Technology Review

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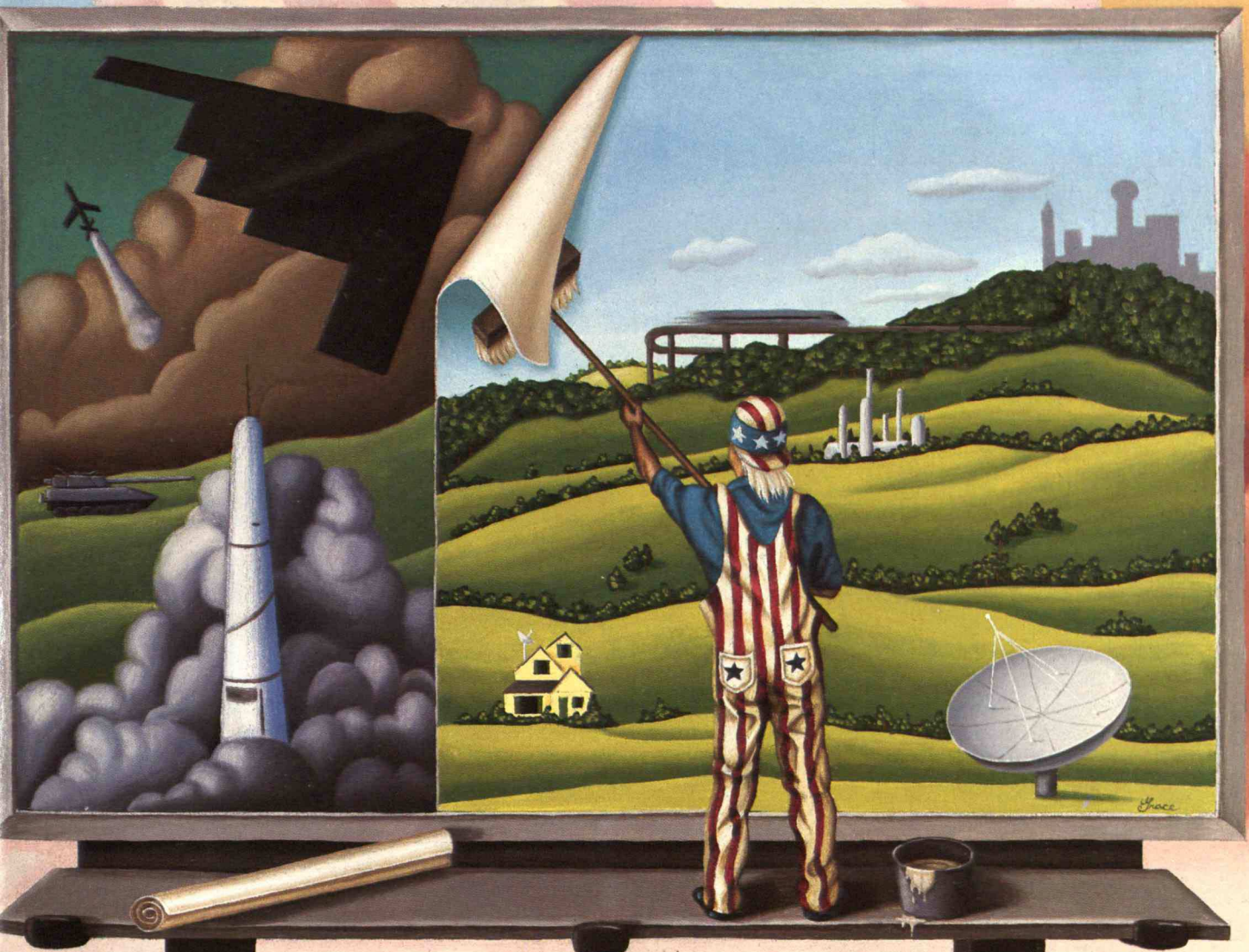
Redirecting R&D for a Post Cold War Economy



ALSO IN THIS ISSUE:

★ *COMPUTER ECSTASY* ★

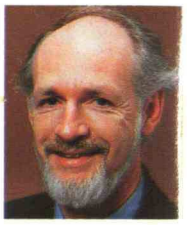
★ *THINKING GLOBALLY, ACTING REGIONALLY* ★

★ *UNDERSTANDING ANIMAL RIGHTS* ★

★ *GREEN ENTREPRENEURS* ★

In 1917 Boeing built its first airplane, 20

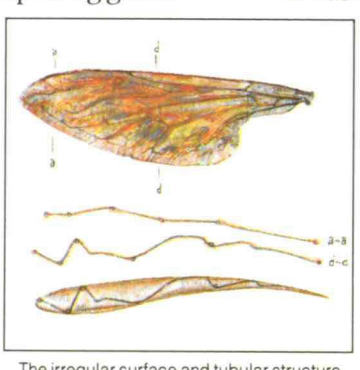
If you are an engineer or scientist, we'd like you to consider Boeing as a place to pursue your career. That's what this advertisement is all about. It's based on the belief that a good way to learn about a company is to meet the people who work there. To that end, we'd like to introduce Dr. John McMasters, a research aerodynamicist and one of some 20,000 engineers at Boeing. In his workaday world, he helps design Boeing jetliners. In his spare time, he's a self-proclaimed paleoaerodynamicist.



Ask Dr. John McMasters to define the proper field of study for an airplane designer and he'll say, "Everything that flies. All the time, professionally and avocationally."

That includes jetliners, certainly. And also insects, seeds, birds, bats, a certain reptile that executes aerial maneuvers of surprising grace and precision, hang gliders and boomerangs. Plus things that once flew, but don't now, such as pterosaurs.

Especially pterosaurs, in fact. They dominated flight for 120 million years and, reptiles or jets, all flying things encounter the same basic problems.



The irregular surface and tubular structure of insect wings are an elegant solution to a very difficult flight problem.

Sit back and ask McMasters to elaborate. It's a fascinating story.

You'll learn that 20 years ago, as a graduate student, he embarked on what he now describes as a ridiculously complex enterprise: the study of general locomotion.

"It was not the least bit modest," he says. "I envisioned a grand theory of optimal locomotion embracing the entire range of natural and man-made devices traveling through the air, on land, and in or on water."

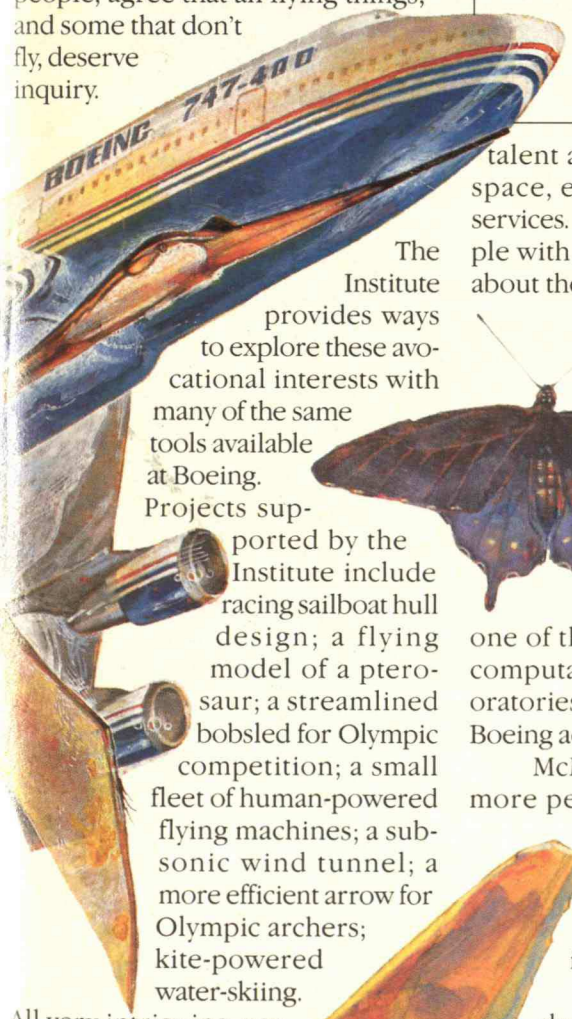
His unified theory remains elusive, but the search has been hugely rewarding.

McMasters' investigations have included jumbo jets, bat wing architecture, the wing geometry of soaring birds, the

nillion years after reptiles learned to fly.

complexities of flapping flight, and similarities between hang gliders and flying reptiles.

Along the way, he helped found the Flight Research Institute (FRI). Members, including many Boeing people, agree that all flying things, and some that don't fly, deserve inquiry.



The Institute provides ways to explore these avocational interests with many of the same tools available at Boeing. Projects supported by the Institute include racing sailboat hull design; a flying model of a pterosaur; a streamlined bobsled for Olympic competition; a small fleet of human-powered flying machines; a subsonic wind tunnel; a more efficient arrow for Olympic archers; kite-powered water-skiing.

All very intriguing, you say, but so what? What difference does it make?

There are at least two answers.

McMasters points out that Boeing needs the best scientific and engineering talent available in aviation, aerospace, electronics and computer services. The company looks for people with ideas and a lively curiosity about the world and its possibilities.

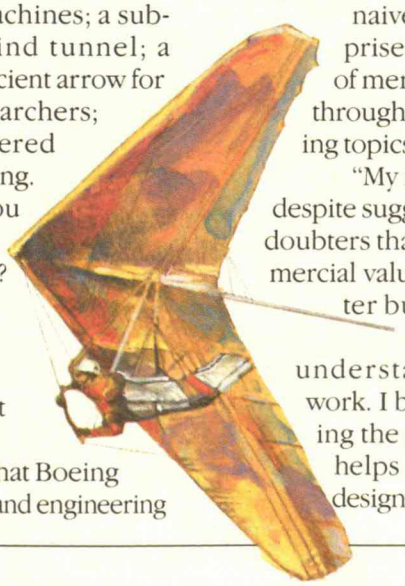
Boeing supports inventive minds in many ways, contributing to higher education, helping employees pursue advanced degrees, creating courses and institutes if necessary, including one of the world's most advanced computational fluid dynamics laboratories—one of the tools used by Boeing aerodynamicists.

McMasters' second answer is more personal: "What began as a naive but serious enterprise has become a sort of merry drunkard's walk through a range of fascinating topics.

"My inquiries continue, despite suggestions from some doubters that there's little commercial value in designing better butterflies, and thus no merit at all in understanding how they work. I believe understanding the principles of flight helps make one a better designer of devices that do have commercial value.

"Equally important, I believe it's periodically valuable to stand back from the details of a career to see a whole picture—to see one's work in full perspective.

"The effort can be immensely refreshing. And humbling."



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If you have questions about the opportunities for scientific and engineering professionals, include a note specifying your area of interest, and a knowledgeable Boeing engineering representative will respond. We are an equal opportunity employer.

Dr. McMasters is a research aerodynamicist at Boeing Commercial Airplanes Division. He has taught at Purdue University and Arizona State University and has written 65 technical papers, reports and articles. He is preparing a book on the Biological Origins of the Aeroplane. McMasters is a graduate of the University of Colorado and Purdue.

The pinion feathers at the wing tips of large land-soaring birds are a natural model for winglets on the newest Boeing 747 jetliner.

BOEING

TECHNOLOGY REVIEW
APRIL 1992

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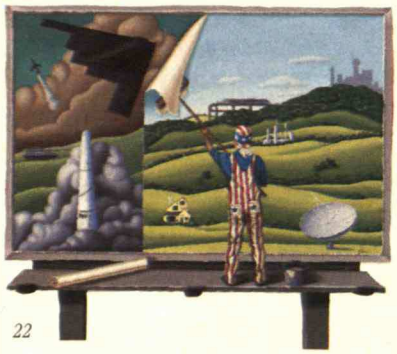

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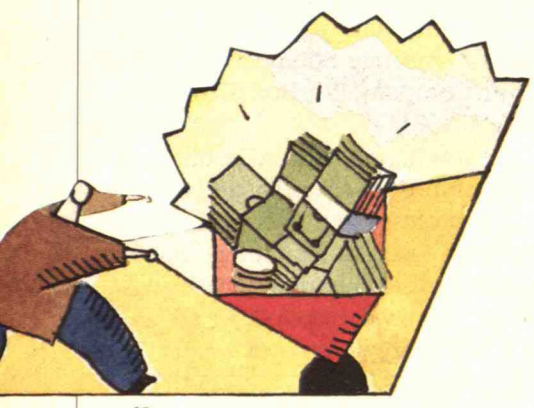

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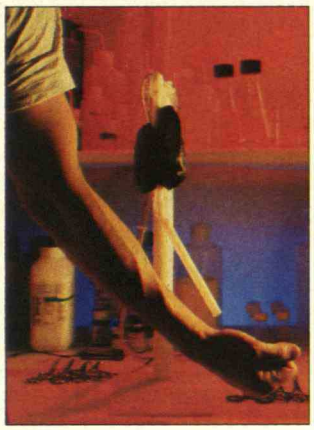
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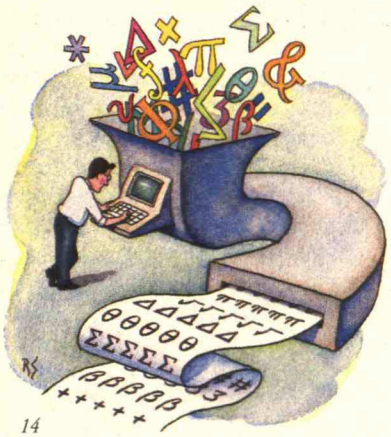
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DEPARTMENTS

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First Line

Helping the Russians, Helping Ourselves

LOOKING beyond their present struggle just to survive, the people of the former Soviet Union hope to develop market-based economies on a par with those of the Western democracies. They clearly have a long way to go, and they'll need a great deal of help—the sooner, the better—if they are to stay on track.

Americans generally sympathize with the former Soviets and wish them well, but so far we've been more talk than action. With our own economy in the doldrums, major mobilizations of capital have seemed out of the question. Yet most experts agree that what people there need most is nonpecuniary "technical assistance"—the benefit of Western industrial and commercial experience, relayed in person and over extended periods by its practitioners—in running capitalist enterprises.

"Technical assistance should come without bells and whistles," says William Robinson, a Seattle-based attorney who represents American companies doing business in the former USSR. Help should consist of "such fundamental Western-style management skills as operating a plant," he says, and involve "line guys working in the trenches with each other."

But if such help is to ultimately prove useful, the helpers must stay awhile. "People typically come through, spend four hours on site, then get on a plane and fly away," says Cynthia Stone, director of Newgate Ventures, a venture capital firm in New York with projects in the former USSR. "We need to build a grid there of people who log extensive time on the ground" developing useful working relationships.

For their part, the former Soviets not only yearn for such sustained technical assistance from the West, they'd especially like it American-style. But as *Newsweek* recently noted, the United States "is frittering away its leverage while Germany and others gain influence and access at America's expense." Things could easily be otherwise. "The Russians don't feel comfortable with these people," says Robert Watson, co-director of the Soviet Energy Project at the Natural Resources Defense Council. "They want American technology, and they want Americans working with them. Yet here we are sitting on our hands."

We in the United States have great incentive to get off our hands—or, perhaps more accurately in these recessionary times, off our duffs—because helping the former Soviets is a great opportunity both to do the right humanitarian thing and to help ourselves. The technical expertise and management savvy they so desperately need is in excess supply here at home because of scaled-down business activity and straight-out unemployment.

Let's invade the former USSR with capitalist workers and managers to create powerful partners and new markets.

Western government agencies, companies, trade associations, professional societies, unions, and foundations usually think in terms of helping sister institutions in the republics develop or change, but they could also get down to the real nitty-gritty by establishing programs that send skilled individuals there for extended stays. Programs with the practical put-'em-back-to-work philosophy of the old Work Projects Administration and Civilian Conservation Corps, which served the United States so well in its own Great Depression, combined with the idealistic spirit of the Peace Corps would offer intense and rewarding outlets for the skills and talents of a wide variety of Americans.

Although federal prompting of such activity is necessary, it is not sufficient. Direct government action is needed along two complementary tracks: to coordinate the diverse efforts of companies and other organizations; and to run a centerpiece national program that unambiguously represents U.S. policy—foreign, trade, industrial—and commitment.

One possible vehicle for the latter is the Peace Corps itself, which has already begun work in Eastern Europe. But its volunteer levels there are relatively modest, and most individuals pursue projects such as the teaching of English. The Peace Corps could greatly expand its scope to embrace a broader spectrum of technical and management skills, and fortify itself with resources both human and monetary—of private as well as public origin. Perhaps the plan to establish a Eurasian Foundation for Democracy, which Secretary of State James A. Baker announced at the end of January, is a modest start.

Graham Allison, professor of government at Harvard University, has bigger ideas. He proposes a vast program for the former Soviet Union—supported by all the Western nations—analogous to the Marshall Plan that helped European countries rebuild their economies after World War II. "This would provide confidence," he says, relaying to the former Soviets that "you won't fail from an absence of our efforts." And it would establish "strategic direction," especially if led by "people of great stature and authority," he adds.

Such initiatives could raise what used to be called "cultural exchange" during the depths of the Cold War to a vastly greater scale, enriching all parties in the process. It could stimulate entire nations, including our own, by helping to create economically powerful partners and whole new markets for the resulting products and services. And it would be a fine way for national leaders to address foreign policy and domestic issues simultaneously. ■

—STEVEN J. MARCUS

TechnologyReview

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Letters

CITIZENS AS POLICYMAKERS

Work my colleagues and I have done at Harvard University's Jefferson Physical Laboratory corroborates what John Doble and Amy Richardson say in "You Don't Have to Be a Rocket Scientist . . ."(*TR January 1992*). In a pilot experiment we initiated in 1980 with the Public Agenda Foundation, we found that flawed or uninformed ideas about scientific policy issues are not immune to relatively brief intervention.

Our study convened population-representative groups of nine to fourteen persons each, located in six different cities across the United States, to discuss for an evening questions of policy or ethics and make decisions about them. All the questions seemed to require significant scientific and technical understanding—for example, one concerned the separation of isotopes of fissionable material.

At the beginning, each of the several participating groups produced rather predictable top-of-the-head judgments that revealed the level of scientific and technological ignorance found in many polls. But after each group had debated the scientific and technical issues with the aid of explanatory materials furnished to them, it made a second decision, which turned out to be about the same as the results obtained separately from groups of professional scientists. Thus with some care and resources, one can hope to engage inexpert citizens in working through scientific problems that have social and political dimensions.

GERALD HOLTON
Mallinckrodt Professor of Physics and Professor of History of Science
Harvard University

Doble and Richardson's research on public participation in policy decisions is irrelevant. Participants in the exercise were unbiased and randomly selected, but in actual issues such as waste disposal, landfill location, emission controls, and anything nuclear, public participants have a direct interest. In fact, to participate fully as interveners, parties must demonstrate that they will be personally affected by a given decision.

And who could argue with the conclusion that people can learn from well-prepared, colorful, concise presentations followed by a discussion? (Of course, one might ask who produced the "balanced" 20-minute videotape.) The authors' glowing report that the majority of the participants in the study came to agree with the scientists is also rather odd: if that is the result, why not just ask the scientists in the first place?

Finally, it's worth noting that agreement with scientists in general is hardly common for real public interest groups. In many cases, their position is represented only by a fringe scientist, and since it is driven not by science but by their agenda, it does not change.

A. DAVID ROSSIN
Visiting Scientist
University of California at Berkeley

The writer served as assistant secretary for nuclear energy in the U.S. Department of Energy from 1986 to 1987.

PEER REVIEW RECONSIDERED

"Peer Review: Treacherous Servant, Disastrous Master" by Charles W. McCutchen (*TR October 1991*) is interesting, but the way the author presents his case weakens it. He commits a classic gaffe by making abstruse, out-of-context statements that a nonspecialist audience cannot hope to evaluate.He also decries the "unpleasantness" in scientific debate, yet his comments about professional rivals have a distinctly snide tone. And as he himself admits, his remarks are heavily anecdotal. This is a particular problem when he is describing allegations of questionable conduct

that are still unresolved—especially those having to do with his own work. Readers are confronted with assertions they have no way of critically assessing.

All this notwithstanding, I'm basically in sympathy with Dr. McCutchen. Whereas humanistic scholarship is intrinsically conservative and has achieved its greatest glories when at its most preservationist—from passing on the classics in the Dark Ages to maintaining traditional cultural values in Eastern Europe during the Soviet occupation—science is revolutionary by nature and has known its finest hours when at its most disruptive—from Galileo to quantum mechanics.

I see no quick fixes for this dilemma. Maintaining multiple funding channels as Dr. McCutchen suggests seems prudent: peer selectors and agency selectors both play politics, but they're not the same politics, so diversity is promoted.

ERWIN S. STRAUSS
Fairfax, Va.

I can confirm that in my own field of orthopedics, the politics of reviewing are intense, just as McCutchen suggests. For example, the last grant proposal I sent to the NIH was reviewed by a committee that included people with backgrounds in mechanical engineering, endocrinology, biochemistry, and physiology. There were practicing orthopedic surgeons on the panel as well. But only four of the nineteen committee members might have had some detailed knowledge about the scientific aspects of my proposal. These four people control much of what happens in an orthopedic sub-field loosely called orthopedic biomechanics, and the political pressures on them must be substantial, since everyone knows who they are.

I also concur with Dr. McCutchen that time constraints can present major problems in reviewing. Meetings of review committees for grants can go on forever, and taking time to debate differences of opinion in a gathering of nineteen overworked people, most of whom won't understand what is being debated, is not encouraged. What generally happens is that the primary and secondary reviewers of the grant under consideration air their opinions and the floor is opened to discussion. Clearly, a strongly positive or negative evaluation from one of those two reviewers will set the tone, and the discussion will be as short as possible. If there is enough dissent, I am told, a minority opinion is generated. However, given all the pressure everyone is under, I wonder how many minority opinions actually emerge from NIH committees.

Despite these difficulties, we should not forget how well the review system is really doing. Nor should we overlook the forces that hold political posturing in check. After all, politics has nothing to do with whether a device works. Perhaps you can get a fraudulent paper into press, and even get money to work on it, but if you ever start a company to produce something based on fraudulent data, you'll go broke. You can fool Daddy Warbucks, but not Mother Nature.

TIMOTHY P. HARRIGAN
Professor of Orthopedic Surgery
University of Missouri-Kansas City

FROM RED TO GREEN

"Managing Russia's Environment, Market-Style" by Steven J. Marcus (*TR January 1992*) provides a concise overview of the challenges facing Soviet environmentalists as the country moves from an authoritarian government to a market economy overseen by democratic institutions.

We at the Natural Resources Defense Council (NRDC) maintain several programs in the former Soviet Union, cover-

Continued on page 70

MIT Reporter

GENETICISTS' NEW DARLING

Construction workers at the Whitehead Institute for Biomedical Research are installing an incongruous piece of equipment this spring—a rooftop greenhouse. When it's finished in May, MIT biology professor Gerald Fink, the institute director, will fill it with row after row of his favorite plant—a spindly weed that tastes horrible, doesn't cure anything, and has no commercial value.

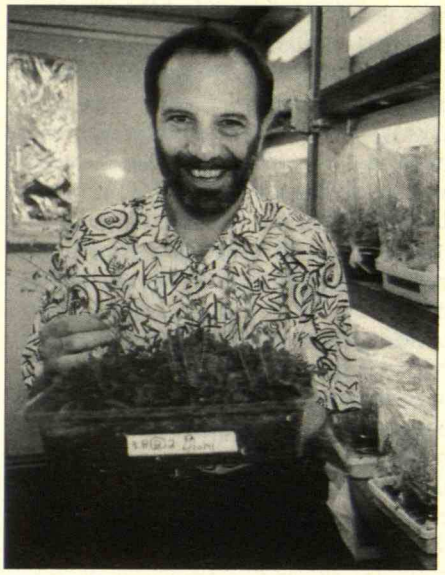
This is not a case of indulging the boss's quirky hobby. The greenhouse is a sign of the growing fascination with *Arabidopsis thaliana*, a plant that is fast becoming the new darling of the genetics research community. Nicknamed "the fruit fly of the plant world" because of its advantages as a genetic model, *Arabidopsis* has been embraced by hundreds of labs around the world in the last five years.

Fink, who has used his influence in the genetics community to promote *Arabidopsis*, says research on the plant will speed up efforts to improve crops and ornamental plants through genetic engineering; may lead to the discovery of new drugs; and could shed light on developmental processes in a wide range of organisms, perhaps even humans.

But Fink says that what really attracted him to *Arabidopsis* was a basic curiosity about the "unusual life forms" we call plants. They can't run away from predators, so evolution has provided them with powerful chemical means for warding off foragers. They can't run after mates, so they have coopted insects to act as marriage brokers. Plants "demonstrate a different way of dealing with what we consider the major problems of life," Fink says.

Such matters have long been studied by plant biologists, but their genetic underpinnings have remained obscure. The reason: while studies on simple organisms like fruit flies and nematode worms have allowed geneticists to make great strides in understanding animals, there has been no comparable model system for studying plants.

Enter *Arabidopsis*. This nondescript



Just as geneticists have made great strides in understanding animals by studying fruit flies, researchers (including MIT biologist Ethan Signer, left) hope to better understand flowering plants through the weed Arabidopsis thaliana.

member of the mustard family is the perfect plant for the urban research lab. It stands less than a foot tall, has a life span of only six weeks, produces thousands of seeds, needs minimal care, and can be grown in a test tube. Even better, *Arabidopsis* has the smallest genome, or set of genes, of any known flowering plant. And its DNA is virtually free of the repeated chemical sequences that, in most other plants, make life tough on researchers trying to create mutant strains or locate genes of interest.

It was the discovery of these genetic features in the mid-1980s that triggered the explosion of interest in *Arabidopsis*. In strong support is the National Science Foundation, which pumped $7.8 million into U.S. *Arabidopsis* research last year and helped set up a 10-year multinational research project on the plant and its genome.

A Big Find

Perhaps the most important findings have come from the floral development studies of Elliot Meyerowitz, a California Institute of Technology biologist. By studying *Arabidopsis* mutants with misplaced flower parts, Meyerowitz identified three genes that turn on early in development. The genes define four concentric regions of the flower and guide the cells in each part to become the proper sexual organs.

Soon after Meyerowitz's discovery, other researchers found the same pattern in snapdragon, and Fink expects sexual development will prove similar in all flowering plants. "If you understand it in *Arabidopsis*, you understand it everywhere," he says.

The agricultural applications of the research could be enormous, Meyerowitz notes, because almost all major crops are the products of flowers, namely fruits and seeds. "When we can manipulate the development of those flowers," he says, "it will be a very powerful tool for feeding people."

In theory, the fastest way to achieve such manipulation will be through genetic engineering. But while biologists have a number of techniques for introducing new genetic material into plants, the results are usually disappointing, says MIT biologist Ethan Signer. Instead of replacing an existing gene, a new gene often ends up at a random place in the plant's DNA, with no effect—or worse. And even if a gene inserts itself at the right spot, its effect might be muted or negated by another gene in the plant. By studying how DNA is repaired and shuffled in *Arabidopsis*, Signer hopes to find more reliable ways to replace existing plant genes with "new and improved" versions.

Meanwhile, work on *Arabidopsis* that could have important implications for human health is under way. At Harvard Medical School, geneticist Frederick Ausubel is studying how the plant responds to infections by bacteria called *Pseudomonas*, which also infect people. Some of his research involves trying to identify the specific genes that allow *Arabidopsis* to fight off the bacteria, thereby aiding the design of drugs targeted to that invader alone. This would be an

PHOTO: MIT NEWS OFFICE