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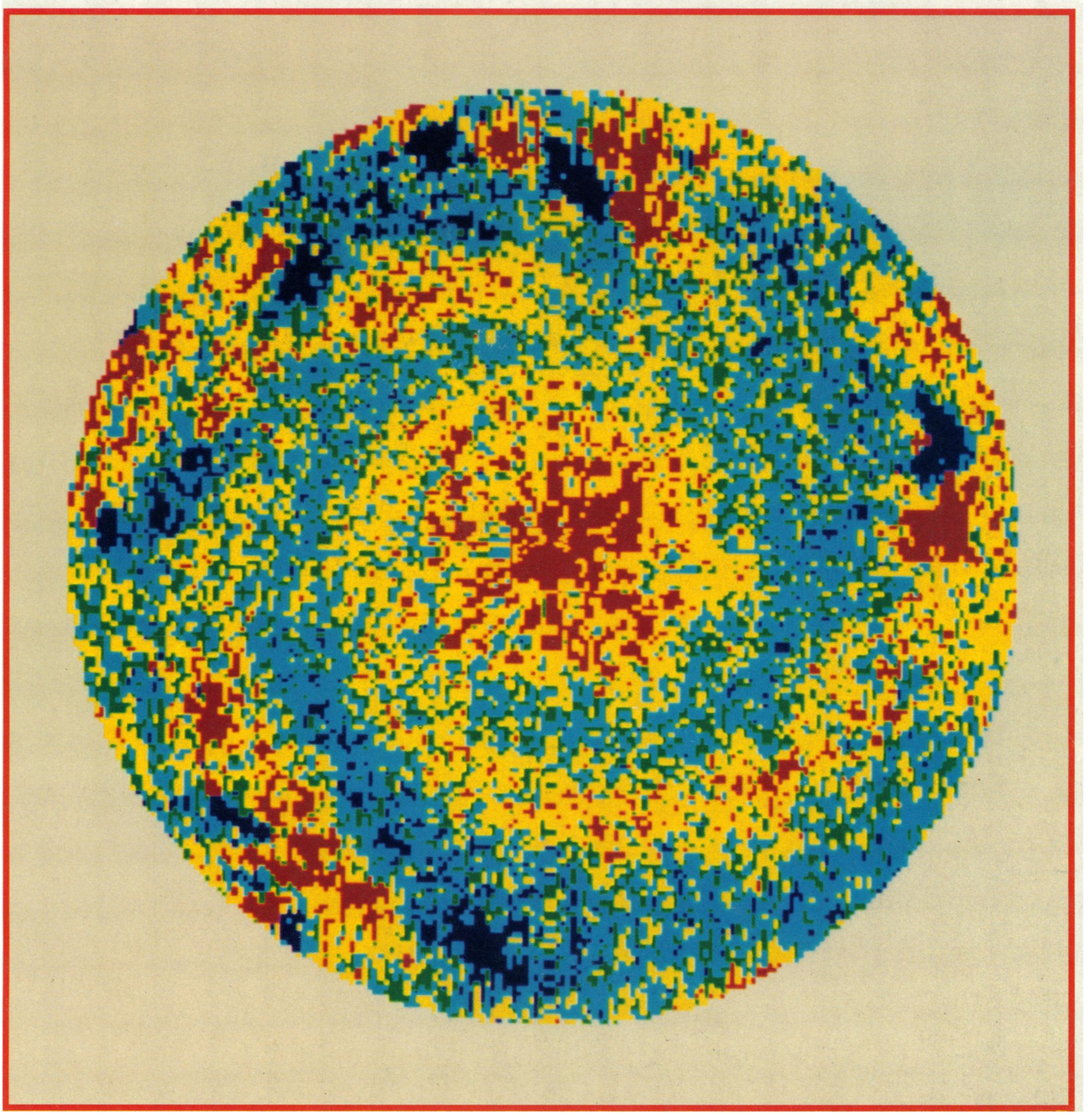

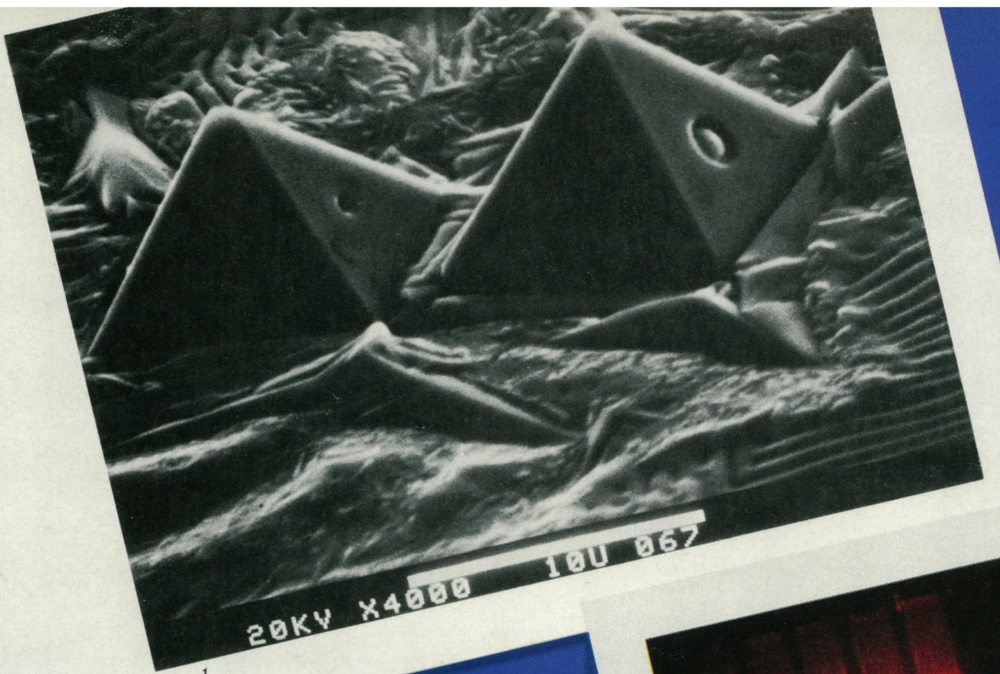

Fig. 1

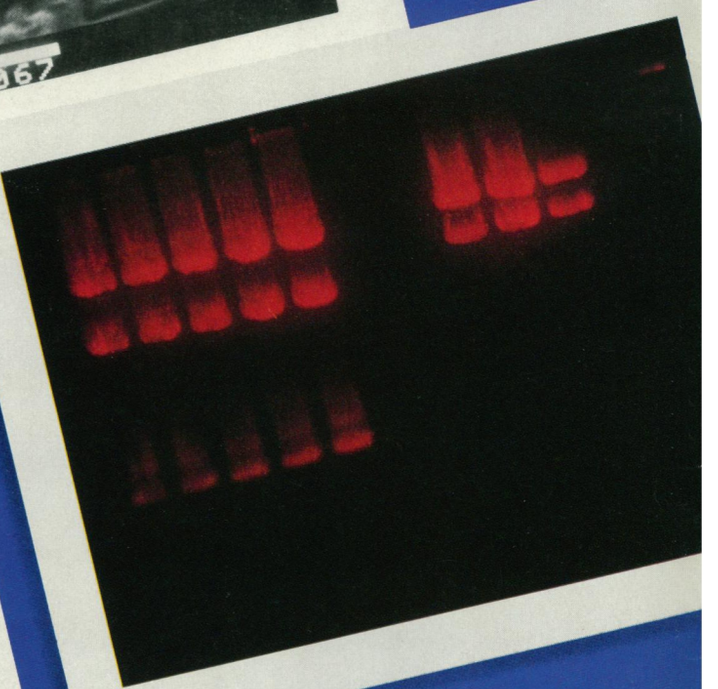

Fig. 2

Fig. 3

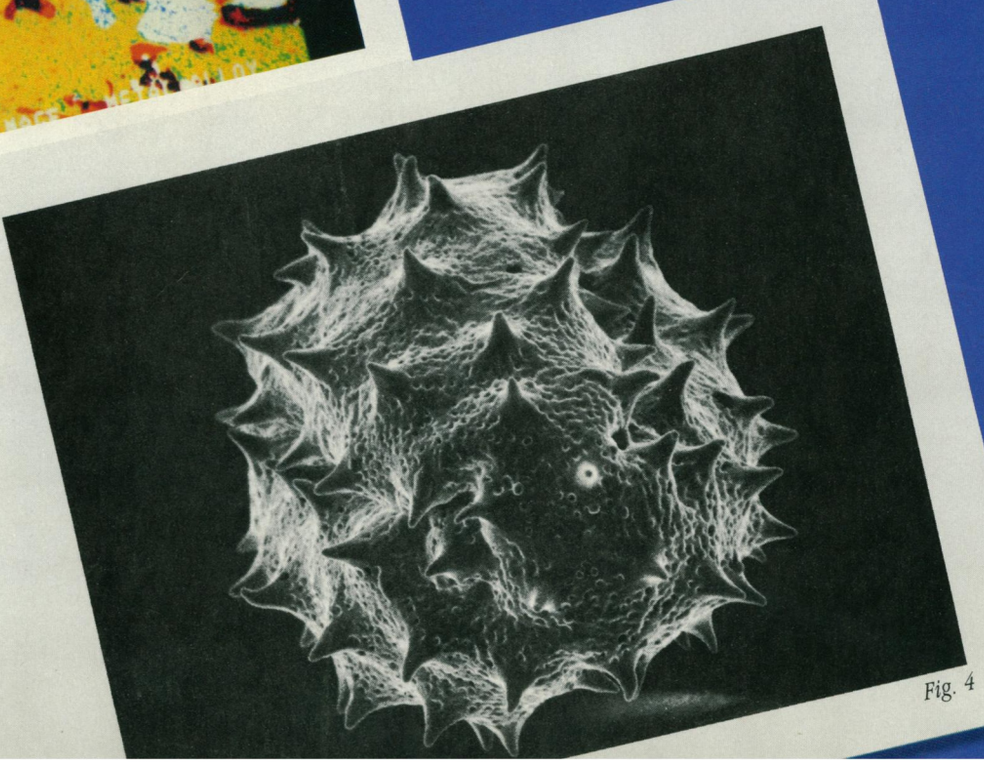

Fig. 4

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COVER Polar view of the sun constructed from Kitt Peak magnetograms, showing magnetic flux drifting from the sunspot belt toward the negative-polarity north pole during August 1983. The poleward streams, which form a rigidly rotating spiral pattern, gradually establish a strong "topknot" polar field as the 1986 sunspot minimum approaches. See page 712. [Image created at the Naval Research Laboratory from data provided by J. W. Harvey]

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This Week in
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Bold fusion

An unusual collaboration between physicists and economists is taking place in an effort to develop fresh approaches to some thorny economic problems. The participants, who share an interest in complex systems, bring to the collaboration widely disparate problem-solving approaches and intellectual backgrounds. It is hoped that among the payoffs of this bold experiment will be the formulation of realistic economic models and improved economic forecasting. Pool describes the changing attitudes and evolving relations of the participants and some of the early collaborative ventures (page 700). Whereas the economists were at first surprised to discover how heavily the physicists relied on intuition (and the physicists were equally surprised to find how mathematically rigorous the economists were), now they are running simulations and adapting other physical science paradigms and methodologies to their problems.

Crustal fluids

Two major sources of fluids in the earth's crust are meteoric fluids derived from rain and snow and metamorphic fluids generated in the crust during devolatilization processes. Which type will predominate in crust in any given region appears to depend on the region's tectonic style (page 733). In the Canadian Cordillera, where the two types of fluids have distinguishable isotopic signatures, isotopes were evaluated in quartz veins of two regions that are similar in most ways except in their structural styles. Quartz veins east of the Rocky Mountain trench, where thrust faulting had occurred, had isotopic signatures characteristic of metamorphic water. West of the Rocky Mountain trench thrust faulting had been followed by strike-slip and extensional faulting; crustal fluid there had the signature of meteoric water, which apparently percolated deep into the crust through steeply inclined interconnected fracture systems. Nesbitt and Muehlenbachs discuss how their findings affect models of fluid flow in the crust and how they account for the uneven distribution of gold deposits in the Canadian Cordillera.

Rotational spectroscopy of polyenes

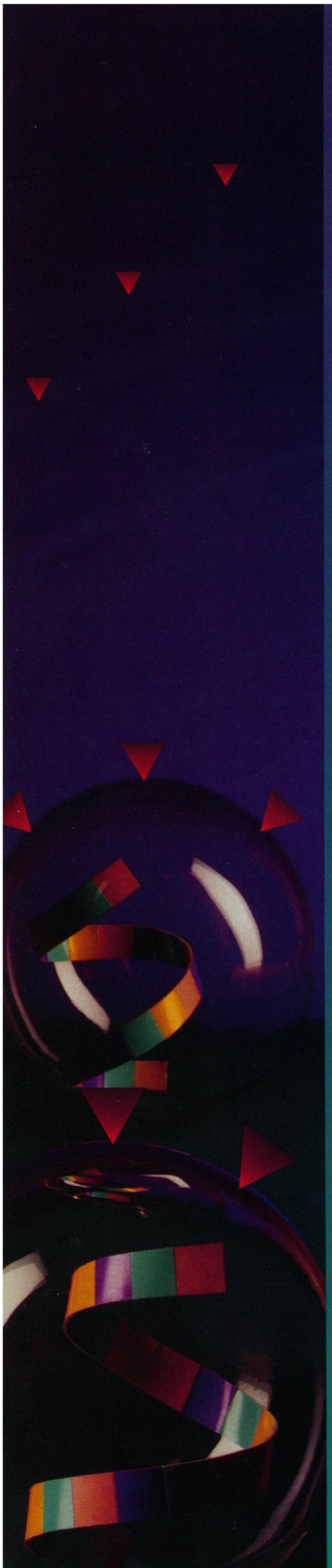
Structural information on linear polyenes has figured into theories describing the visual system, photoisomerization in cis-trans systems, and the nature of electronic structures. Links between the chemical composition of a molecule and its color were also first established with linear polyenes. One uncertainty regarding these molecules has been the extent (if any) to which they are distorted after excitation by light. For planar linear molecules in the gas phase, this question can be addressed by studying rotational spectra, because the rotational frequency of a molecule will change if the structure changes from (largely) planar to nonplanar, much as a figure skater can change her speed by raising or lowering her arms. Pfanstiel *et al.* studied the rotational spectrum of the linear polyene *all-trans*-1,4-diphenyl-1,3-butadiene (page 736). Both the ground state and the first excited state were found to be essentially planar, and structural changes that occurred upon excitation could then be inferred.

Immune tolerance versus autoimmunity

The thymus is an organ that, early in life, sorts through newly developing T cells and eliminates those that might react with (and therefore destroy) self components. Mice of the B6AF1 strain whose thymuses have been removed during the first few days of life apparently retain some of these self-reactive cells and are prone to the development of autoimmune diseases of the ovaries, testes, thyroids, and stomachs. One population of self-reactive cells, Vβ11 cells, was found by Smith *et al.* to be virtually absent in lymph nodes of normal adult mice but to be greatly enriched (about tenfold) in lymph nodes of adults that had been thymectomized in the first few days after birth; these cells were present in high numbers in thymuses of all neonatal B6AF1 mice (page 749). Thus the thymus does not fully weed out self-reactive clones of cells in the first week of life; undeleted self-reactive cells may normally be eliminated in subsequent weeks, either as they recirculate back through the thymus or by a "peripheral tolerance" mechanism (perhaps the prevention of activation of self-reactive cells) operating in lymph nodes and other peripheral lymphoid tissues. With this system, it should be possible to learn how lymphoid tissues are seeded by T cells and how self tolerance and autoimmunity are brought about.

Monkey perceive; neuron do

A population of nerve cells that fires in response to perceptions rather than to physical sensations has been identified in the visual cortex of the brain in rhesus monkeys (page 761). The cells, located in the superior temporal sulcus, responded during a study of binocular rivalry in which each eye, peering through a stereoscopic viewer, watched grids moving in different (one upward and the other downward) directions. The perceived motion in the experimental trials was ambiguous, alternating between up and down, whereas, in control trials in which both eyes saw grids moving in the same direction, the perception was straightforward. The monkeys "reported," by a quick eye movement, how they perceived the direction of the moving stimulus: the eyes had been trained to dart to the right if the movement was perceived as upward and to the left if downward. Logothetis and Schall point out that integration of information regarding visual stimuli is complex and that this handle on neurons of perception may contribute to an understanding of how and why different visual stimuli are favored or suppressed.



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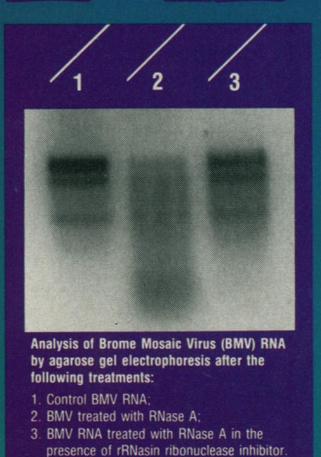

Analysis of Brome Mosaic Virus (BMV) RNA by agarose gel electrophoresis after the following treatments:

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Reliability of Electric Service

On 14 June, a particularly vicious storm hit the Washington, D.C., metropolitan area. It destroyed thousands of trees; many of them fell over electrical distribution lines. In the course of minutes about 150,000 customers lost electricity.

Such experiences stimulate questions about the reliability of the electrical system as a whole. Earlier there was excessive generating capacity. Generation of electric power in the period between 1980 and 1986 rose by 1.5% per year. Utility planning was adjusted accordingly. However, for 1987–88, the average yearly increase was 4.2%.* During the first half of this year consumption rose another 3%. Accordingly, questions are now being raised about adequacy of future reserves. The situation differs from region to region, but now in the north and middle Atlantic states reserves are on the low side. The intertie system connecting utilities in Pennsylvania, New Jersey, Maryland, and the District of Columbia already this summer has been forced to reduce voltage by 5% on four occasions.

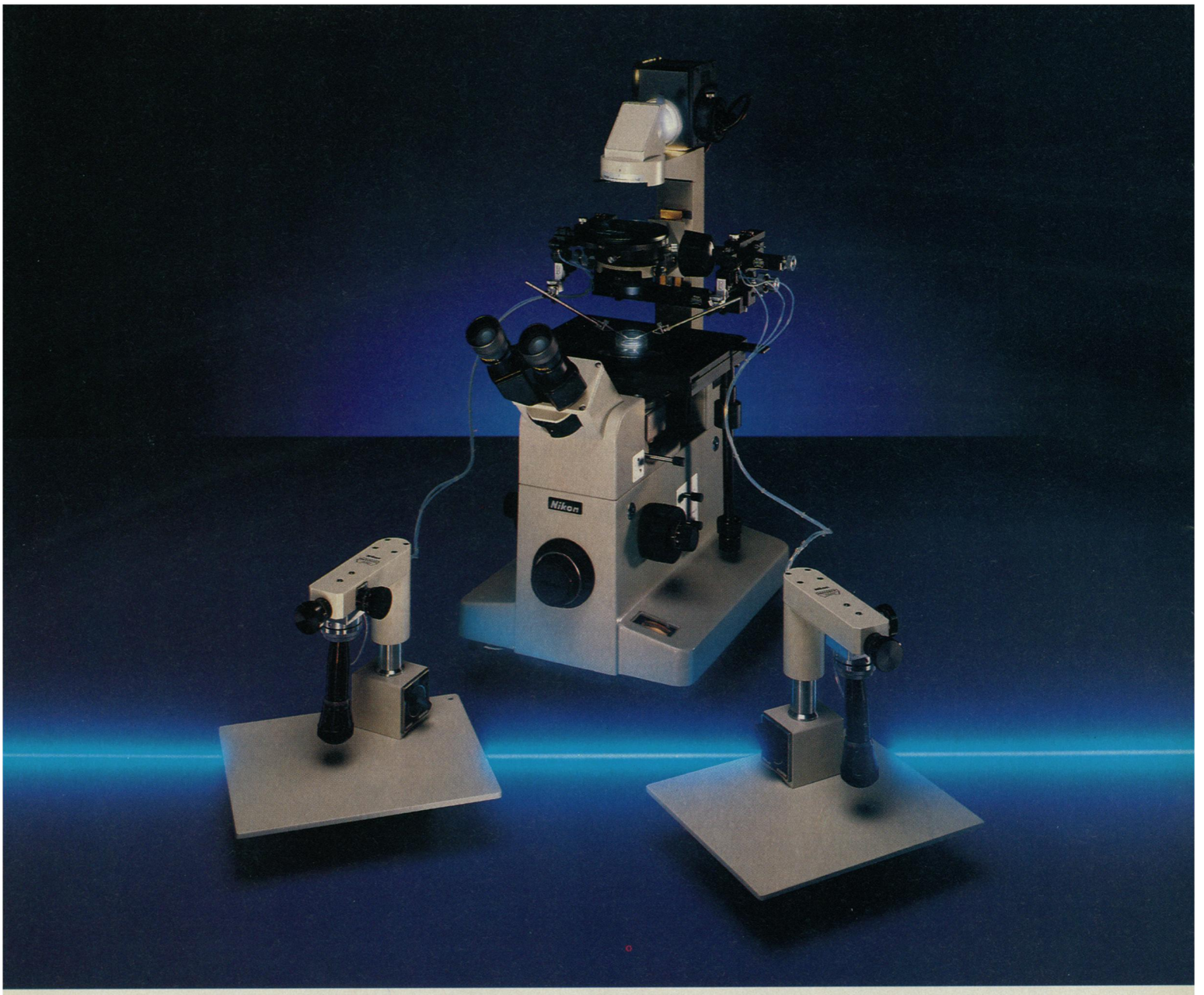
A person who is accustomed to a proper response when flicking a switch is not likely to realize the complexities of reliable operation of an electrical system and the need to have reserves to cope with contingencies. Publications of the North American Electric Reliability Council (NERC) can give one a glimpse of some of the problems. For example, a Generation Availability Report 1983–1987 presents extensive data on the reliability of the more than 4000 electric generating units that represent 91% of the installed capacity of North America.

The NERC report presents detailed figures on outages of all types of plants. Data relevant to coal-fired plants in the 600- to 799-megawatt range illustrate where failures occur. Each plant on average sustained a total of 7.7 forced outages per year due to failures in the boiler. In addition, other systems of the plant accounted for more than 5.6 forced outages per year. Partial failures also led to reduced output. Beyond that, scheduled maintenance required cessation of generation. In all, the average equivalent outage time for boiler-related reasons was 1122 hours out of an annual 8640. Other components of the plant, including the steam turbines, generators, and pollution control equipment, caused further outages totaling about 800 hours. Thus the average plant of this type was available only 78% of the time. Similar figures were noted for other fossil fuel–fired installations.

About half of the outages due to the boiler system result from leaks in boiler tubing. A 600-MW boiler has about 100,000 meters of 6.35-centimeter diameter stainless steel tubing containing about 10,000 welds. Analysis has shown that failure of the tubing occurs for at least 22 reasons—most relate to extreme conditions present in a modern boiler. A 600-MW boiler consumes 10,000 tons of coal and the oxygen from 140,000 tons of air each day. In the center of the boiler, temperatures range up to 2000°C, and the average upward velocity of the gas stream and fly ash is nearly 100 kilometers per hour. Turbulent velocities may be much greater. Near the edges of the boiler, where the water-filled tubes are located, temperatures are as high as 1600°C. In the superheater, which is at the top of the boiler, the temperature of fluid within the tubes is 500°C or more. In some installations, the fluid pressure is 270 atmospheres. Pressure in the fire side of the boiler is slightly below atmospheric. If a tiny leak occurs in the tubing, the hot reactive H_2O cuts a large hole leading to a forced outage. The tubing is also subject to hydrogen embrittlement from the inside. On the outside it is exposed to sulfur compounds, NO_x, and at times to excess oxygen. Occasionally tubing may be exposed to a reducing environment that can also cause failure. Other factors leading to failure include erosion due to impact of fly ash, stress rupture, and fatigue due to vibration.

The NERC Generating Availability Data System pinpointed boiler tube failures as a major source of forced outages. This has led to a cooperative effort involving a number of utilities. They have used extensive data concerning tubing failures. Their efforts, coordinated by the Electric Power Research Institute, have resulted in a substantial decrease in forced outages. This precedent is likely to be followed by other cooperative efforts to reduce other types of outages and thus to increase the reliability of the electric system. Complexities, however, are such that progress will be slow.—PHILIP H. ABELSON

*Department of Energy, "Monthly energy review, March 1989" (DOE/EIA-0035, Energy Information Administration, Washington, DC, 1989).



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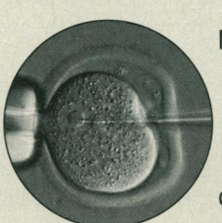

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Letters

Biotechnology: Society's Role

Daniel E. Koshland, Jr., in his editorial (p. 1233) for the 16 June issue "The new harvest: Genetically engineered species," transcends the scientific syllogisms of the lead articles in that issue when he concludes, "Whether society prefers to have wolves or dogs remains to be seen." "Society," that is, the public, has little say about the present and future applications of biotechnology. And is the choice either wolves *or* dogs? Must we remake every natural thing into our own image of perfection and utility?

While the multiple pleiotropic health problems of genetically engineered pigs (Articles, 16 June, p. 1281) are duly noted, we should also remember that the "engineering" of wolves into dogs by selective breeding has resulted in much animal suffering, especially in purebred dogs now afflicted with more than 200 genetic disorders.

Perhaps we should ask not whether society prefers to have wolves or dogs but rather whether we prefer to have a natural world or an industrialized biosphere. The preservation of wildlife and wildlands depends in part on the judicious application and containment of new biotechnologies. It is doubtful, in view of the high probability of the doubling of the human population within the next 40 years, that making pigs grow faster and stay lean and continuing to regard meat as a dietary staple will help preserve the diversity and integrity of the earth's biotic community.

MICHAEL W. FOX
Executive Director,
Center for Respect of Life and Environment,
2100 L Street, NW,
Washington, DC 20037

ICBM Modernization

John M. Deutch's article "The decision to modernize U.S. intercontinental ballistic missiles" (23 June, p. 1445) effectively argues that a road-mobile single-warhead Midgetman is preferable to the rail garrison ten-warhead MX on the grounds of survivability. Deutch devotes less attention to silo-based alternatives, but he does state that, in terms of survivability, the MX in the multiple-shelter "carryhard" system may be equivalent to a silo-based Midgetman. Specifically, a single MX missile movable among ten shelters is said to be equivalent to ten Midgetmen (with the implicit assumption that the survival probability for targets is the same for both systems). This claim is based on the fact that the mean number of surviving warheads, $<N_S>$, is the same for the MIRVed and unMIRVed systems; however, it fails to take into account the fact that the probability distribution for the number of surviving warheads is quite different for the two systems.

A more appropriate measure of survivability is the minimum number of surviving warheads at a given confidence level, C. This number, $N_{S,min}$, is simply related to $<N_S>$ (in the case of a Gaussian distribution) by $N_{S,min} = <N_S> - y[2n(1 - P)<N_S>]^{1/2}$, where n is the number of warheads per missile and P is the probability of survival of each target (*1*). The parameter y is related to the confidence level by $\text{erf}(y) = 2C - 1$.

To illustrate, with 500 warheads and $P = 0.1$, we have $<N_S> = 50$ for either system. But if we wish to have $N_{S,min} = 50$ at $C = 90\%$, we must deploy 594 warheads at $n = 1$, but 860 warheads at $n = 10$. The fact that the MIRVed system has a wider probability distribution adds 45% to its cost when measured in terms of dollars per minimum number of survivors.

MICHAEL I. SOBEL
Brooklyn College
of the City University of New York,
Brooklyn, NY 11210, and
Center for Energy and Environmental Studies,
Princeton University,
Princeton, NJ 08544–5263
HAROLD FEIVESON
Center for Energy and Environmental Studies,
Princeton University

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Eos Meeting

Eliot Marshall (News & Comment, 16 June, p. 128) describes our first Earth Observing System (Eos) meeting as an "inquisition." Was I perhaps at some other meeting?

In response to an Eos Announcement of Opportunity sent around the world, NASA received hundreds of proposals from interested scientists in all fields of earth science who want to play a major role in this mission. About 150 investigators were selected this past February. In March, we held our first "all hands" meeting at the Goddard Space Flight Center for the selected scientists to meet one another and exchange ideas for a few days, since they will be sharing data

with one another for the next two decades. About 500 scientists and their collaborators attended; the numbers were limited only by the size of our largest auditorium. I had numerous calls from attendees praising the favorable climate for freedom of expression and the openness of questioning.

Marshall focuses on some minor remarks about the need for support for graduate students in competition with funds for "satellite building." This need is not really in dispute. One needs to consider the complexities of the scientific issues and the ambitious step forward that is Eos. Of course training the next generation of students is important. In NASA we have recognized the need for new talent and advancing beyond the hardware issues that we do understand. We must now address the problems of understanding the earth as a planetary body if we are going to learn to predict this changing system. The primary goal of Eos is directed toward understanding the earth on the global scale; the data, not the hardware, are the hallmark of Eos.

Marshall does not report the key role in Eos to be played by the 28 interdisciplinary investigator teams that were selected for Eos. The interdisciplinary investigators have specifically been brought into Eos early, long before any hardware is built or flown, to aid in the scientific direction of Eos and to see that the unprecedented flow of Eos data will indeed become scientific information to be placed at the service, ultimately, of mankind. The interdisciplinary scientists will guide the development of the data and information system. They are expected to use all the data from the Eos instruments and to publish their results in the open literature. Their work is to lead to the development or improvement of theoretical models that will shed further light on the earth as a system. Eos interdisciplinary scientists come from a multitude of universities and national research organizations from around the western world.

All of us have come to recognize the urgency and importance of earth science in the next century, and we have little time for distraction. All of the ideas reported by Marshall are good: James Hansen's, Dixon Butler's, Francis Bretherton's, and those of the 500 who attended this meeting and the thousands who will use the Eos data. Our problem is sorting and establishing the priorities, finding out the missing pieces of the puzzle, deciding those we can afford, and encouraging participation by partners nationally and internationally who can help and contribute.

What did the meeting produce? More scientific insight, organization into scientific teams, and plans for developing our scientific strategy.

In the next century the nations of the world will depend on understanding this unique and fragile planet on which we live.

GERALD A. SOFFEN
Goddard Space Flight Center, Greenbelt, MD 20771

Rabies Vaccine Trials

Marjorie Sun's articles (News & Comment, 30 June, p. 1535; 14 July, p. 126) report on the proposal of the Wistar Institute to conduct trials on South Carolina and Virginia islands of a new vaccine to orally immunize wildlife against rabies.

Although Wistar's approaches to the health authorities in South Carolina and Virginia were not significantly different, the resulting decisions of the health officials from the two states are in sharp contrast. In his letter of 5 July 1989 announcing that he had approved the proposed trial on Parramore Island, Virginia State Health Commissioner C. M. G. Buttery stated, "Virginia is proud to be a part of this first important step toward controlling wildlife rabies." The letter of 31 March 1989 of South Carolina

Health Commissioner M. D. Jarrett stated "We do not believe that the health and environment of the citizens of South Carolina can be assured if these trials are conducted. Therefore, we cannot allow these proposed field trials to proceed." Whereas Virginia health authorities were satisfied that the risks, if any, of conducting the proposed trial were minimal and acceptable with respect to the potential benefits resulting from the trial, South Carolina health authorities asked for absolute assurance that such risks did not exist.

Another issue which arose in both states is whether the relevant parties in each state would be adequately protected by means of indemnification and an insurance policy provided by Rhône-Mérieux, the manufacturer of the vaccine, against monetary judgments resulting from suits brought by third parties. Contrary to the remark attributed to a South Carolina health official, such insurance has been in place for over a year, is current, and has never lapsed. Although Virginia health officials were satisfied by the indemnification and insurance provided by Rhône-Mérieux, the owner of Parramore Island in Virginia is a private group, the Nature Conservancy, which must also grant its approval for use of the island for the vaccine trial.

In a sense, the existence of such wide divergences among state health authorities may be a blessing for organizations wishing to test novel biological materials and who must obtain approval at the state and the federal level. A major element of the local decision process is a reading by state officials of the local political scene. The result of this reading may override any judgment by state health officials based solely on scientific considerations. In selecting sites for field trials, scientists must also be acutely aware of the local political scene and not base their choice of sites on scientific considerations alone.

WARREN CHESTON
Associate Director, The Wistar Institute, Thirty-Sixth Street at Spruce, Philadelphia, PA 19104–4268

Mirror, Mirror . . .

No wonder women need new sources of support in the sciences, when we are referred to as members of the "fair sex" in as august a publication as *Science* (News & Comment, 14 July, p. 126).

SUSAN J. KOHLER
Department of Medicine, Harvard Medical School, Boston, MA 02115

NANCY H. KOLODNY
Department of Chemistry, Wellesley College, Wellesley, MA 02181

I was surprised by Constance Holden's arch reference to women as "the fair sex" in her article "New support for women scientists." It is unfortunate that an article that was intended to encourage women should instead reinforce the use of such patronizing language.

ALICE WEAVER FLAHERTY
Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139

Response: The phrase was a modest attempt to spoof stereotypes. Obviously, it misfired.—CONSTANCE HOLDEN

Erratum: In Eliot Marshall's News & Comment article "Clean air?" Don't hold your breath" (5 May, p. 517), Bernard D. Goldstein's affiliation was incomplete. Dr. Goldstein is a professor at the University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School and director of the Environmental and Occupational Health Science Institute, a joint program of Rutgers University and UMDNJ–Robert Wood Johnson Medical School.

Erratum: In the report "The reservoir for HIV-1 in human peripheral blood is a T cell that maintains expression of CD4" by S. M. Schnittman *et al.* (21 July, p. 305), reference 10 on page 308 should have read, "K. Clouse *et al.*, *J. Immunol.* 142, 431 (1989)."