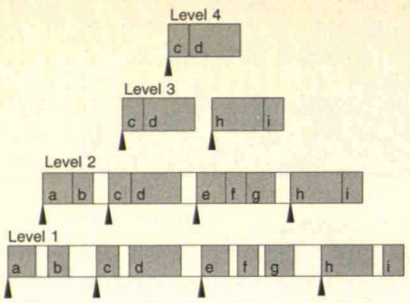
Arons has also worked to free listeners from the sequential tyranny of audio information so they can scan without repeatedly hitting a tape recorder's fast-forward and rewind buttons. He has included a program enabling SpeechSkimmer to search for long pauses—those greater than nine-tenths of a second. These often indicate that a speaker is giving another person the floor or collecting thoughts before changing the topic or making an important or summary point. Arons' system plays the first five seconds of speech following these pauses, then searches and jumps to the next. These segments let a user gain a general idea of the content without listening to whole sentences.

The same software can be operated in reverse so that users can browse backward through a recording, still listening to each five-second segment in understandable forward fashion. And to hit more highlights, Arons is creating a program that analyzes an entire recording for pitch, since speakers (of English, at least) often introduce new topics by raising their pitch. The software selects the top few pitches, then presents the first five seconds of speech following them.

Arons has tied the programs together with a palm-sized touch pad. Each of eight columns on the pad controls a separate function, such as reverse skim. Users control a recording's tempo according to how high or low they touch each column. Arons decided to develop this touch pad because he believed the PowerBook's computer screen should stay blank. "It makes sense to include aural feedback for an ears-only application," he says. "That way you leave the eyes free for other work," such as skimming through written notes.

Arons's system represents the newest wave in personal computing, says Mitch Stein, who manages Apple Computer's Human Interface Technology Group. Although many manufacturers are com-

PHOTO: ASSOCIATION FOR COMPUTING MACHINERY



Arons's device can compress raw audio information (level 1) by removing short pauses and tightening longer ones (level 2), playing only the first five seconds of speech after the remaining pauses (level 3), and playing the first five seconds of speech following raised voice pitches (level 4). The latter often occur when a speaker introduces a new topic.

ing out with ever-smaller computers, keyboards must remain limited by finger size. Programmers are therefore often turning to voice for input and output. The "really exciting" work, according to Stein, will be in combining the ability to search computerized audio files with speech recognition—the capacity to identify particular words or phrases.

Developing such "wordspotting" is Arons's next plan for SpeechSkimmer. But finding specific words, or sounds such as laughter, in a recording can be quite a task, says Lynn Wilcox, a computer scientist at Xerox Palo Alto Research Center who is also working on this problem. The computer must begin with a sample of the word in the speaker's voice. That's relatively easy if the listener recorded the tape, since he or she could insert a particular phrase, such as "Find this," at important points. But without such "voice marks," locating a word that comes from a novel voice poses a huge computing challenge still to be solved.—*P.J. Skerrett*

Testing the Heart

Spontaneous abnormal heart beats, or arrhythmias—such as the one that killed Boston Celtics captain Reggie Lewis last year—fell about 400,000 Americans annually. For years, the "gold standard" for predicting and treating those at risk has been the electrophysiologic (EP) test. But that costs up to $10,000 and is invasive: it involves snaking a catheter tube to the heart before jolting it with low voltages to see if they will induce a temporary arrhythmia. (Physicians can reverse the condition with continued low voltage or, if necessary, high-energy shock treatment.) Doctors therefore typically use the test only on people who have previously had an arrhythmia, to determine whether those patients are subject to another episode. Unfortunately, about one-third of the people who die from spontaneous arrhythmias have never had symptoms of heart disease.

Now, after 10 years of work, MIT scientists may have come up with a simple, safe alternative that could cost a few hundred dollars per use. The new technique, known as an alternans test, could be applied more broadly. For example, it might be useful for all people who have had heart attacks, says Richard J. Cohen, director of the Harvard-MIT Center for Biomedical Engineering, who headed the research team. Since not all heart attacks involve arrhythmias, many heart-attack victims currently do not undergo the electrophysiologic test, he points out. Yet they are at greater risk for arrhythmia.

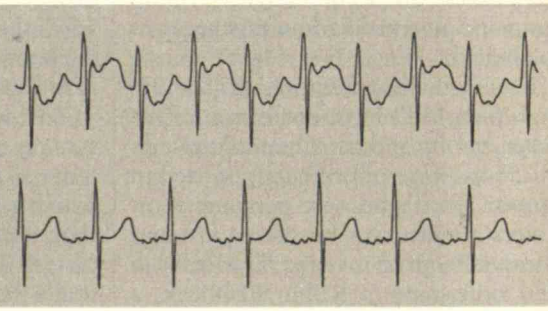
The test developed by Cohen and Joseph Smith, who worked in Cohen's lab as a graduate student and is now a cardiologist at Washington University in St. Louis, builds on the commonly administered electrocardiograph (EKG), in which several electrodes placed on the chest measure the pattern of voltage signals generated by the heart's activity. The team devised the test after Cohen hypothesized that, despite a normal-appearing EKG, a heart susceptible to a spontaneous arrhythmia might exhibit an abnormal pattern with subtle beat-to-beat variability.

Cohen and Smith devised a software program that breaks each heartbeat into numerous points in time, then compares the height of the voltage signal at each point to corresponding points on many other beats. In both animals and people known to be at risk for spontaneous arrhythmia, the program indicated—after elimination of signal noise coming from sources such as respiratory and skeletal-muscle activity—an "alternans" pattern. That form is characterized by a sequence of beats with alternating shapes.

Most recently, Cohen and cardiologists Jeremy Ruskin of Massachusetts General Hospital and David Rosenbaum, until recently of that hospital and now at Case Western Reserve University, found in a long-term study of 66 patients that the alternans test's ability to predict future arrhythmias was "virtually identical" to that of the standard EP test, Cohen says. After 20 months, 81 percent of the people flagged by the altrnans test had an arrhythmia, while only 6 percent of those who did not test positive suffered the same consequence, the researchers have reported in the *New England Journal of Medicine*.

Since the study was completed, MIT has licensed the patent for the alternans test to Cambridge Heart, Inc., of Burlington, Mass., of which Cohen is a founder. He says the firm is working on a version that could be used in a doctor's office. At least in the beginning, people testing positive would be offered an EP test to confirm results, he says, although he hopes that someday the alternans test would replace the other altogether.

Mark Estes, director of cardiac services at New England Medical Center and an expert on EP testing, says that



Software that can distinguish between the EKG pattern of a person in danger of suffering a life-threatening arrhythmia (top) and the recorded heartbeat of other people (below) could lead to a non-invasive predictive test far less expensive than the current procedure.

DIAGRAMS: ASSOCIATION FOR COMPUTING MACHINERY; HARVARD-MIT CENTER FOR BIOMEDICAL ENGINEERING