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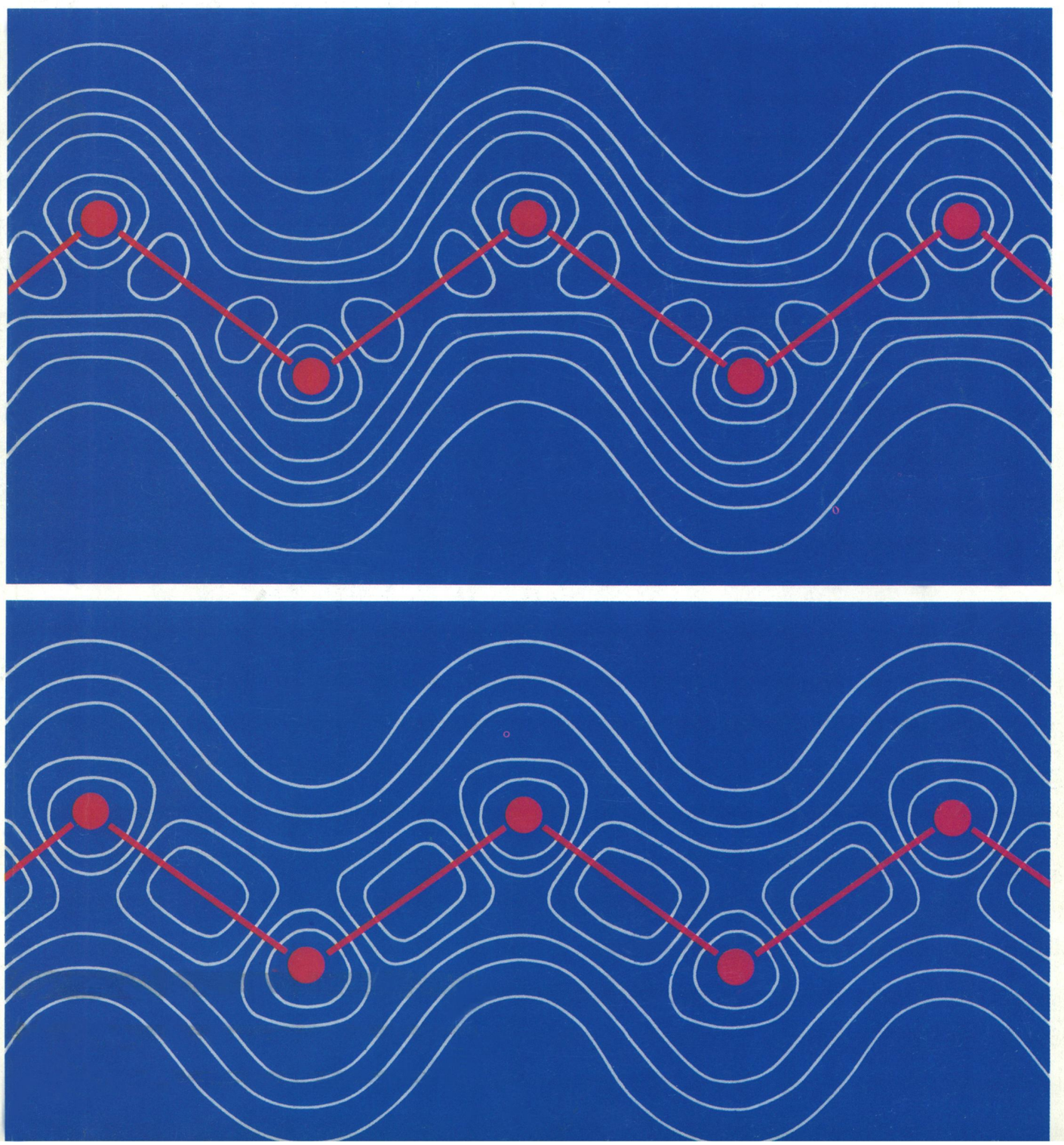

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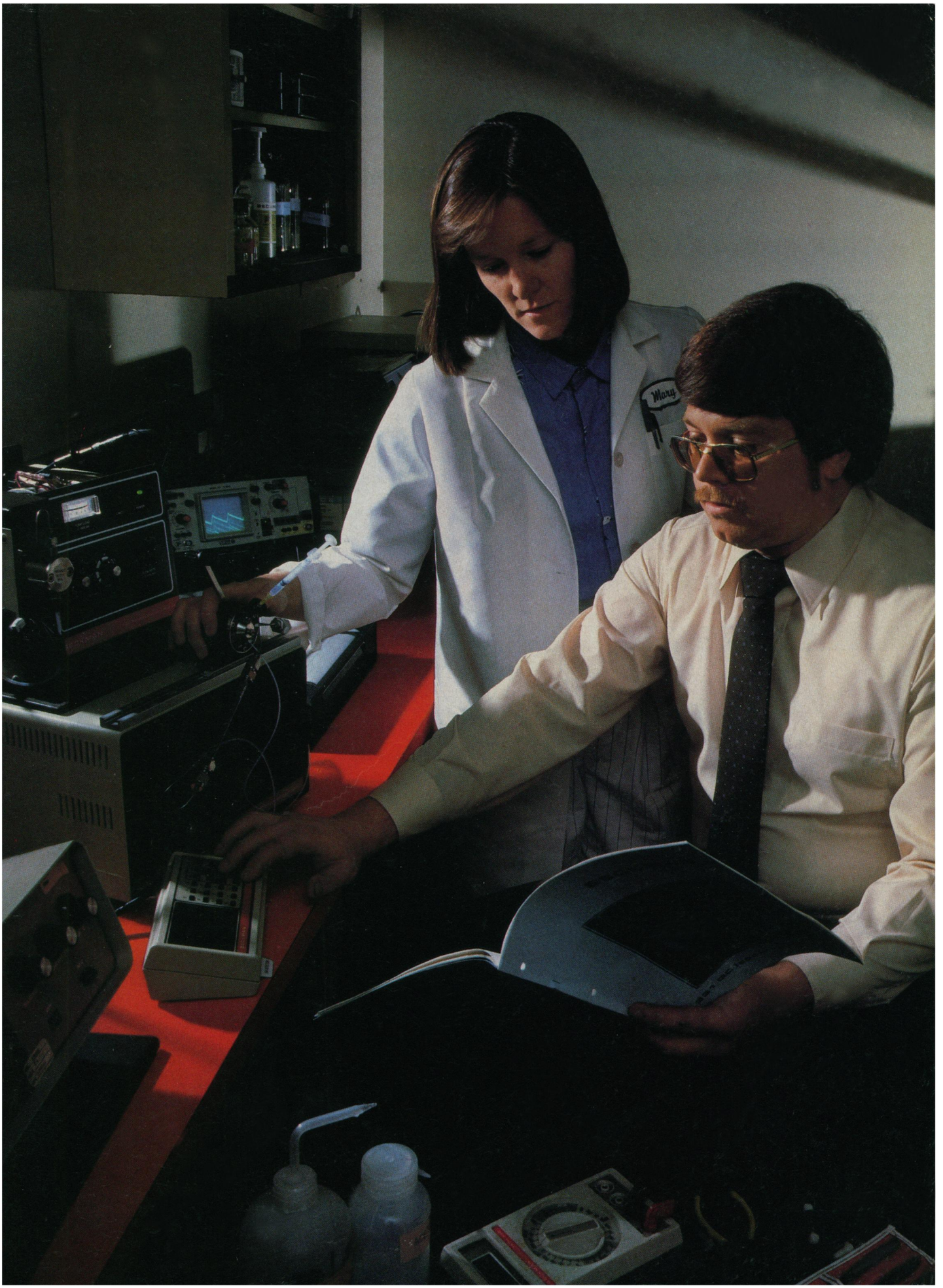
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■ The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve 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.

COVER Topological maps of electron densities for diamond (upper) and silicon (lower). Red disks represent atoms and red lines are drawn along the scaled covalent bonds in a 110 plane. The pileup of electronic charge forming the covalent bonds has two peaks for carbon and one for silicon because of the lack of *p* electrons in the carbon atom core. It is speculated that this is the origin of the difference in the multiple bonding character of these elements and why "carbon gives biology, but silicon gives geology." See page 549. [Marvin L. Cohen, University of California, Berkeley 94720; design executed by Margareta Slutzkin and Marianne Friedman, M and M Graphic Designs, Oakland, CA]

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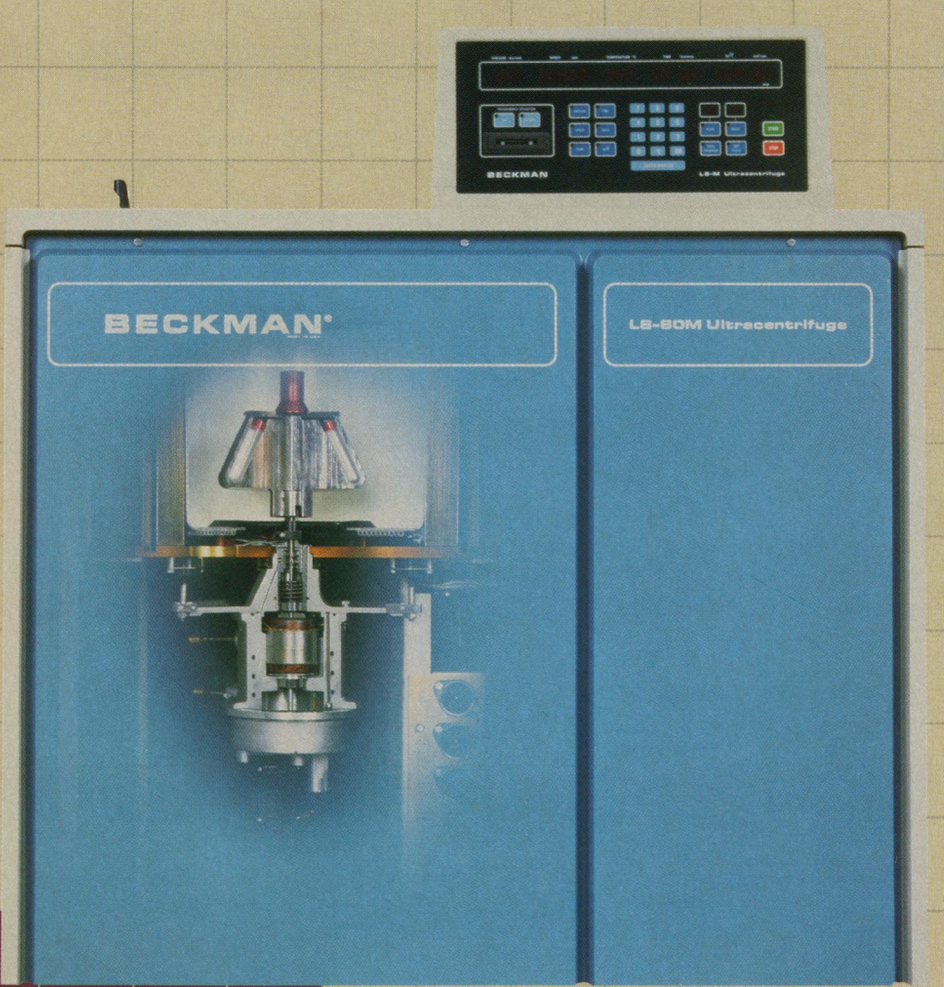

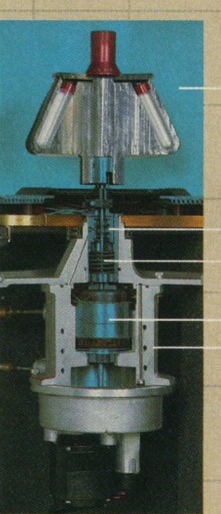

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This Week in
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Fertility in the United States

THE fertility rate in the United States is below the replacement level and is likely to remain there for the foreseeable future (page 554). From the first United States census in 1790 to the present, the birthrate in this country has continually declined except for an occasional reversal, the largest of which was the baby boom (1947 to 1964) that followed World War II. In the recent decade, fertility has stabilized at a low of 1.8 births per woman. Among the factors that, in the late 1950's and afterward, led to and then sustained this low rate are the trend toward postponing marriage, the rise in the use of contraception, the increase in abortion, and changes in the status of women in U.S. society. Westoff discusses these and other social and economic variables—how immigration affects the size and composition of the population and how ethnic, racial, religious, and class factors affect fertility—that have contributed to the birthrate's negative momentum and that will figure into predictions of future fertility trends.

Anemone-fish symbiosis

GIANT sea anemones live symbiotically with anemone fishes in the Indo-Pacific region, and they are drawn together through chemical mediators (page 585). Young fish apparently are attracted to the right anemone partner by chemicals secreted by the anemones. The fish swim with active oriented movement, tail wagging, and seesawing toward the anemone shelters. Murata *et al.* describe the isolation and characterization of chemicals, called synomones, squeezed or extracted from anemones. Each synomone attracted only those guest fishes that are known to coexist with the host anemone from which the chemical was obtained; distinct synomones were secreted by single anemones to attract fish of different species. Through synomones, fish apparently locate the anemones that will provide them with a good home; other fish going to the same anemone can be killed by the anemone's toxic secretions.

Radar glory from Jupiter's moons

HIGHLY unusual and intense echoes with bizarre polarization patterns are recorded when radar signals reflect off three of Jupiter's Galilean moons, Callisto, Europa, and Ganymede (page 587). Eshleman proposes that the anomalous echoes can be attributed to the focusing of signals by craters beneath the moons' icy surfaces; cratering and resurfacing are known to occur on these moons. Total internal reflection within the buried craters would cause signals to bounce around and split; the signals would be repolarized, concentrated, and focused. The effect would be much like that observed in the optical phenomenon of "the glory," in which observers from an airplane, for example, see a bright halo around the shadow that the plane casts onto clouds. The model not only accounts for the strengths of the echoes, their unusual polarizations, and the bright echoes coming from all zones of the moons, but also predicts echo strengths for the three moons that correspond with their theoretical cratering rates.

Paramyosin in schistosomiasis vaccine

SCHISTOSOMIASIS vaccines containing the protein Sm-97 (either purified or along with other larval or worm constituents) induce significant protection against infection in mice; the gene that codes for a portion of Sm-97 has now been isolated and cloned by Lanar *et al.* and the protein identified (page 593). The deduced amino acid sequence of the gene product in conjunction with other data point to the identity of Sm-97 with paramyosin, the protein that forms the core structure of muscle myosin filaments in schistosomes and all other invertebrates. Paramyosin is thought to contribute to the "catch" mechanism whereby contracting muscles sustain large tensions with little energy expenditure. It is unclear how paramyosin serves as a target for immunity; one possibility, speculated upon in this report, is that the protection provided with paramyosin-containing vaccines might come from a series of interactions among components of the immune system, culminating in the activation of macrophages that can kill larval forms of the parasite.

Malaria control by mosquitoes

ONE of the world's major serious infectious diseases, malaria, is transmitted from vertebrate host to vertebrate host by mosquitoes; mosquitoes have now been bred in which the malaria parasite's life cycle and spread are halted (page 607). Mosquitoes bite hosts, some of whom are diseased, and ingest blood meals. In the mosquito's digestive tract, the malaria eggs are fertilized, the motile zygote burrows through the midgut wall, multiplicative development occurs producing many organisms, and parasites migrate to the salivary glands from which they are passed on to new hosts. Through mating and selection procedures, Collins *et al.* have developed strains of *Anopheles gambiae* mosquitoes—the primary transmitters of malaria in Africa—that inhibit parasite maturation. The mosquitoes were fully refractory to several simian, avian, and rodent malaria parasites and showed partial refractoriness to a number of human and simian parasites. Refractoriness involved encapsulation of the developing zygote. Over 40 generations of mosquitoes expressed the refractory trait. The feasibility of introducing genes for refractoriness into a mosquito population has thus been demonstrated; eventually it should be possible to use a similar gene-introduction strategy to change the capacity of naturally occurring mosquito vectors to transmit the malaria parasite.

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SCIENCE

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Overhead and Symbiosis

Basic research in the United States depends on one of the most highly selective symbiotic relationships in nature. It is largely carried out by a combination of cheap labor (called "professors") and ultracheap labor (called "graduate students"). They are housed in impoverished institutions (called "universities") that are continually begging for funds from wealthy aunts (called "private donors") and a very wealthy uncle (called "the federal government"). Everyone should be delighted by this arrangement. The federal government gets fundamental research at a cheap price, the universities obtain funds to help them in their primary mission of education, the students obtain a subsidy during their apprentice period, and the private donors get the psychic satisfaction of contributing to a worthy cause.

Disaster looms when individuals in a symbiotic system reason that if one is getting enough of a good thing, it might be better to have even more. The universities decide that the rich aunt and uncle will never notice if a small amount of their money is diverted to help a group of the worthy downtrodden (called "the humanities"). The research investigators complain that "their" money is being diverted and forget that universities need to maintain an atmosphere in which ideas flourish. The federal government gets nervous and demands increasingly detailed accounts of time and effort. Over the last 20 years overhead rates have doubled, from an average of 20 percent to one of 40 percent. In addition, there are vast discrepancies: overhead varies from 30 percent in some universities to 100 percent or more in others. No one really believes that an institution with a 30 percent overhead is very efficient and one with a 100 percent overhead is a bunch of fumblers. Rather, they regard the high rate as a clever way to enrich that institution with federal money. University administrators, spurred by either envy or altruistic passion, then try to get "their fair share" by creative financing.

It is, therefore, pleasant to note that a first step in bringing this problem into line has now been taken by the Office of Management and Budget after discussions with a representative group of university administrators and scientists. A flat 3.6 percent cap on allowable indirect costs for the salaries of professors and department chairmen has been set, and federal requirements for detailed effort reporting have been eliminated. Negotiations on caps for other portions of indirect costs are under way. Some flexibility will be needed to allow for minor variations, but the wide range existing today needs to be curtailed.

A fixed national rate would have numerous advantages. First, it would provide an incentive to be more efficient. Second, with a flat fee, all institutions would of necessity pull together for an equitable system rather than compete with each other for a dwindling share of research dollars. Those who enjoyed manipulating the system in the past might argue that each university is a special case. There are extra heating needs in Minnesota and extra air conditioning needs in Texas, but they tend to compensate for one another. The overhead should be sufficiently handsome to provide an optimistic atmosphere that generates originality.

Another way to minimize future problems is to make the overhead contracts more explicit and more uniform. Both the institution and the investigator will then know what the investigator is entitled to receive and what the university is required to give. At present, there is considerable bitterness when grants are charged for items the investigator believes should be part of overhead. It is frequently difficult to obtain a copy of the overhead contract and even more difficult to decipher it. After clarity should come a willingness to adapt. If the originally set maximum percentage of overhead is too low, it may have to be adjusted to reflect reality. But at least the correction would be a concerted effort in a common cause.

To be generous is very important. Universities are always strained for funds, and education becomes more complex in our sophisticated society. The new tax bill may be particularly hard on private universities, and they cannot be allowed to fail. Yet symbiosis requires restraint from all parties. It has been said that a gentleman is one who has more privileges than he chooses to exercise. The shift from symbiosis to parasitism can be caused by a slight deviation beyond what is appropriate. The beginning step that has been taken provides a good foundation for future progress. The system needs to be preserved and improved.—DANIEL E. KOSHLAND, JR.

Creativity and Manic Depressive Illness

We were pleased to see the generally well-done Research News article "Manic depression and creativity," by Constance Holden (15 Aug., p. 725), but we would like to clarify several points about our own and others' research.

1) Creativity of our research subjects was not based solely on "participation in the arts and crafts," but rather on a wide range of vocational and avocational activities assessed over each subject's adult lifetime. We developed a new tool, *The Lifetime Creativity Scales*, for just this purpose, so that we and other researchers could study real-life creativity in general populations, rather than being limited only to activities that are socially recognized as creative or are in particular fields that have traditionally been regarded as creative.

2) Our results suggest that, on the average, it may be the *better-functioning* relatives of manic depressives, and not manic depressives themselves, who carry a particular advantage for creativity. This is an important distinction for at least two reasons. First, it suggests that, in our research sample at least, certain traits associated with liability for bipolar disorder, rather than psychopathology or suffering per se, are conducive to heightened creativity. Second, it suggests that our findings may be of practical relevance, not only to the 1% or so of the population who may develop frank bipolar disorder, but also to the much larger proportion who may carry a genetic liability for the disorder.

3) We *do* have definite hypotheses—genetic and environmental—as to why there may be a link between creativity and liability for bipolar disorder. We have hypothesized that enhanced creativity may reflect a "compensatory advantage" within the families of manic depressives, roughly analogous to the increased resistance to malaria in individuals heterozygous for the gene for sickle cell anemia. We also hypothesize that environmental influences interact with genetic liability for bipolar disorder, such that environmental intervention may not only help to prevent the development of psychopathology but also enable individuals to realize unusually great creative potential.

4) It is misleading to state that "modern science has taken next to no interest in exploring the connection" between creativity and psychopathology. Rather, although there has been a good deal of interest in this possibility, it has until recently usually taken the form of theoretical speculation rather than rigorous empirical research. An important reason for the relative paucity of such research has been the scarcity of funds to support it. We hope that Holden's article will encourage other agencies to join the small number of sources, such as the Spencer and Boston Mental Health foundations, now supporting this pathbreaking research.

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American Education

Mark Crawford's briefing "Education statistics found to be inadequate" (News & Comment, 10 Oct., p. 147) is, for the most part, a commendable report on the recent National Academy of Sciences study of the Center for Statistics. Crawford has brought to the attention of *Science* readers the results of too many years of neglect of the Center that officials of the Department of Education have been pointing out now for some time and that were compellingly documented by the Academy.

The briefing incorrectly states as my own view that "more money is not needed at present." In fact, and on this point I differ with the members of the Academy's panel, I believe that improvements in quality and timeliness are not likely to find support alone but must accompany an expansion of the statistical program itself and that does require more money.

The Executive Branch, Congress, states, educational institutions, and decision-makers in them need a more complete reporting of the condition and progress of American education, one that fills long-standing data gaps about teachers, finance, student achievement, and other policy issues. They should expect, and demand, that such data meet the qualitative standards set out by the Academy.

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AIDS and the Physician

David Jenness points out in his editorial "Scientists' roles in AIDS control" (22 Aug., p. 825) that the principal tools available to stop the spread of AIDS over the next few years will be information, education, and prevention campaigns. To be effective, these campaigns will require the dedicated efforts of social scientists, public health workers,

and medical researchers. However, another group of individuals is essential to the success of any public education effort dealing with a health issue—physicians practicing in metropolitan and rural communities across the nation.

At least three levels of commitment and communication are needed from physicians if the spread of AIDS and infection by the virus human immunodeficiency (HIV) are to be curtailed. First is the care required by patients with AIDS and by the families and friends of the patients. Second is the need for counseling of sexually active persons about preventive measures for sexually transmitted diseases and about the meaning and significance of infection by the HIV virus. Third is communication with the public at large about the medical and psychosocial aspects of AIDS and about the preventive measures necessary to reduce transmission of the HIV virus. It is at this level that a collaborative effort of physicians, social scientists, and public health workers is most needed. The American Medical Association is preparing, collecting, publishing, and distributing a wide variety of articles and monographs on AIDS and HIV transmission.

The AMA has also initiated a program to help and encourage physicians to become public spokespersons on the health care and societal issues associated with AIDS. This program includes establishing a speakers bureau of concerned physicians in state and county medical societies across the country. Collaboration in this effort by social science and public health groups is encouraged and welcomed by the AMA. Stemming the spread of AIDS and the HIV virus requires the resources of all of us.

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Multivariate Analysis

Part of the description of multivariate statistical methods by Peter C. Jurs in his article "Pattern recognition used to investigate multivariate data in analytical chemistry" (6 June, p. 1219) may inadvertently encourage inappropriate use of these methods. In the social sciences, where analyses to discriminate between groups have long been familiar, the lack of statistical sophistication of some investigations has led to dubious procedures that exploit random variation in the data. Chemists should be wary of repeating the error.

Discriminant studies, like multiple regression studies in general, are often pursued in an exploratory way and involve a large number of variables. A common pitfall is underestimating the probability of having arrived at seemingly impressive results solely by chance variation in the sample. Jurs has discussed this issue elsewhere (*1*). He points out in his *Science* article that exploratory discriminant analysis may be of little use unless the number of cases is several times greater than the number of variables, and that consequently it is often necessary to reduce the set of variables considerably by some "objective means." It is in the reduction that inadvertent exploitation of random variation may occur.

One of the major examples described in the article is an attempt to discriminate between two groups of 24 people for which 214 variables were measured. Objective means of reducing this set would be to select a few variables a priori, on the basis of a theoretical model or empirical results from previous studies, or to identify summary composites on the basis of a factor analysis, as Jurs has done in another study (*2*). In this example, however, the variables were selected a posteriori on the grounds of how well

they appeared to contribute to the desired classification of the two sample groups.

The problem is most clear in the analysis of 65 variables chosen, objectively, as the most commonly occurring (p. 1222). The investigator selected six of these variables—not by objective means but on the grounds that they worked best—and then made a formal discriminant analysis of those six variables. But in effect the analysis involved 65 variables, *more* than the number of cases. The results are therefore suspect; the relevant statistical question for the believability of the results is not whether the classification success might have been found just by chance for six variables, but more nearly for the best six chosen opportunistically from 65 possibilities.

There is nothing wrong with all this as exploration. (And in other respects Jurs' exploratory analysis was very sophisticated: There was an additional selection criterion that the variables not discriminate among other subdivisions of the data and an "internal validation" showed that the findings were not the result of a few highly deviant subgroups in the sample.) But discriminant functions prove to be notoriously poor in external validation, that is, in classifying samples other than the one on which they were based. A serious case for the validity of the pattern recognition in such an exploratory study can be made only by means of actual prediction in a subsequent study.

These remarks have pertained to prediction, which was the focus of Jurs' article. But much more could be said about weaknesses of the procedure for purposes of explanation. Even if the procedure for identification of variables were legitimate, and prediction were significantly better than chance, little credence could be placed in the meaning of the particular coefficients found for the sample unless all important variables were known to be included in the analysis (or were known to be uncorrelated with the variables already included). The inclusion of a single important missing variable could significantly change all of the values, even the signs, of the coefficients.

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Minneapolis, MN 55455

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Response: I agree that one must be careful about getting results in discriminant studies that are due to chance and are not as meaningful as they appear to be. In addition to the paper cited by Ahlgren, we have published twice more on this subject (*1*). With respect to the selection of six variables from 65 in the cystic fibrosis work, we selected six chromatographic peaks that possessed several attributes simultaneously, both with respect to the desired separation, but also with respect to the undesired separations. In addition, while I agree that prediction on true unknowns is the most satisfying test of discriminants, such unknowns are not always available in real studies. Finally, it is true that the results obtained in exploratory data analysis are dependent upon the variables used, and one can seldom be sure that all important variables have been included in the analysis in this type of work. We must do the best we can.

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1. T. R. Stouch and P. C. Jurs, *J. Chem. Inf. Comput. Sci.* **25**, 92 (1985); *Quant. Struct. Act. Relat. Pharmacol. Chem. Biol.* **5**, 57 (1986).

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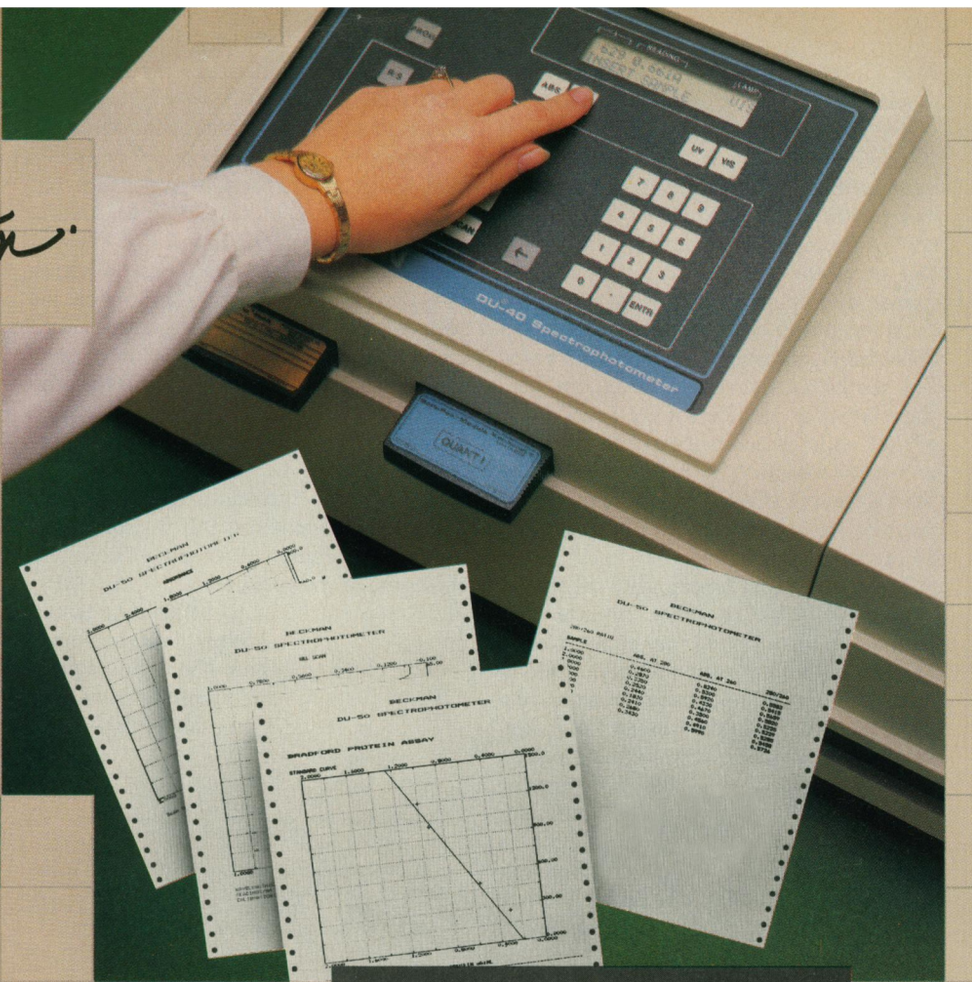

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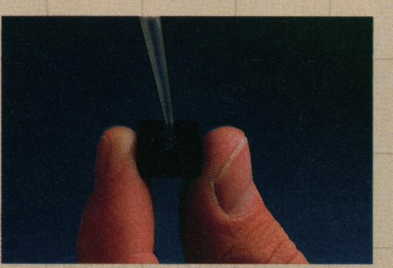

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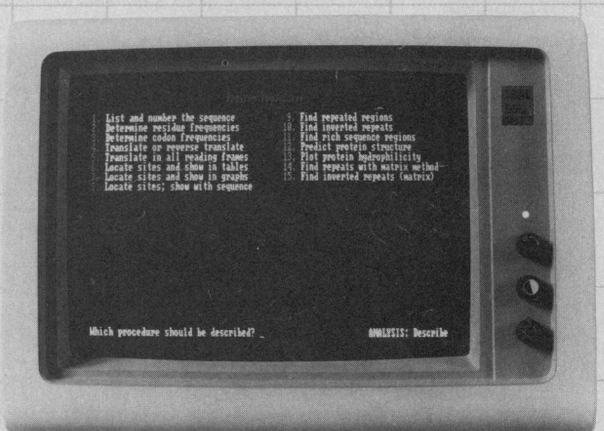

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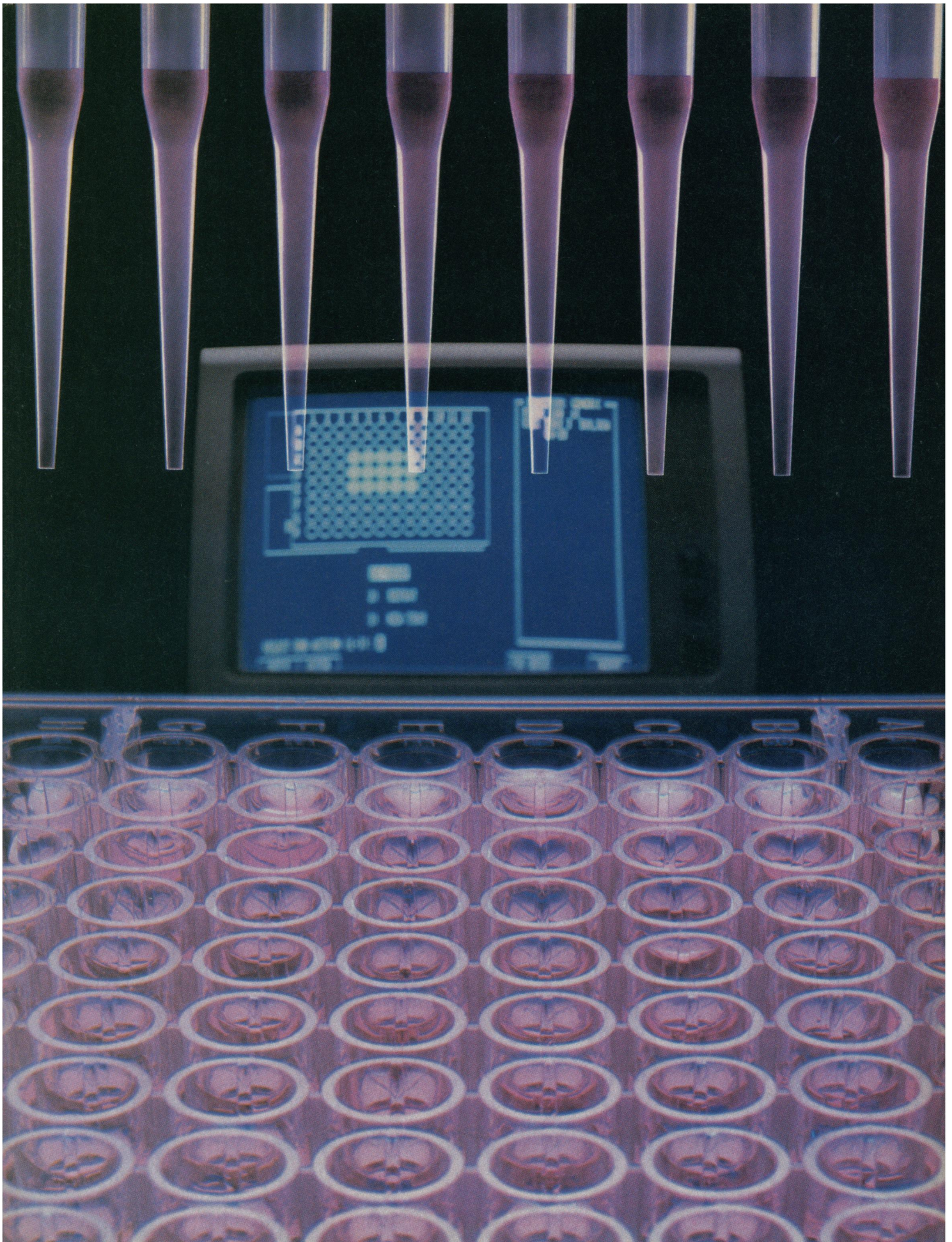

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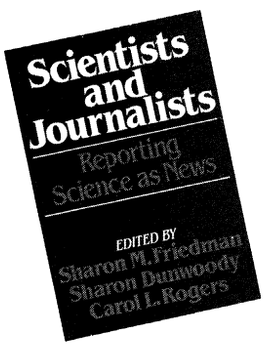

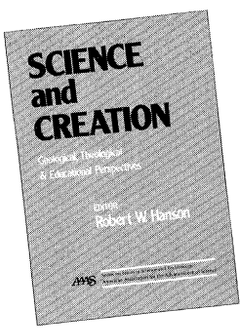

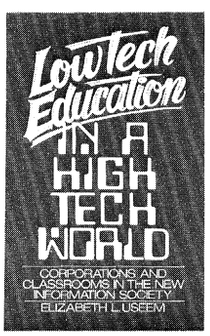

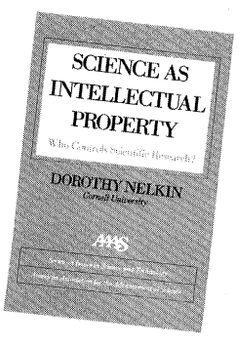

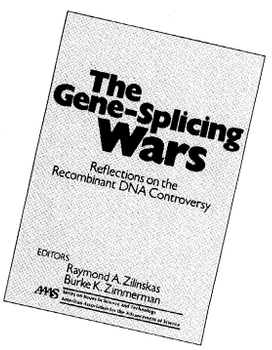

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Particle Physics in Retrospect

Inward Bound. Of Matter and Forces in the Physical World. ABRAHAM PAIS. Clarendon (Oxford University Press), New York, 1986. xvi, 666 pp., illus. $24.95.

Inward Bound is an account of "particle" physics from X to Z—from the discovery of x-rays by Roentgen in 1895 to the discovery almost a century later, by Rubbia and 135 collaborators, of the neutral boson that mediates the weak interactions. Two books really make up *Inward Bound*. The first, constituting the first two-thirds of the volume, is a history of the period from 1895 to 1945; the second, which Pais calls a memoir, covers the postwar years. The distinction is of importance. A memoir, as Pais indicates by quoting the *Oxford English Dictionary*, is a record of events that have come within the personal knowledge of the writer. What Pais means by a history was defined in his superb biography of Einstein, *Subtle Is the Lord*. It is an account based on an unavoidably subjective selection of information from a pool that can be assumed to be incomplete. Pais there also noted that though questions like "Why did A create what he did, why did B readily accept what A created, why did C resist A's new ideas?" can be distilled from the historical record their answers are beyond history. Somewhere between the question and the answer lies what Pais has called the edge of history.

In *Subtle Is the Lord*, Pais was willing to indulge in such "extrahistorical" speculations, and that epic work was humanized by his willingness to trespass at the edge of history. The same is true for the first part of *Inward Bound*. The memoir, on the other hand, is a depersonalized—one might almost say dehumanized—account of the great advances that have taken place in high-energy physics in the last four decades, in which the building blocks of matter have been uncovered and the dynamical laws describing their interactions, laws valid to distances of the order of 10^{-17} centimeter and energies of the order of 100 billion electron volts, have been established.

Both periods are illuminated by Pais's felicitous style, his extraordinary scholarship, and the wealth of detail he has incorporated in the text. The references alone make *Inward Bound* an invaluable historical document. But above all it is the quality of Pais's mind that makes it memorable. Pais is a deeply learned authority who writes with lucidity and avoids frills but also shows an acute aesthetic sense and a fine sense of humor. His own accomplishments in physics, moreover, are such that he properly appreciates the achievements he writes about.

The book is admittedly a Whiggish history, but then I do not believe one can escape some Whiggism in the history of science. The Whiggish idea of progress must, since there has been progress in science, come into the writing of its history. Moreover, the illumination of later theories helps make the earlier landscape clearer, demarcate boundaries and approaches, and organize the narrative.

The concerns of Pais's own research are reflected in his selection of topics: beta-decay and the weak interactions receive dominant emphasis in the historical section of the book. The heroes of the pre-1945 account are Rutherford and Dirac, and of the two Rutherford is the more fully (and lovingly) portrayed. Both are supremely intuitive and fearless physicists. Others are as insightfully drawn—for example, Thomson, Planck, Bohr, Pauli, Heisenberg—yet somehow Rutherford represents a *beau ideal* for Pais. The historical segment is humanized by these portraits; it also is enlivened by Pais's judgments and insights. For Pais, "progress in science depends vitally on a backlog of experimental data in need of interpretation." His treatment of the period prior to about 1905 is intended "to demonstrate that in all of the twentieth century (to date) the experimental backlog in physics was never greater than during its opening years." Similarly, the greatness of Thomson and the reasons he is credited as the discoverer of the electron are masterfully detailed: not only did he determine the ratio of charge to mass for these particles, he also a few years later measured their charge. Additionally, the historical part of the book is peppered with stimulating and controversial statements: on the pitfalls of search for general patterns of laws of history, and more specifically laws of the history of discovery, on the influence of Zeitgeist, on the role of individuals in history, and much else.

Whereas one might have inferred that the title of the book alluded to an inward journey, Pais's account of the events that have occurred during his own career refers only to quarks, gluons, leptons. Here Pais avoids discussing individuals. The memoir is primarily a history of ideas, with some attention to the instrumentation that has made it

recognition phenomena in the operation of incompatibility systems. He admits, however, that the book is biased toward his own research interests and that another book (by another author) is needed to deal with the theory and mathematical modeling that he covers less thoroughly. One-fifth of the text is devoted to Richards's interests: heterostyly (51 pages) and agamospermy (53 pages).

The introductory chapter makes some statements easily subject to misinterpretation; for example that "hermaphrodites can self-fertilize whereas unisexuals cannot" (p. 2) could be read to mean that plants with perfect flowers *do* self-fertilize (thus excluding the important role of incompatibility or other mechanisms that prevent this in many species). This statement also does not distinguish two kinds of hermaphroditic individuals: plants with perfect flowers and monoecious ones with unisexual flowers. This confusion is compounded in the glossary, which refers to monoecious flowers as well as to monoecious individuals; the term correctly refers to plants and not flowers. Likewise that "self-fertilization tends to reduce genetic variability" (p. 2) surely is not what the author intended to say; the distribution of variability may differ in xenogamous and autogamous breeding systems, but the level of variability is dependent on selection and is not an artifact of the breeding system alone. "Self-incompatibility will lead to more outbreeding and greater genetic variability than will self-compatibility" (p. 3) is a statement that is true only if accompanied by qualifications concerning levels both of outbreeding and of genetic variability. An "interesting feature" of monoecious species is "that they can change sex" (p. 4); the sentences that follow this puzzling assertion explain what the author means, but it is a showstopper for an informed reader and probably an uninformed one as well. The glossary poses additional problems. The term "breeding system" does not appear there. A monocarpic plant is one that "only flowers once." A carpel is "the segment of an ovary." Definitions of the Darwinian terms "legitimate" and "illegitimate" for classes of pollination of heterostylous plants exclude tristylous species.

Richards is to be commended for dispelling the common notion that agamospermy (the production of seeds without syngamy) is an evolutionary dead end. Indeed, anyone who has attempted to maintain a lawn free of dandelions will have an intuitive suspicion of this assertion. Most agamospermous species that have been studied appear to be facultatively so, and retain some level of sexual reproduction combined with asexuality. The balance between relative levels of sexuality and asexuality in successive reproductive phases may vary and seems to be under environmental control, though the specifics of this control are scarcely understood. Richards contrasts the "real world" of agamospermy with the "hopelessly naive" mathematical models that assess its long-term success in a given evolutionary line. His own work with the dandelion genus *Taraxacum* has gone a long way toward providing an understanding of the mechanics and significance of sexuality and asexuality combined in the same organism.

Botanists, in particular, do not always distinguish clearly between inbreeding as a term of population genetics and the various factors, such as levels of selfing and of assortative mating or population size, that contribute to levels of inbreeding. Indeed, one commonly finds the term "inbreeding" used interchangeably with "selfing." Richards, however, keeps the distinctions clear and realizes that the mechanics of reproduction must be distinguished from the genetic consequences of different reproductive modes.

The flaws mentioned above may diminish the value of this book as a textbook, but a seasoned reader will doubtless recognize most of the infelicities as such and benefit from the book's many positive qualities. The book is wide-ranging in coverage, provides an excellent review of many interrelated topics, and lacks the doctrinaire quality and sketchy literature reviews of some recent volumes that cover some of the same territory. It also points to many general topics that require investigation; the "explosive expansion" of research that Richards refers to will doubtless continue.

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Petrology

Fluid-Rock Interactions during Metamorphism. JOHN V. WALTHER AND BERNARD J. WOOD, Eds. Springer-Verlag, New York, 1986. x, 218 pp., illus. $44. Advances in Physical Geochemistry, vol. 5.

In the last few years a lively debate regarding the nature of fluid-rock interactions at depth has been carried on in the geological literature. This debate has centered on the amount of fluid involved in metamorphism (lots vs. almost none), the sources of the fluid phase, and the mechanisms of fluid migration through material with low permeability. A review of current thinking on the mechanical and chemical aspects of fluid-rock interactions has been sorely needed.