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SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



A photograph of a Beckman Model TJ-6 Centrifuge. The machine is a boxy, industrial-style device with a blue-grey upper body and a black lower body. The top lid is hinged and is shown open, revealing the interior where four rotors are mounted. Each rotor holds several test tubes; the tubes in the top rotor are orange, the bottom-left rotor has blue tubes, the bottom-right rotor has green tubes, and the bottom-center rotor has red tubes. The front panel of the machine features a control interface with a large white knob on the right, a power switch, and several smaller knobs and buttons labeled 'BRAKE', 'TIME', and 'START'. The text 'BECKMAN Model TJ-6 Centrifuge' is printed on the front panel. The background is a collage of text from a testimonial.

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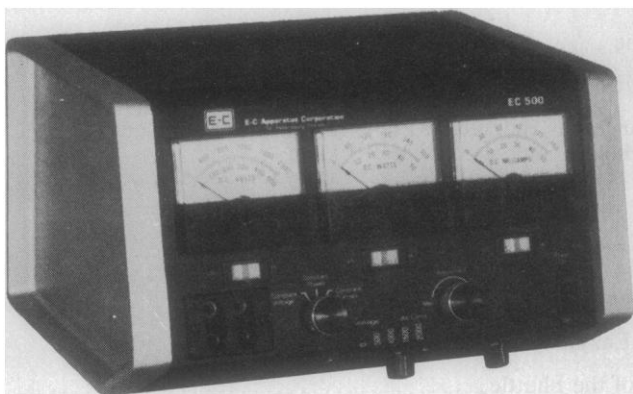
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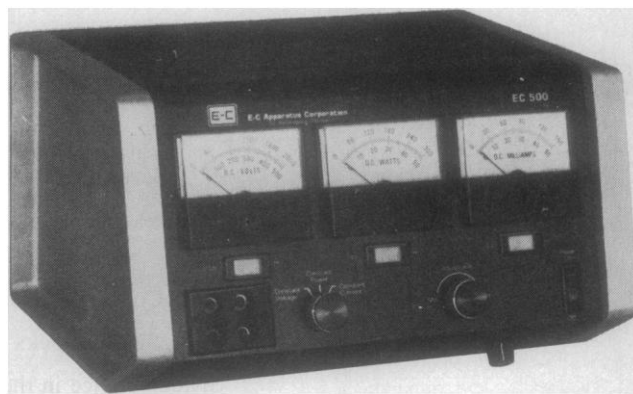
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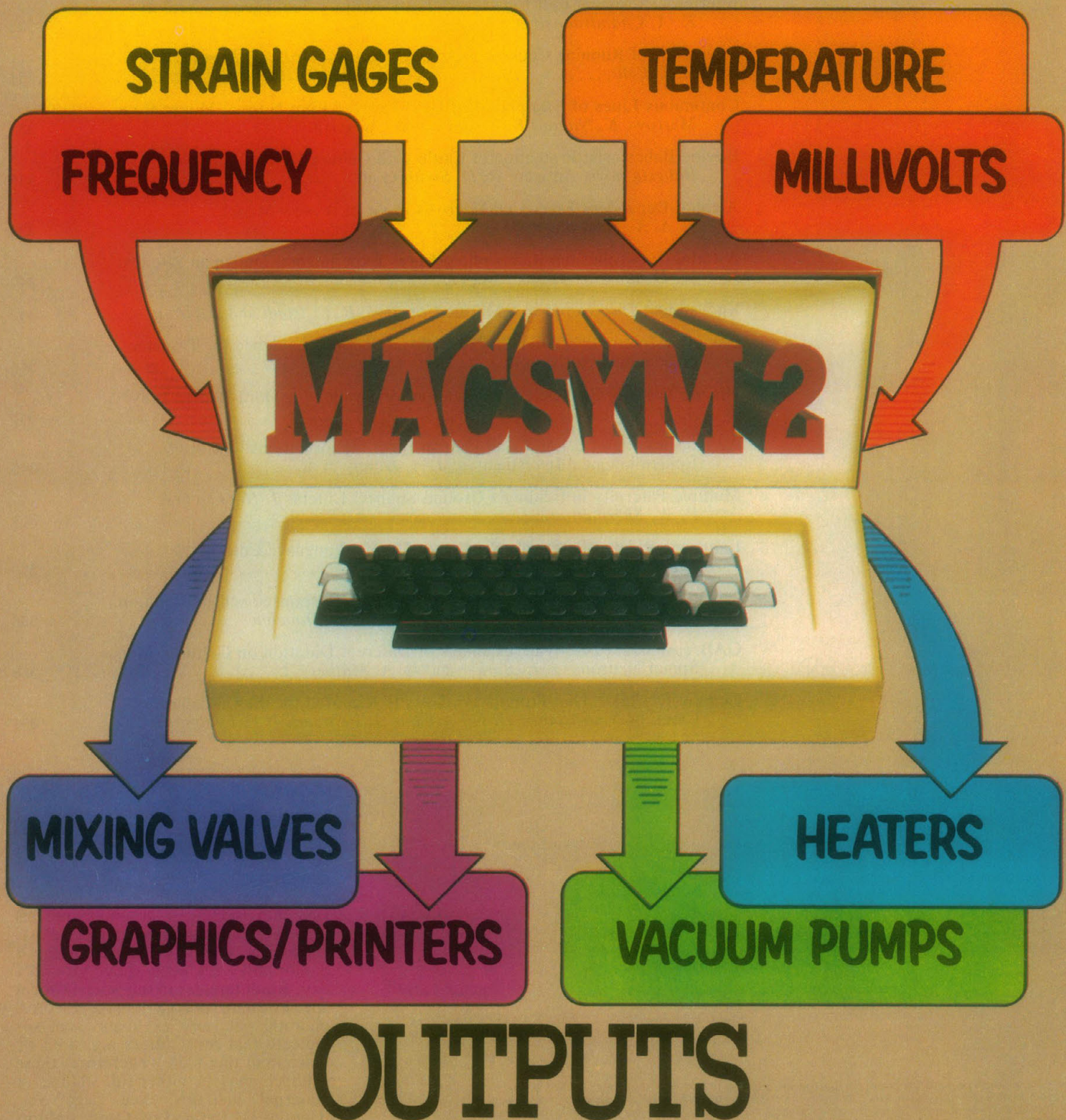
COVER

Juvenile Belding's ground squirrels (*Spermophilus beldingi*) at Tioga Pass, California. These littermates (about 1 month old) have been above ground 1 day. Adult females in this social rodent species mate polygamously. Electrophoretic paternity exclusion analyses indicate that most litters are sired by more than one male. Therefore, these squirrels may be either full siblings or maternal half-sibs. See page 351. [George D. Lepp, Los Osos, California]

The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

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70 AOT(0,1)=0.5*SIN(X)
80 IF X>5 DOT(1,1)=1
90 IF X<5 DOT(1,1)=0
100 WAIT.5 GO TO 60**

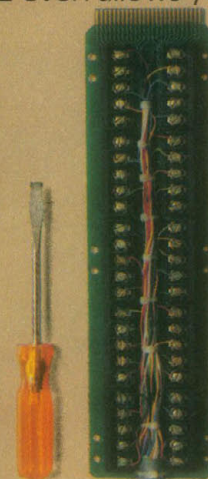
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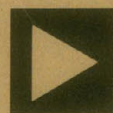
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¹Tu, C.-P.D. and Cohen, S.N., *Gene*, **10**: 177, 1980

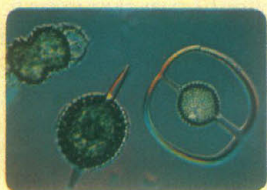
²Maxam, A.M. and Gilbert, W., *Methods Enzymol.*, **65**, 1980

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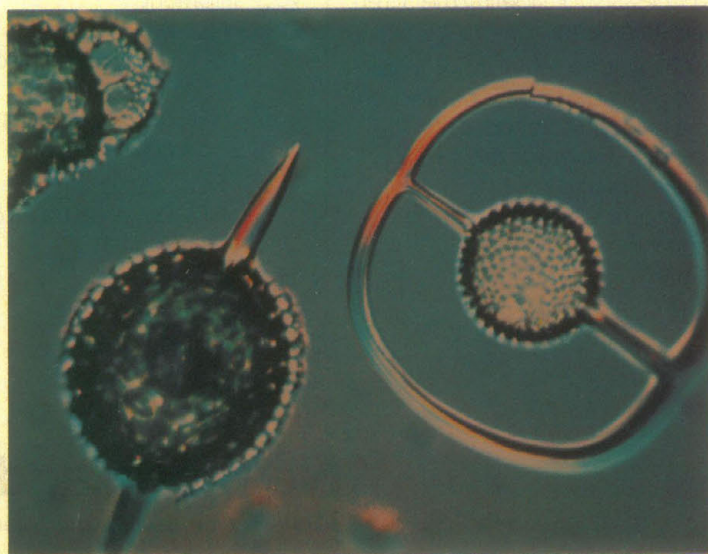
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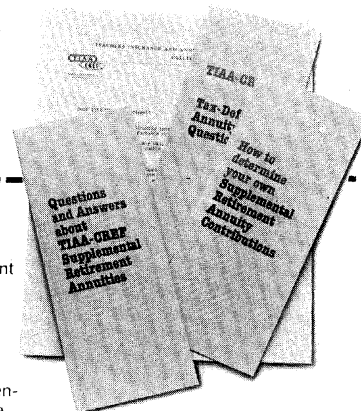
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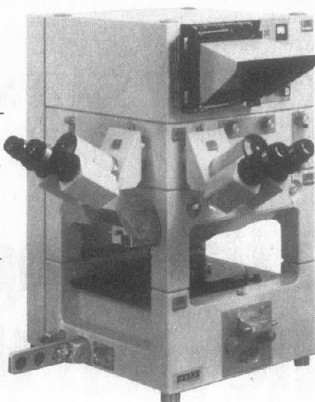
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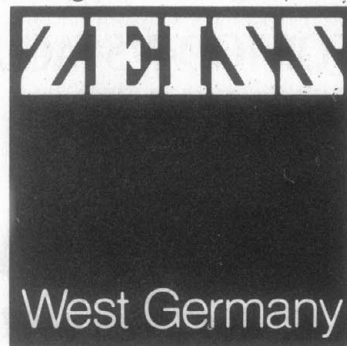
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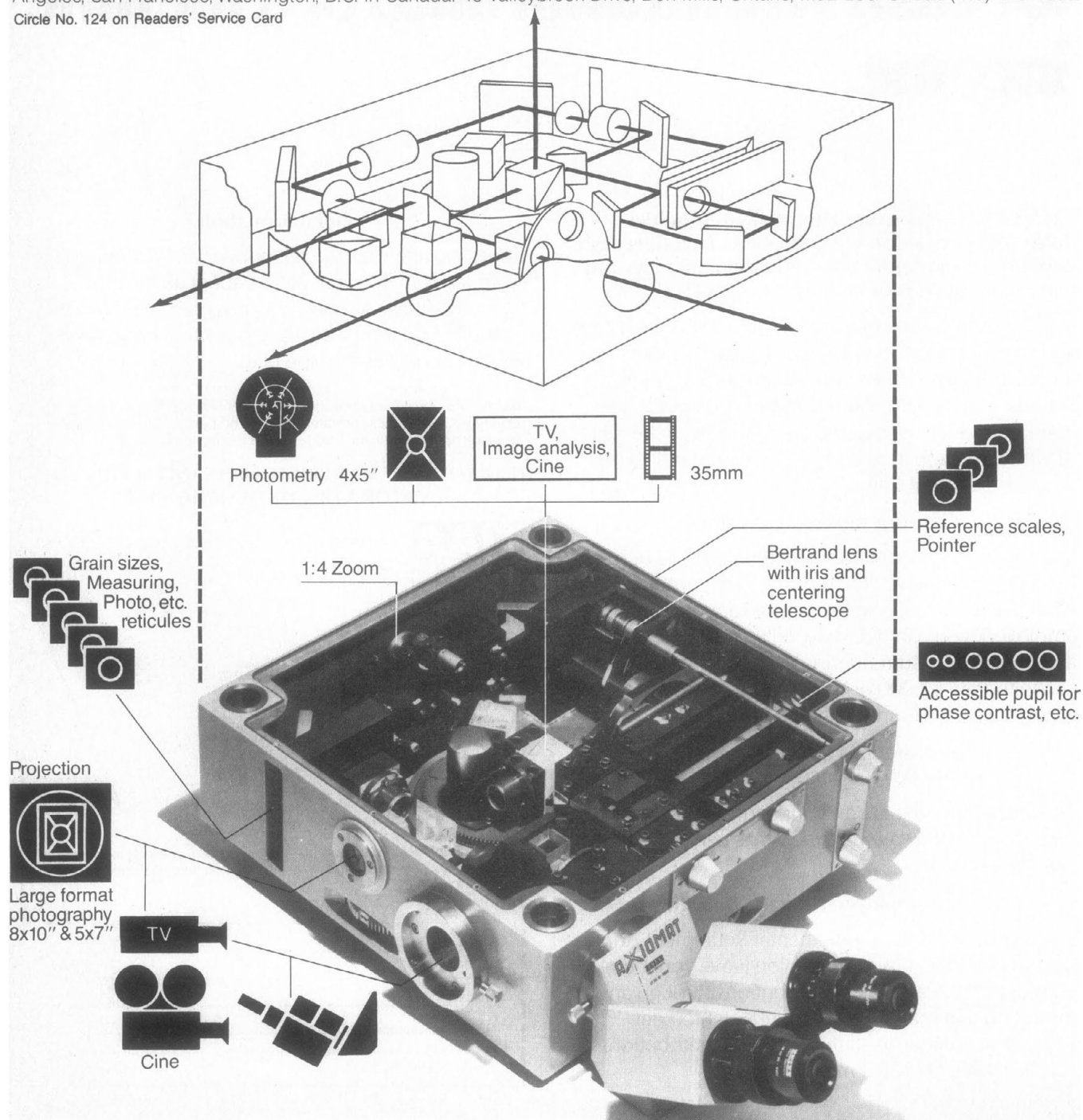
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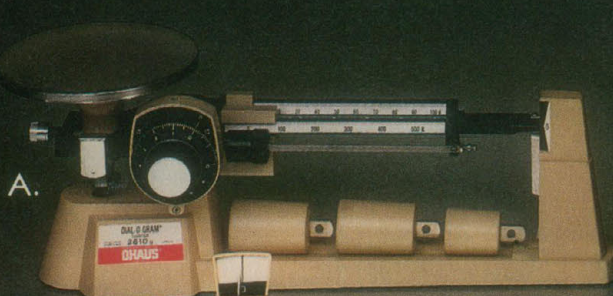


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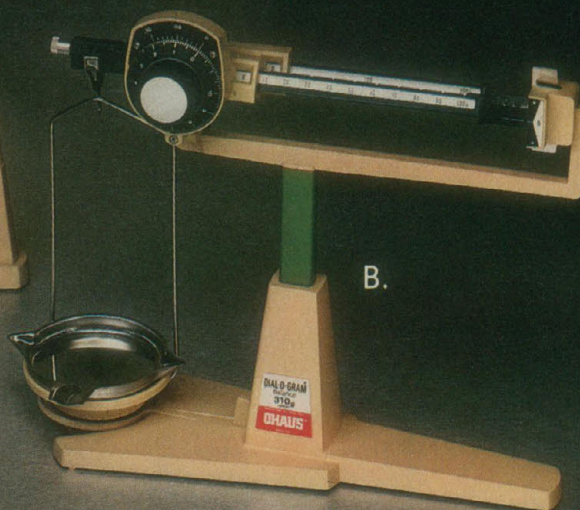
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There are many. Cross-contamination is substantially decreased because air from an infected animal goes to the exhaust system with an absolute minimal exposure of the other animals. Animal stress is also significantly reduced: the enclosed environment is quiet; drafts and thermal and humidity fluctuations are greatly minimized; and animals can be easily observed without inducing stress. The success of this environment is attested to by the fact that the total number of animals born to a species that breeds poorly (DBA/2J mice) is increased and the percent survival is also appreciably higher. Additional evidence: judging by acceleration of weight gain, newly arrived animals housed in this system become acclimated more rapidly. Further evidence? Even multiple species can be successfully housed in the same rack.

What are the benefits to the research workers?

Since the air in the rack is exhausted into the main exhaust system and does *not* re-enter the animal room itself, research workers are effectively isolated from animal dander or other allergens, odor, pheromones, microorganisms, and food and bedding dust. Even with the doors of the unit open, the direction of air flow tends to be *from* the room and *into* the unit which helps to contain contaminated air *within* the unit. Result: virtual elimination of allergic reactions and generally, a cleaner, safer, odor-free work environment for the research people.

What are the benefits to research programs?

Because this system greatly reduces the chance of cross-contamination, and because it provides a much less stressful environment generally (e.g., it tends to reduce the amount of animal handling required), the chances of jeopardizing expensive research programs are substantially minimized.

Are there other benefits?

The air velocity is variable and is separately adjustable for *each* shelf. The system offers a choice of bottle watering or a specially designed upfeed serpentine automatic watering configuration that eliminates stagnant water, permits flushing during the day, and significantly minimizes contamination. This rack also permits excellent space utilization since multiple species can be safely housed in the same room. Cleaning is easy; VR-1 can be handled by most standard rack washers. The unit is quiet. And, in summary, it is a most effective isolation system *that can actually divide a room into multiple separate, isolated environments.*

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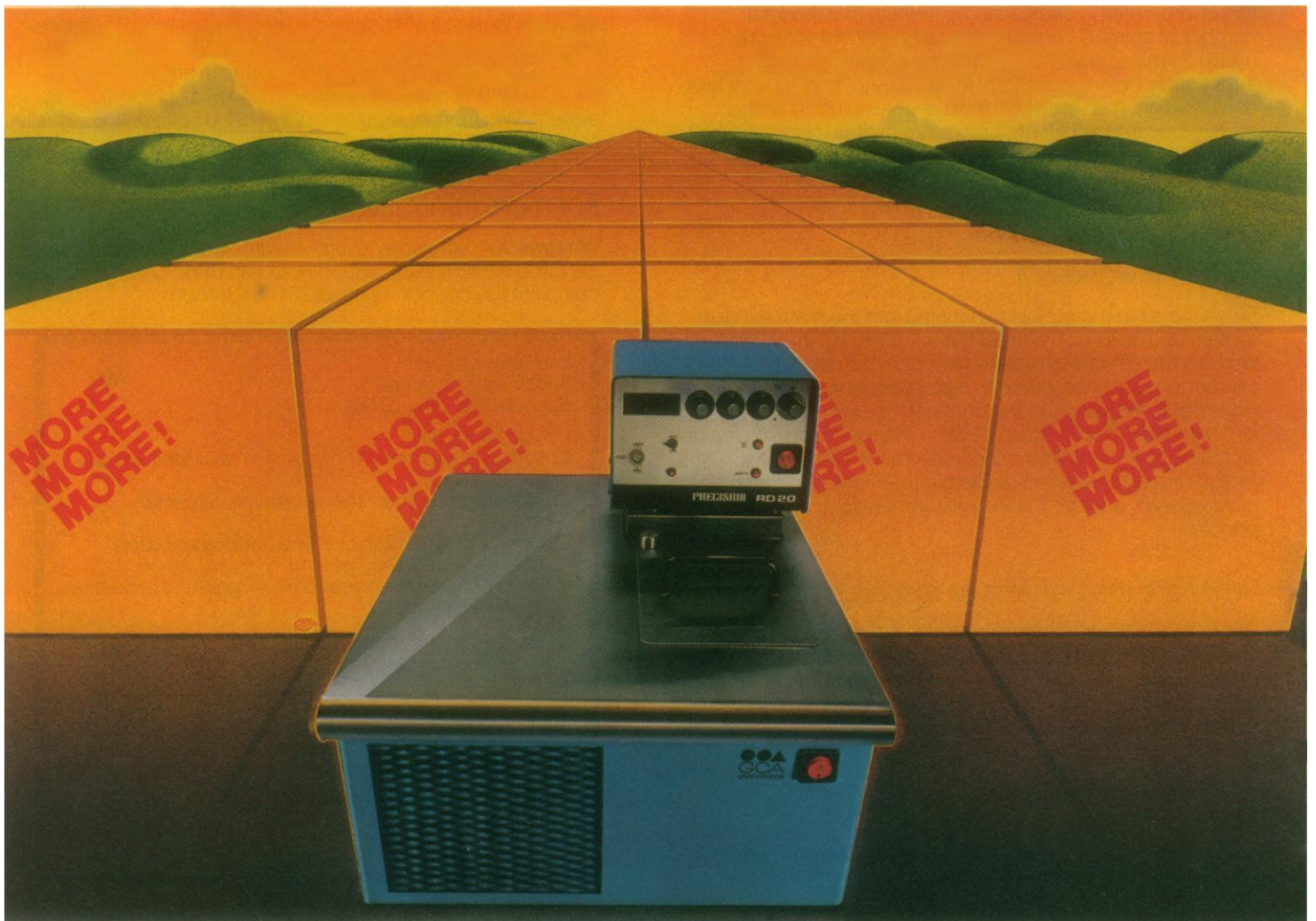
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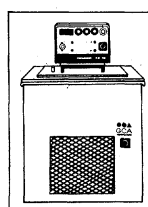


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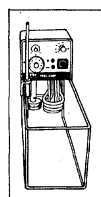
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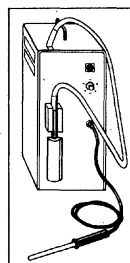
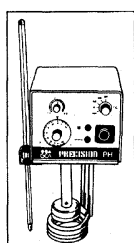
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LETTERS

Evolutionary Studies

In his interesting article about the creationist suit recently tried in California (News and Comment, 20 Mar., p. 1331), William J. Broad notes that this deliberately limited case could prove to be a mere prelude to a major series of legal battles over basic constitutional issues. As adumbrated by the creationist attorney Richard K. Turner, exposing the "religious" nature of evolutionary "beliefs" will be part of the fundamentalists' legal strategy.

Turner cites Popper's falsificationist theory of science, and the notorious deduction that the inability to make predictions denies scientific character to evolutionary theory. In 1980, Popper dissociated himself from this deduction which claims evolutionary studies to be "metaphysical" (1). In these circumstances, Popper's exact words should be quoted: "It appears as if some people would think that the historical sciences are untestable because they describe unique events. However, the description of unique events can very often be tested by deriving from them testable predictions or retrodictions." In short, Popper has now defended the scientific character of the theory of evolution and of paleontology.

Popper's own statement, made after critical reexamination of his views on the methodology of science, proves much broader than those of many experimentalists who claim his views as the basis of their scientific operations. A similarly narrowed view of Darwinism has dominated adaptational research with theories based on current and immediate optimality of all structures and processes. This restrictive research program has been criticized recently by Gould and Lewontin (2), who have set out a number of alternatives in an elegantly presented essay which supports Darwin's own pluralistic approach to evolutionary studies. Credible and successful scientific defense in future creationist trials could require that scientists avoid making narrowly restrictive and unnecessarily dogmatic statements about their scientific methodology.

W. D. RUSSELL-HUNTER
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2. S. J. Gould and R. C. Lewontin, *Proc. R. Soc. London Ser. B* 205, 581 (1979).

Population Growth and Energy Use

In his editorial "It is people who use energy" (30 Jan., p. 439), Kingsley Davis proposes population growth as a major cause of the energy problem.

In the United States, even if population had remained constant from 1955 to 1978, total energy consumption would have increased by 51 percent. To compensate for the increase in per capita energy consumption, the 1955 population would have had to fall by 56.2 million people or 34 percent by 1978.

Davis says worldwide consumption of energy has been growing at a rate of 3.5 percent per year. By contrast, population has been growing at a rate of between 1.7 and 1.8 percent. Thus, while population growth may be a major cause of rising energy consumption, one cannot disregard per capita consumption.

Per capita energy consumption in industrialized countries in 1978 was about 44 times higher than in low-income countries. The estimated annual population growth rates for these two groups of countries were 0.7 percent and 2.2 percent, respectively. While low-income countries accounted for 30.5 percent of the 1978 world population, they consumed only about 2.4 percent of the energy resources. In comparison, industrialized countries accounted for only 15.7 percent of the world population but consumed about 54.4 percent of the energy resources (1). A decrease in worldwide population growth rates, without a decrease in per capita energy consumption in industrialized countries, cannot solve the global energy problem.

ANRUDH K. JAIN

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Population Council,
One Dag Hammarskjöld Plaza,
New York 10017

References and Notes

1. Based on data included in tables 1, 7, and 17 of *World Development Report, 1980* (World Bank, Washington, D.C., 1980). This report classifies 125 countries in six groups: low-income, middle-income, industrialized, capital-surplus oil exporters, and centrally planned economies. Countries in these six groups accounted for 30.5, 20.6, 15.7, 1.4, and 31.8 percent of the 1978 world population but consumed about 2.4, 9.1, 54.4, 1.1, and 33.0 percent of the energy resources in 1978.

Davis infers that part of the energy problem in the United States is that we are letting in too many refugees. People use energy, true. However, I doubt that immigrants are the ones who are surrounded by electrical gadgets at every turn, keep comfortably warm or cool despite the weather, and drive their own cars (plural per family) rather than sup-

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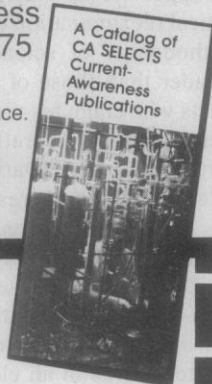
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port public transportation. The relationship between numbers of people and energy use involves more than per capita use figures.

EVELYN STRENG

*Texas Lutheran College,
Seguin 78155*

With respect to Streng's letter, I can say only that immigrants are people, and, like other people, they use energy. They need heat in winter and air conditioning in summer, just as other people do. They eat food grown with fossil fuel, and they drive cars. In fact, the worldwide current of migration from less to more developed countries is exacerbating the drain on energy supplies, because the migrants use more energy after migrating than they did before.

Jain and I agree that a solution to the world's energy crisis requires conservation, particularly in the industrial countries. We disagree when he uses this view to obscure the necessity of population control and implies, as is often done in the Third World, that the energy problem would be solved if the industrial nations were less wasteful.

His own analysis, I think, shows the futility of conservation in face of population growth. If the less developed countries are consuming far less energy than the industrial countries, they are evidently *conserving* it. This enforced conservation, however, is not solving their energy problem; rather, their population increase is creating a demand for fossil fuels which they are too poor to meet, with the result that they are burning up their forests at a prodigious rate and using their land and human resources inefficiently.

In the 38 countries the World Bank singles out as low-income countries (25 of them in Africa and most in the tropics or subtropics), the average population density is two and one-fourth times that of the industrial nations; yet their population increase is three times as fast. Their external public debt and foreign debt service have been rising relative to the gross national product, and their food deficit, already monumental, is forcing them to rely for subsistence on the New World industrial nations. These nations, however, can export food on a grand scale only because their ratio of people to land resources is still reasonably low and because they use copious amounts of energy in agriculture. As the Steinharts, Pimentel, and others have shown, more calories are being used in American food production and distribution than the food itself yields at the table. In the process, we are losing top-

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soil, poisoning rivers and lakes, and exhausting fossil water reserves. As the cost of energy soars, so will the cost of food exports. The unprecedented growth of population in the less developed countries is thus causing an acute energy crisis not only at home but in the world as a whole. Conservation in the industrial states, badly as it is needed and certainly as it is soon to come, cannot compensate for this relentlessly mounting pressure on diminishing resources.

KINGSLEY DAVIS

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Innovation in Science Teaching

Was Frederick Mosteller aware that his important presidential address, "Innovation and evaluation" (27 Feb., p. 881), concluded with the beautiful but tragic example of his point? He suggested that the AAAS sponsor initiatives in science and engineering education. Perhaps he was thinking of a recent 211-page book (1) reporting the results of nine studies under contract to the National Science Foundation. Neither Mosteller nor the authors of that book mentioned teaching methods which have long since proved their value (2).

In 1960 in Roanoke, Virginia, an 8th grade class, using simple teaching machines and a previously untested program, covered all of 9th grade algebra in one term. Their grades met 9th grade norms, and measures of retention a year later were considerably better than normal. The educational establishment should have been delighted. Here was the way to teach algebra! But, 20 years later, the study is forgotten. Forgotten also are scores of equally dramatic experiments. Surely this is an example of a lag in the use of innovations to be added to those so delightfully described by Mosteller.

What is needed in education is not innovation but a change in the establishment that will permit efficient teaching methods to be used.

B. F. SKINNER

*Department of Psychology and Social Relations, Harvard University,
Cambridge, Massachusetts 02138*

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2. E. W. Rushton, *The Roanoke Experiment* (Encyclopedia Britannica Press, Chicago, Ill., 1965).

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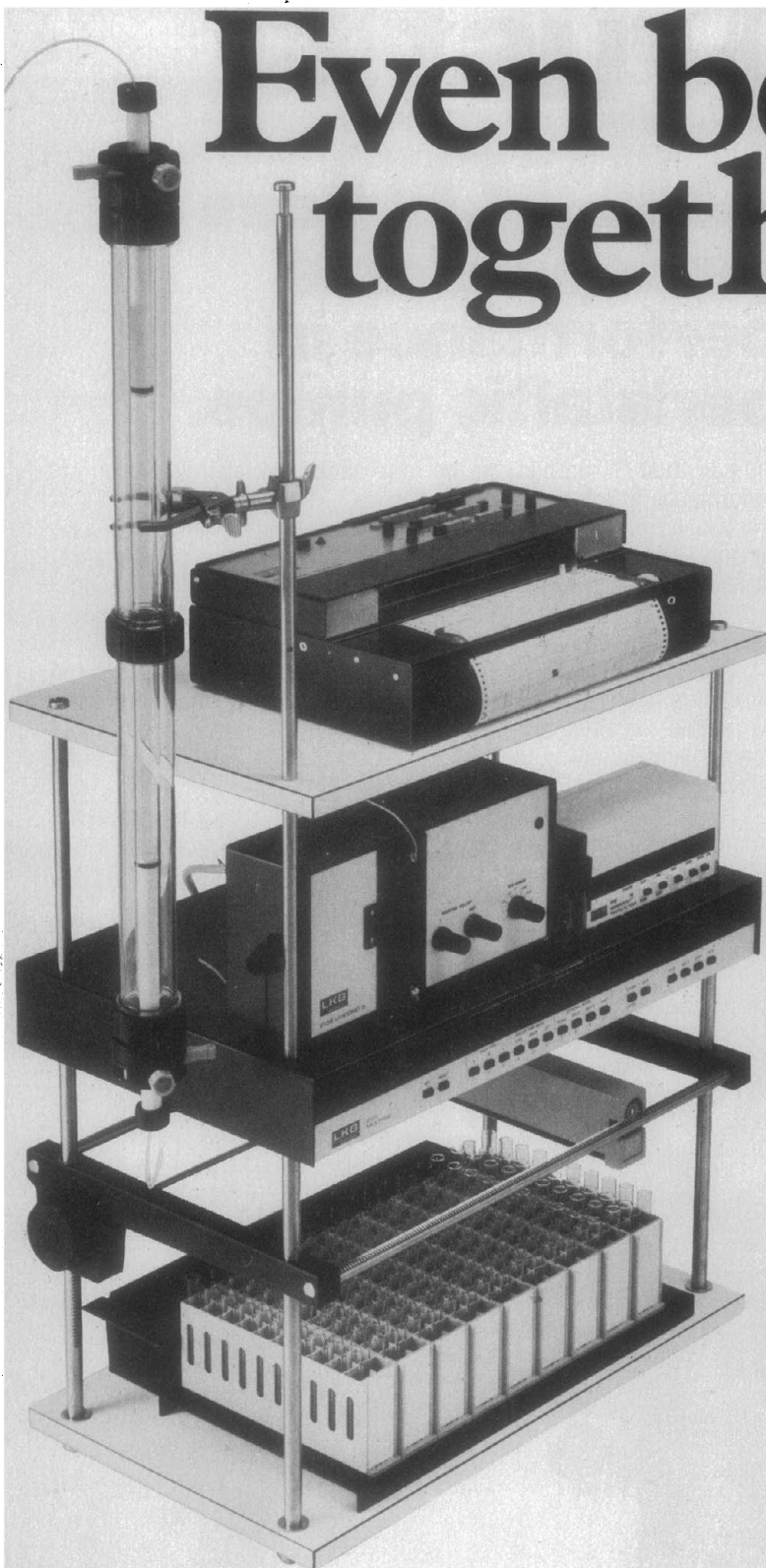
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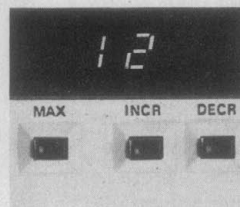
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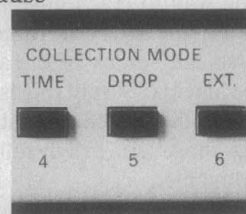
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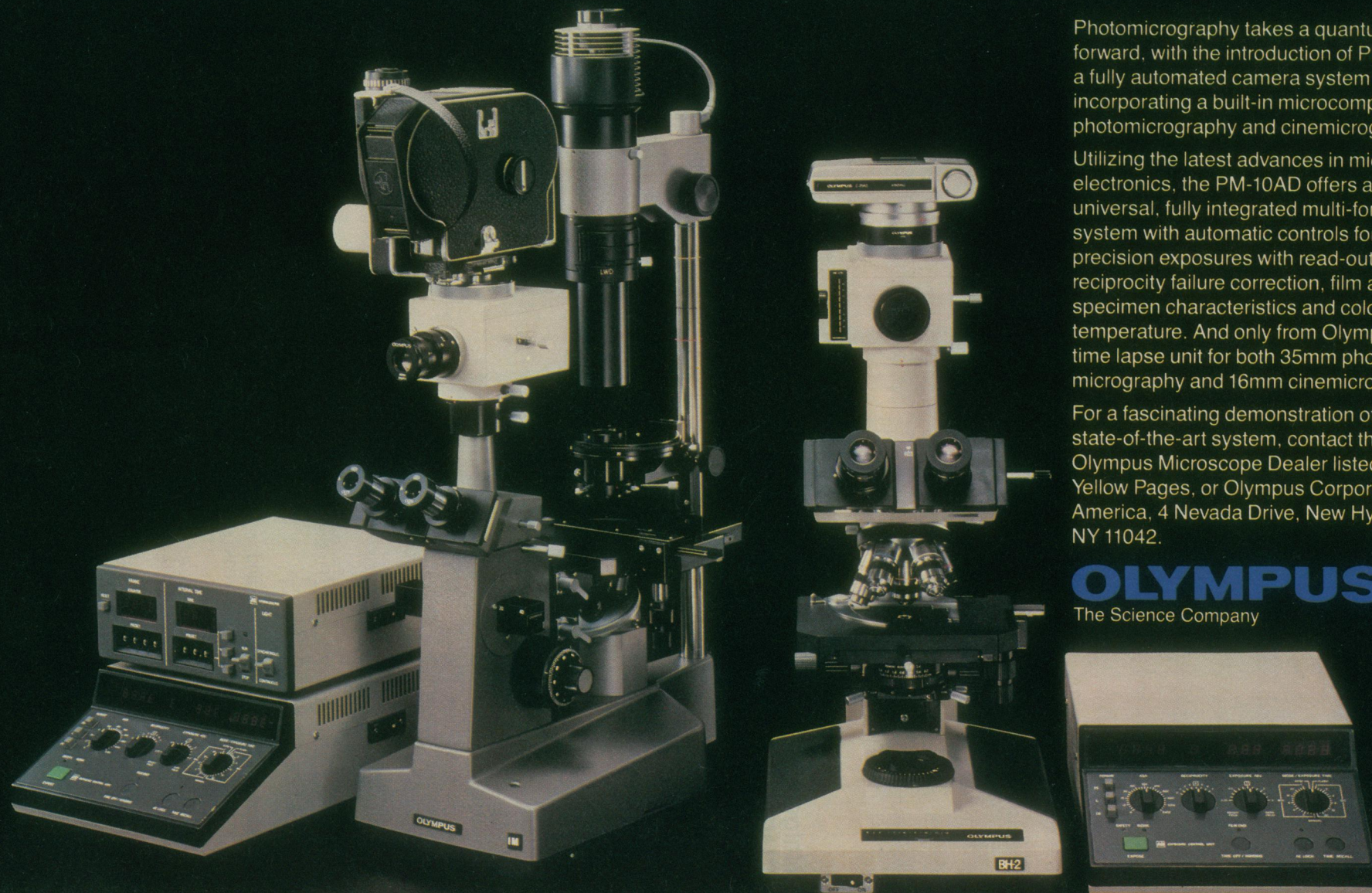
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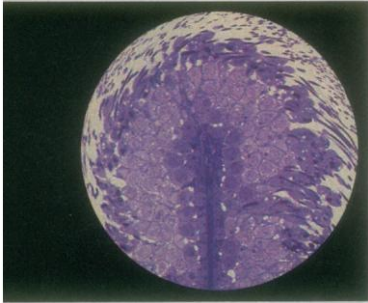
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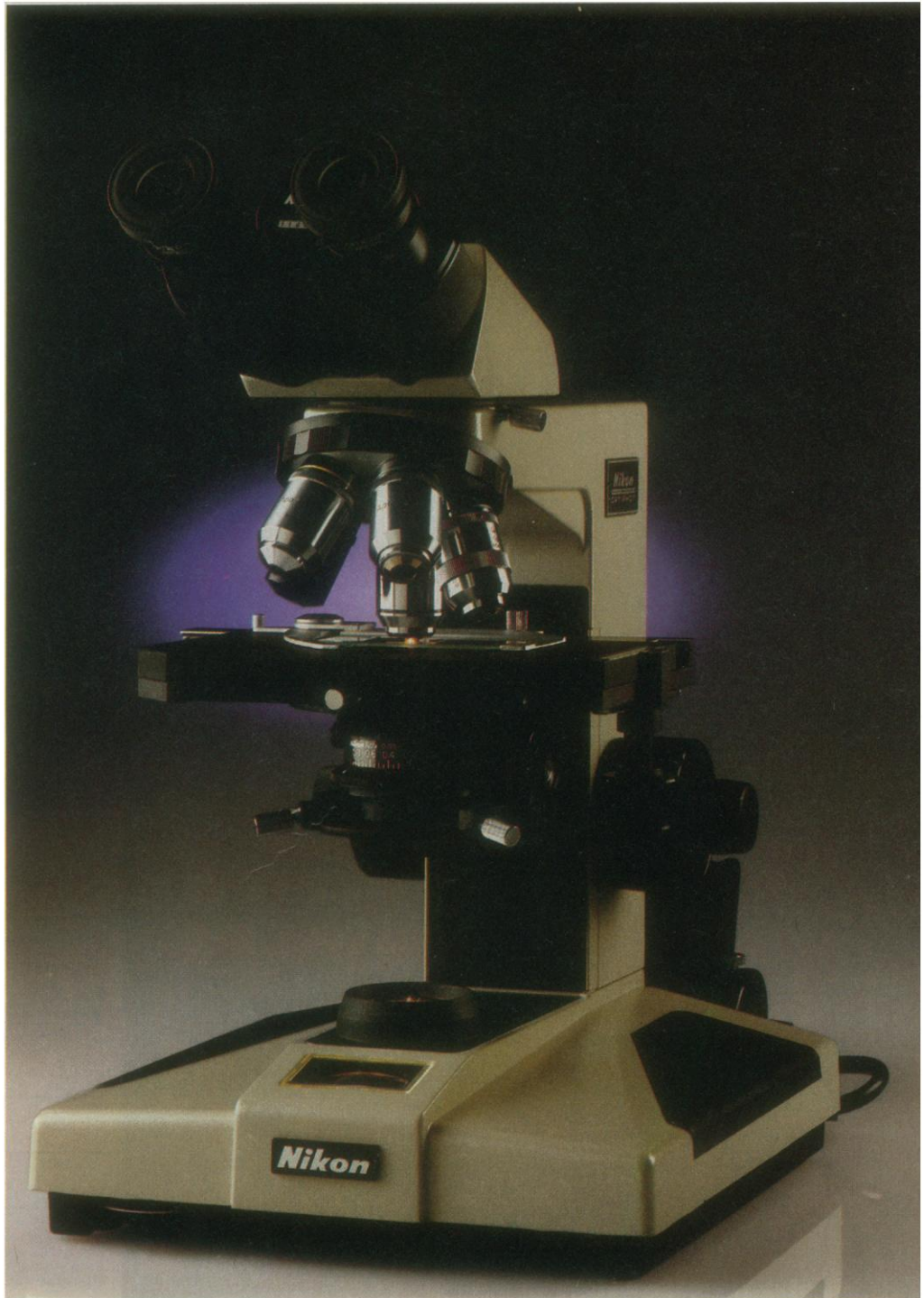
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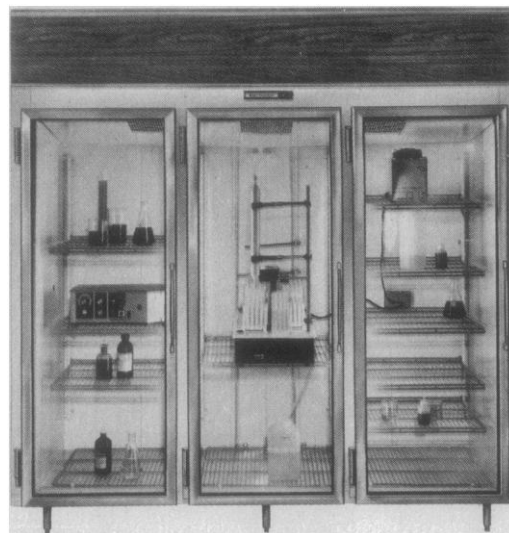
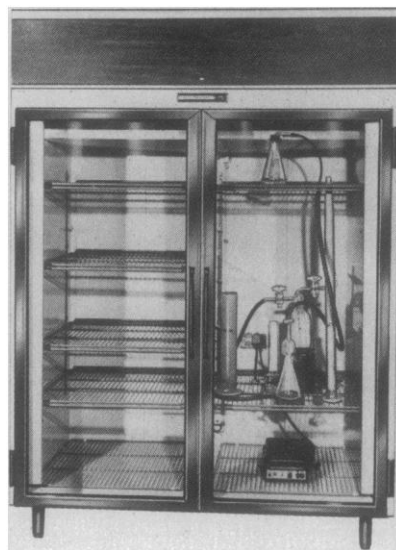
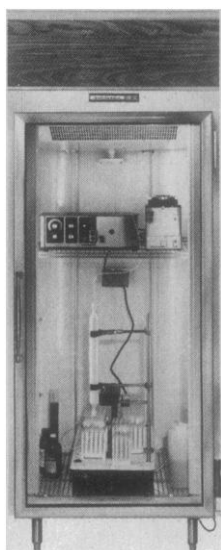
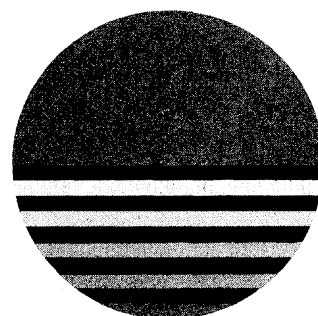


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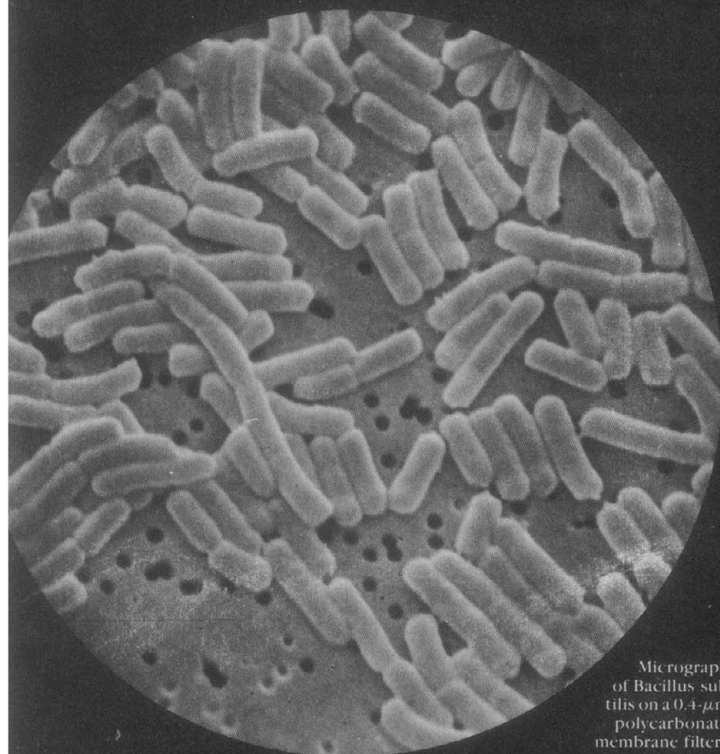
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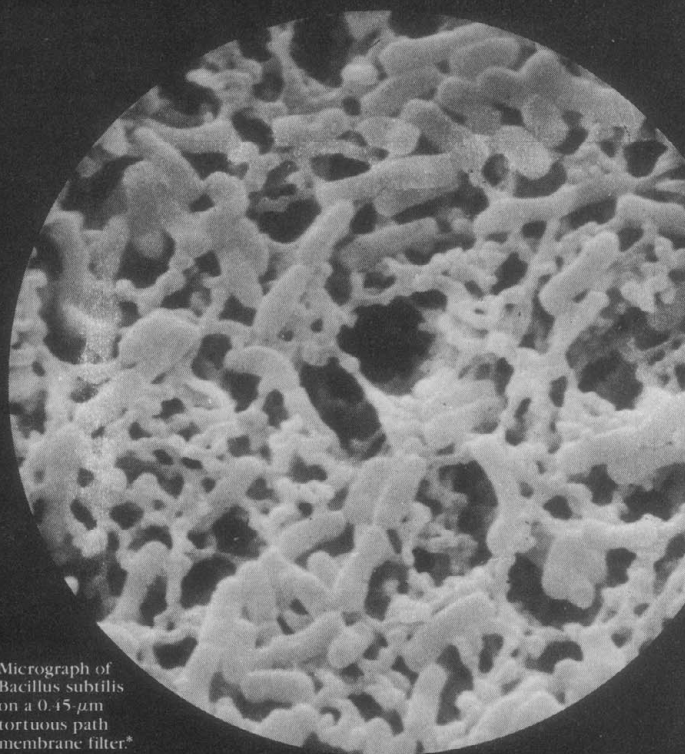
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Taking Science out of Social Science

The new Administration's goals of stabilizing the economy and revitalizing U.S. productivity are worthy of support. William D. Carey* has pointed out that when national budgets are heavily cut, science and technology must expect to share in the reduction. Presumably the reasons arise more from equity than logic, since other developed countries that now surpass us in gains in productivity and compete with us for markets seem to be increasing their portion of the budget spent for R & D. At the same time, the Administration clearly does appreciate the value of research and has retained the overall National Science Foundation (NSF) budget at a substantial level.

Given that cuts are to be made at the NSF, great care should be given to the allocation of research funds. Philip Handler's description† of the cuts raises doubts about this care. Let me take up in detail one small but important division of NSF, Social and Economic Sciences (SES). Under the Administration's plan, SES funds in millions will drop from \$31 to \$24 to \$10 from fiscal year 1980 to 1981 to 1982. Without even allowing for inflation, this gives a reduction of 68 percent in 2 years. Similar deep cuts have been planned for the smaller Behavioral Sciences program. Large cuts in social science research funds announced elsewhere, as at the National Institutes of Health and the Department of Defense, would add to the damage.


Much of social science research supported by NSF produces the methods of measurement and analysis and the concepts that make measurements possible in social, economic, and health problems. When society's leaders plan to change the economy, they need also to know the effects of their changes. We know that innovations, social, medical, and technological, often fail and that they therefore need evaluation. Social science research provides both the tools and the data for such evaluations. More constructively, it often also provides the research to improve the success rates of future innovations. This research frequently finds that the conventional wisdom has been mistaken, indeed that is a common characteristic of social science research which may not endear it to us. For example, Project Sappho‡ found that variables often mentioned in business lore such as size of firm, being first to market, and structure of research did not explain why some companies succeeded and others failed in introducing the same technological innovation. For innovation to flourish, we need more research on innovation, in both science and technology.

Among the better known contributions of social science have been the research leading to the national accounts and gross national product estimates, the systematic development of scientific sampling for objects, people, institutions, and records, and methods of measuring unemployment, agricultural production, and the effectiveness of medical therapies.

Probably not many of us appreciate how extensively the work of social scientists finds uses in business and industry. Of the 285,000 science and engineering doctorates employed in 1977 in the United States, social scientists comprise 27 percent. About one-third of these social scientists have employment outside academia. Of all the scientists in business and industry, social scientists comprise 11 percent.

If we fail to invest in social science research, we can anticipate a drying up of that research among our younger scholars. Worse yet, the best will leave the field altogether or not take it up. With the opening of China to the world, we have seen what an interruption of research can do to a society. It produces a long and sorry period of playing catch-up. The research that we fail to do now will penalize our own generation with a lack of ideas in a decade or so. The NSF has responsibility for enhancing the scientific resources and capabilities of the nation. By withdrawing NSF and other support, we will gradually delete the *science* from research endeavors in social science.—FREDERICK MOSTELLER

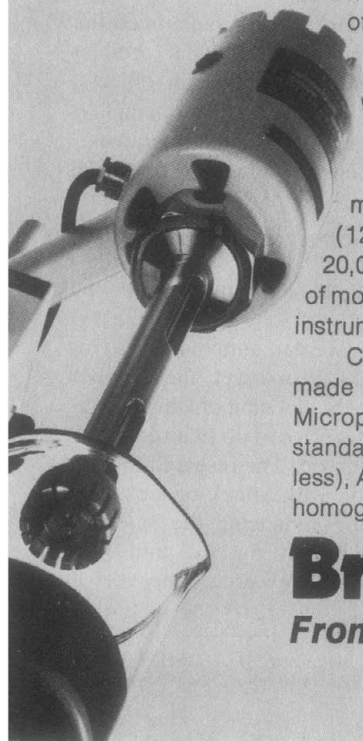
*W. D. Carey, *Science* 211, 879 (1981). †P. Handler, *ibid.*, p. 1261. ‡Science Policy Research Unit, University of Sussex, *Success and Failure in Industrial Innovation* (Centre for the Study of Industrial Innovation, London, 1972).



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