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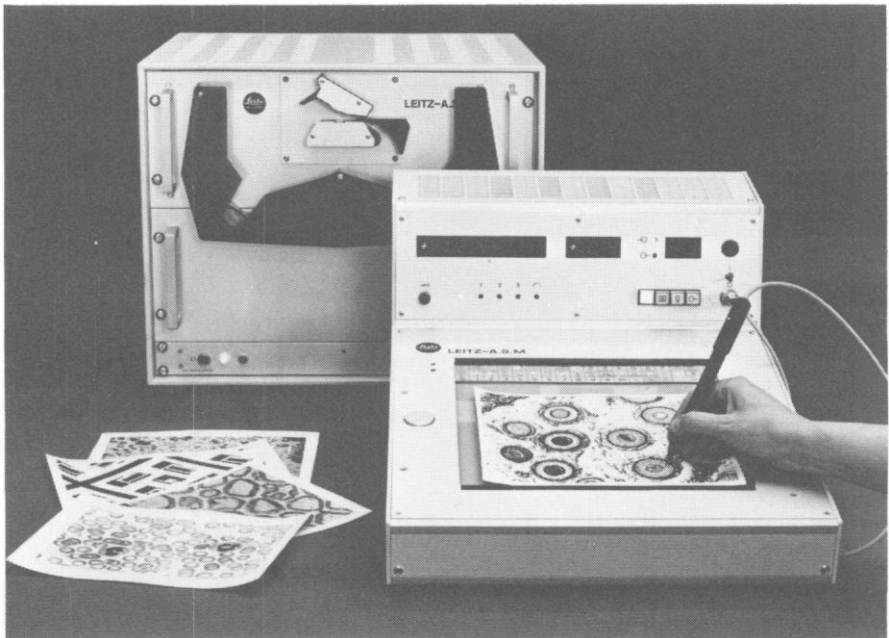
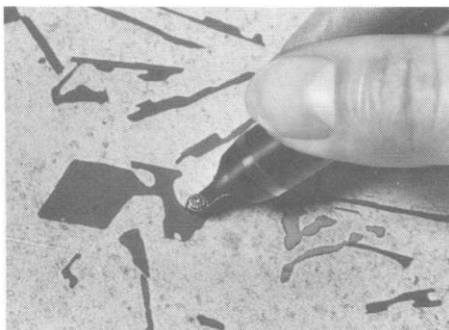
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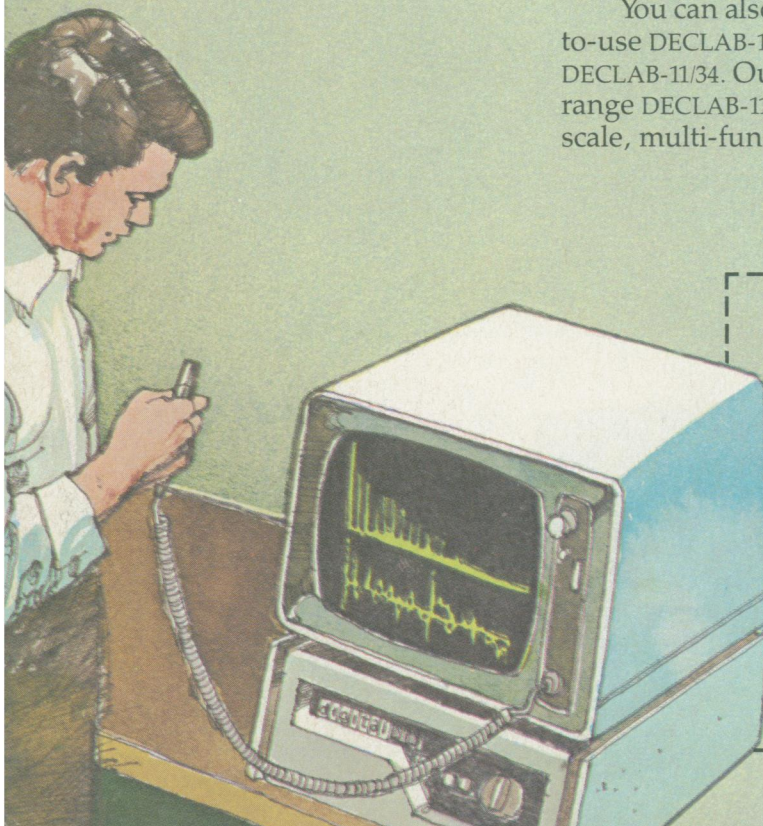
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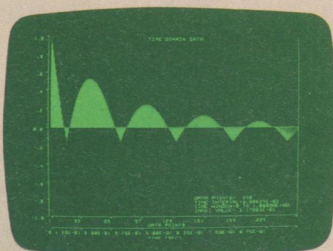
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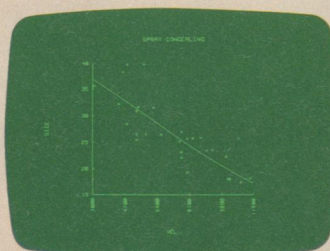
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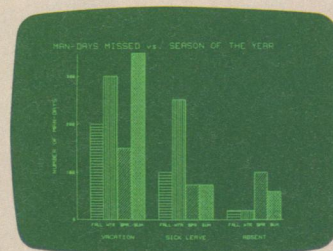
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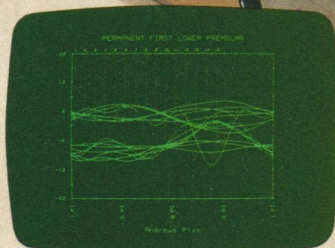
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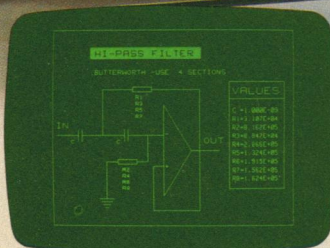
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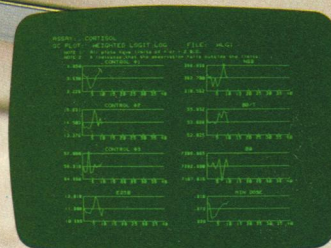
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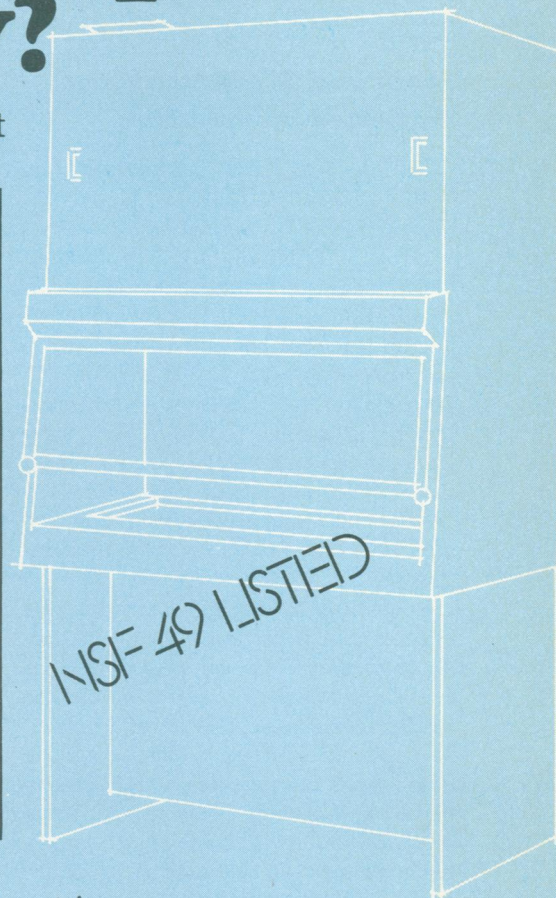
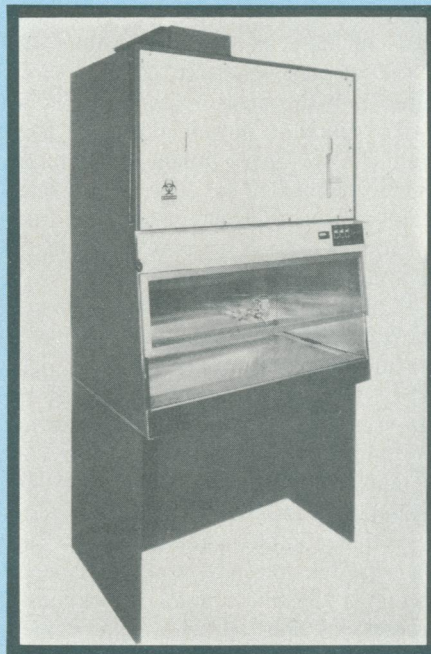
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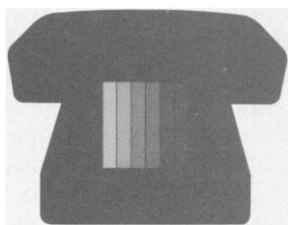
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between the availability of a new technology and its widespread adoption. Projections of the impact of novel technologies may therefore be naive and simplistic. For example, the advent of clonal reproduction of life forms almost immediately raised spectres of the mass production of armies of identical human neonates. I will briefly demonstrate the relevance of some social factors to the impact of research on the cloning of human beings.

Adoption of any technique is unlikely if there is a less costly means of accomplishing the same end. Anthropological studies of the spread of industrial technology in peasant societies indicate that the assessment of cost-effectiveness is based on a remarkably rational balancing of costs and benefits. For cloning of humans to become widespread, some clear advantage of standardization must be found which would outweigh the considerable cost of manufacturing human beings.

Suppose that a corporation, Clone Limited, desires to mass produce 1 million John Waynes and sell them to the U.S. Army, along with ten cloned Bob Hopes to staff USO tours. The immediate problem facing the corporation is the cutthroat competition of natural parents, who are producing nearly 4 million neonates a year at no cost to the government. The investment of tens of thousands of dollars and thousands of hours of child care is necessary to create an 18-year-old. The benefits of producing shoes all of the same size for the clonal army would not outweigh the costs.

Faith in economics of scale should not convince us that clones would be cheap to produce. Medical procedures are among the most rapidly inflating costs in the economy. Foster mothers for cloned ova would presumably demand compensation. If artificial uteri were employed, the capital investment required to produce large numbers of clones would be staggering.

Many advantages of standardization are available by nongenetic techniques. In *Brave New World* Aldous Huxley's scientists bred a race of retardates to serve in menial jobs such as running elevators. Modern self-service elevators illustrate that such jobs can be automated at a much lower cost.

Behavioral uniformity can be achieved without the expense of genetic manipulation. Documentary films of the 1930's show citizens of an advanced nation marching in lockstep, raising their arms at identical angles, and methodically murdering defenseless fellow-citizens. What we see in these films are "behavioral clones." What does it matter that

the storm troopers are not genetically identical?

Having failed in mass merchandising, Clone Limited might well try a more restricted market, turning out copies of such elite human beings as Margaret Mead, Artur Rubenstein, Marilyn Monroe, or Sandy Koufax. These exceptional humans could be expected to be more productive than worker clones, promising returns commensurate with the costs of their production. Merely reduplicating the genetic material of a genius does not solve the riddle of his or her subsequent growth and development. Obviously we do not want to exactly reduplicate the adult genius (it would do no good to have an adult Charles Darwin in 1999 reveal that man was descended from the apes). What we wish is to preserve those exceptional qualities that led these persons to be so successful.

The problems outlined above are susceptible to solutions based on psychological research and experimentation. If one assumes advances in psychology and sociology, one faces the problems of alternative solutions to the problem of genius. There is no shortage of naturally occurring genius. If only .015 percent of infants are potential geniuses, a minimum of 500 each year await discovery in the United States. Investment in psychological testing research on a scale comparable to the basic research needed for cloning would produce comparable results at less cost.

Even if cloned geniuses were available at low cost, the question of their social impact remains problematic. Those who foresee the breeding of master races of Einsteins and Fermis tacitly base their projections on a great man theory of history, a social theory seriously weakened by extensive criticism. Once we recognize that intellectuals are subject to the restraints of their milieu, the idea that we can significantly affect the course of history by judicious breeding is seen in its proper perspective. An extraordinarily expensive program of cloning could, perhaps, double the number of geniuses in the country. They could join the ranks of the thousands of unemployed biologists, chemists, historians, and anthropologists around us today.

A similar disillusionment awaits the mad millionaire who seeks to perpetuate himself by cloning. He will be confronted by an offspring whose early childhood experience, peer relationships, life style, and points of view make him a stranger to his parent.

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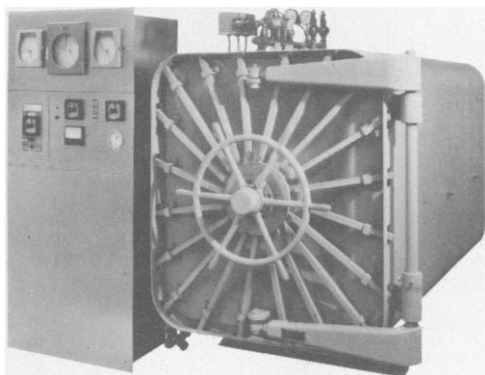
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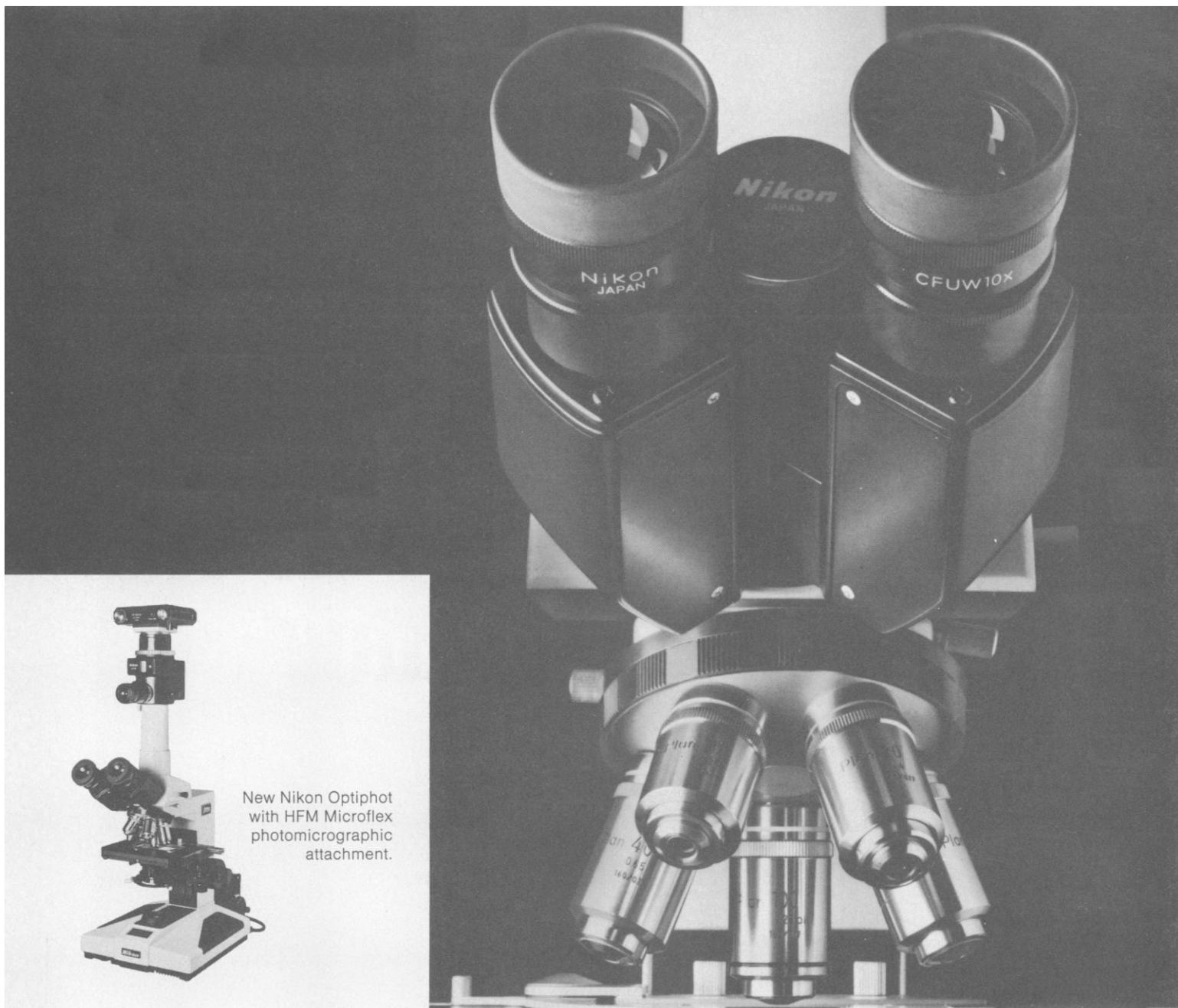


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Uncritical acceptance of bad scientific information can lead to social penalties, as recently emphasized by Comar.* A particularly pernicious aspect of this problem involves numerical data, which are essential in all branches of science and technology and are often needed to arrive at valid operational decisions. Unfortunately, the scientific literature contains many erroneous values. Few scientists or engineers seem to have given much thought to the magnitude of the problem, and some probably regard every numerical entry in a handbook as revealed truth. Yet anyone who has had to seek a particular number in the literature and searched out a dozen or more reports, only to end up with a set of widely disparate values, comes to realize that a substantial intellectual effort and a considerable background in the field are needed to arrive at reliable figures. A number of specialized data centers have grown up to pursue this task in systematic fashion. The largest single organization devoted to such activities is the Office of Standard Reference Data of the National Bureau of Standards (NBS).

Data evaluation in the United States has recently been assayed, with support from the National Science Foundation, by a special committee of the Numerical Data Advisory Board of the National Academy of Sciences (NAS). The committee's report, ably coordinated by Everett Johnson and Robert Marvin, describes the current level of activity, analyzes costs and benefits, and projects data needs of planned federal R & D programs.†

Costs of search and critical evaluation are small: less than 0.2 percent of that for the original research and about one-quarter of the cost of its initial publication. Benefits are often great and are not easily translated into monetary units. The time saved when a data center can use its files and experience rapidly to prepare special compilations can be extremely important when new regulations or legislation dealing with environment, health, or safety are under consideration. A graphic example is the 1976 report of the NAS Panel on Atmospheric Chemistry concerning the effects of halocarbons on stratospheric ozone. Mathematical models for this study required knowledge of the rates of about 100 known chemical reactions in the stratosphere. The Chemical Kinetics Information Center at NBS provided critically evaluated rate constants in a short time. Without them, according to panel member Frederick Kaufman, "we would have had to gather and evaluate a huge volume of data ourselves, and this large added task would have made it nearly impossible to complete the required reports within the allotted time. Many months' work by several senior investigators and many tens of thousands of dollars would likely have been involved."


Perhaps more important is the fact that the selected values had been thoroughly documented and recognized as the best available. Advocates and opponents of controversial proposals such as those to ban SST's or aerosol sprays, tend to select data supporting their position, so that without an authoritative and generally accepted set of data it can become politically impossible to reach any decision. Other benefits of organized evaluation include elimination of multiple efforts and reduction of waste in industrial plant design. This latter benefit is particularly evident today, when rising costs tend to eliminate traditional development stages in favor of mathematical modeling.

Data evaluation is an unglamorous activity, unlikely to win Nobel prizes for its practitioners. Moreover, the very modesty of its cost tends to obscure its importance. It is thus not surprising to learn in the committee's report that current U.S. activity is about one-third to one-half of that required to keep pace. If this situation is to change, a greater awareness of the need for and importance of data evaluation on the part of the scientific community seems essential.—WALTER H. STOCKMAYER, *Professor of Chemistry, Dartmouth College, Hanover, New Hampshire 03755*

*C. Comar, *Science*, 16 June 1978, page 1225. †Committee on Data Needs, Numerical Data Advisory Board, *National Needs for Critically Evaluated Physical and Chemical Data* (Washington, D.C., 1978).

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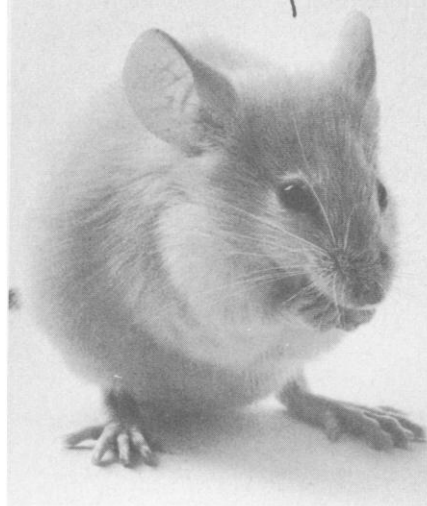
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Isoelectric Focusing. Nicholas Catsimpoalas and James Drysdale, Eds. Plenum, New York, 1977. xvi, 352 pp., illus. \$32.50. Biological Separations.

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Country Scrapbook. Jerry Mack Johnson. Simon and Schuster, New York, 1977. 320 pp., illus. Cloth, \$8.95; paper, \$5.95.

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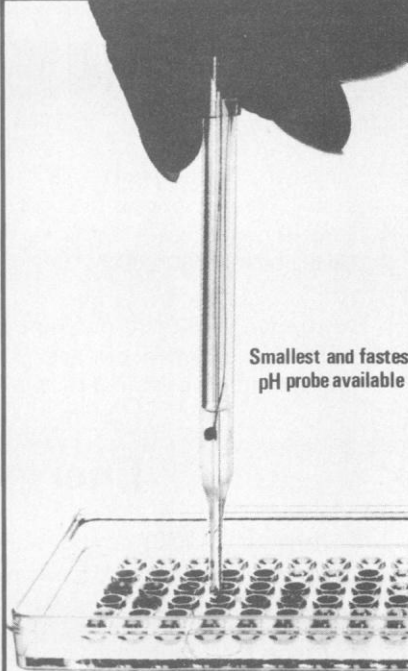
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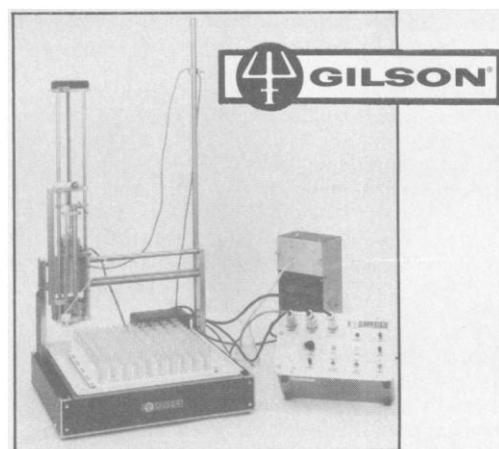
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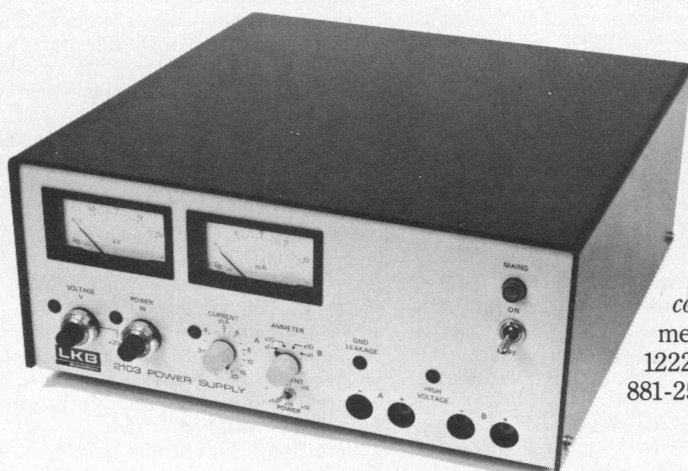
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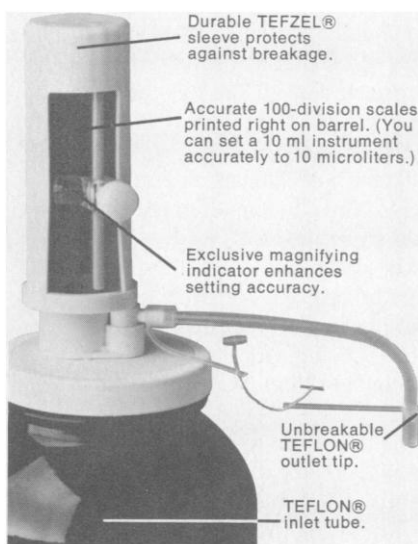
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