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SCIENCE

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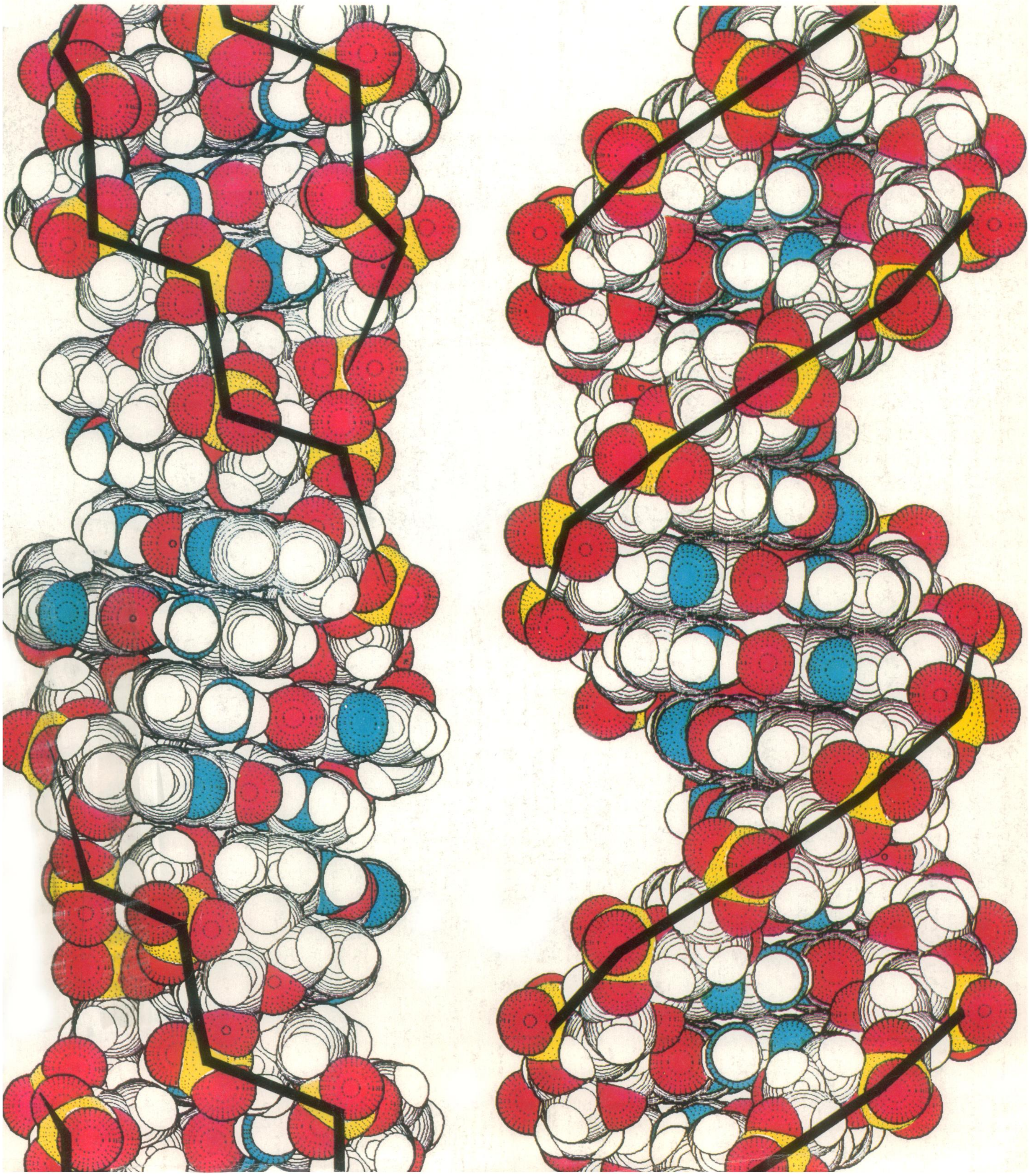

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COVER

Left-handed (left) and right-handed (right) double helical DNA. The superimposed heavy black line goes from phosphate to phosphate and traces the polynucleotide backbone. In right-handed DNA the backbone is a continuous right-handed helix; in left-handed DNA it follows a zigzag course. In these computer-generated diagrams, the phosphorous is yellow, nitrogen blue, oxygen red, and hydrogen uncolored. See page 171. [Computer graphics program developed by Gary J. Quigley, Department of Biology, Massachusetts Institute of Technology]

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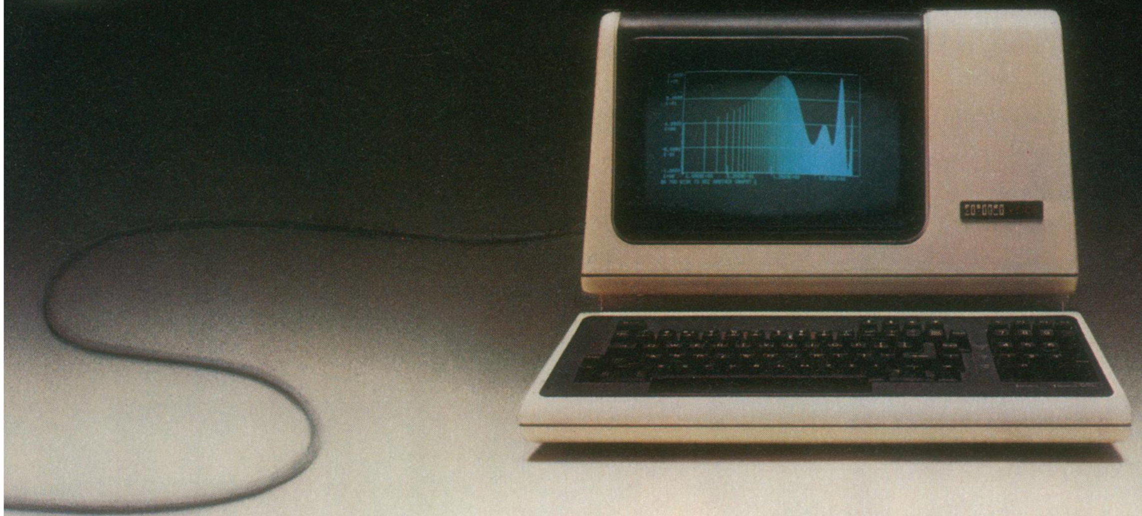

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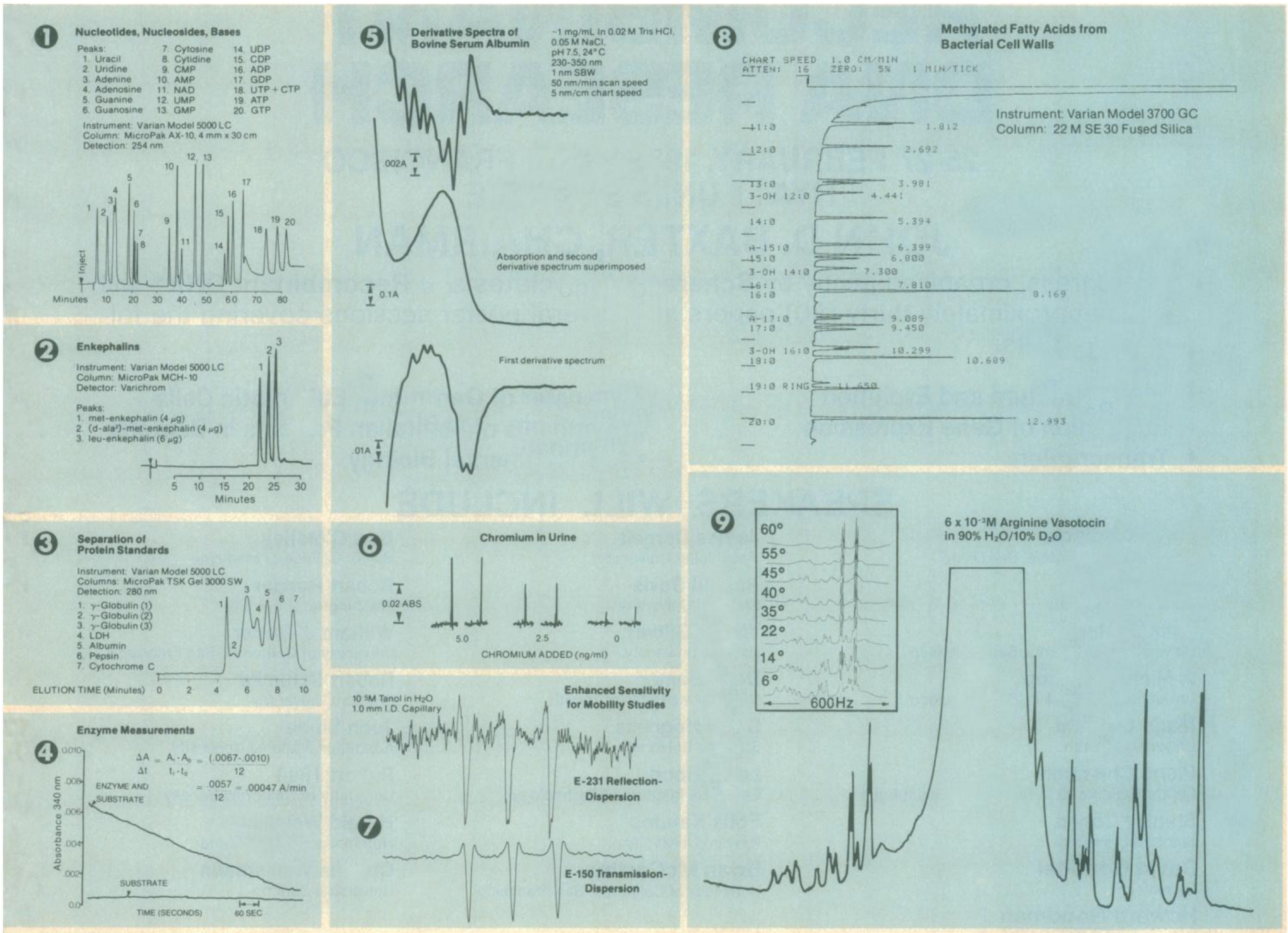

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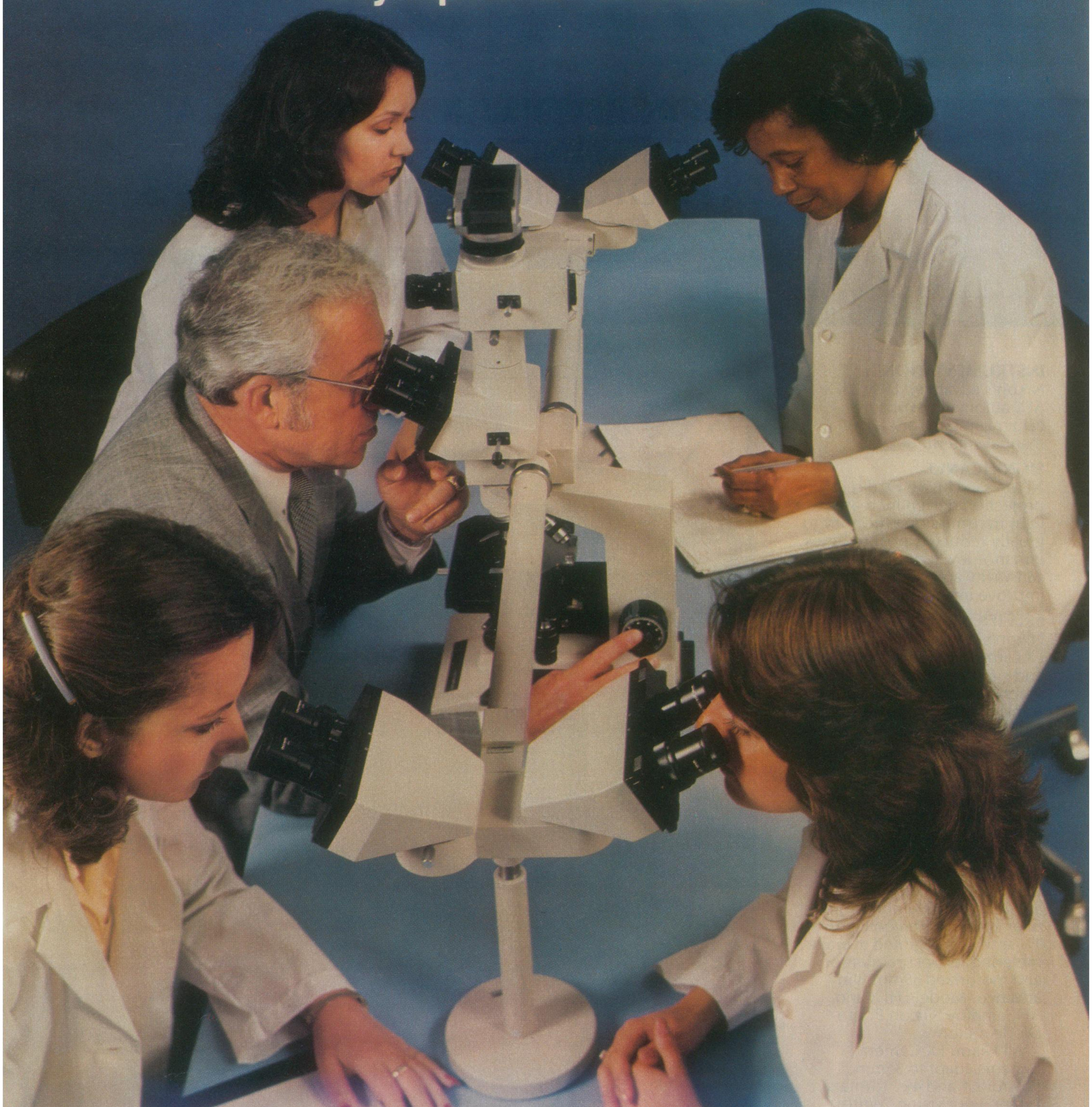

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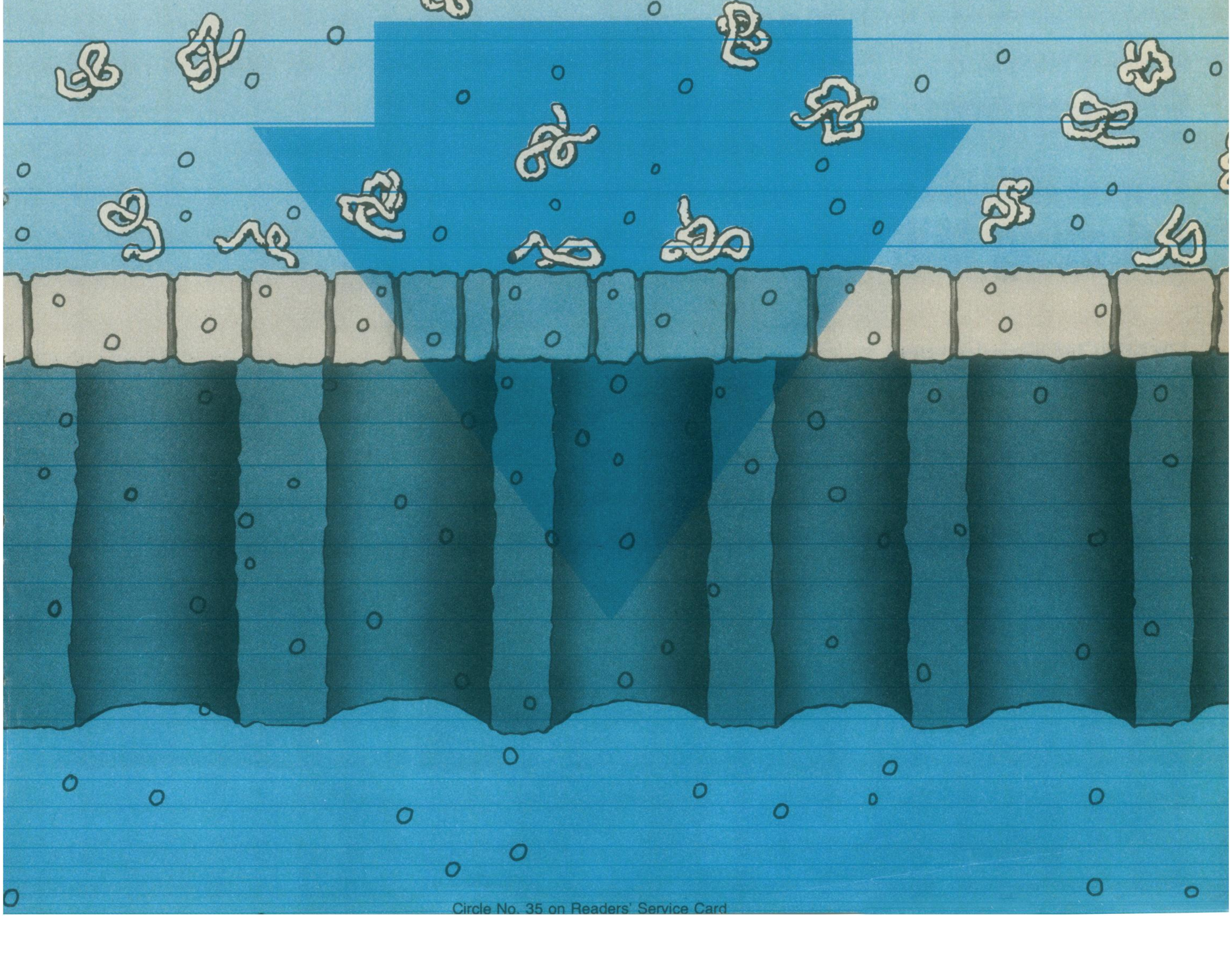

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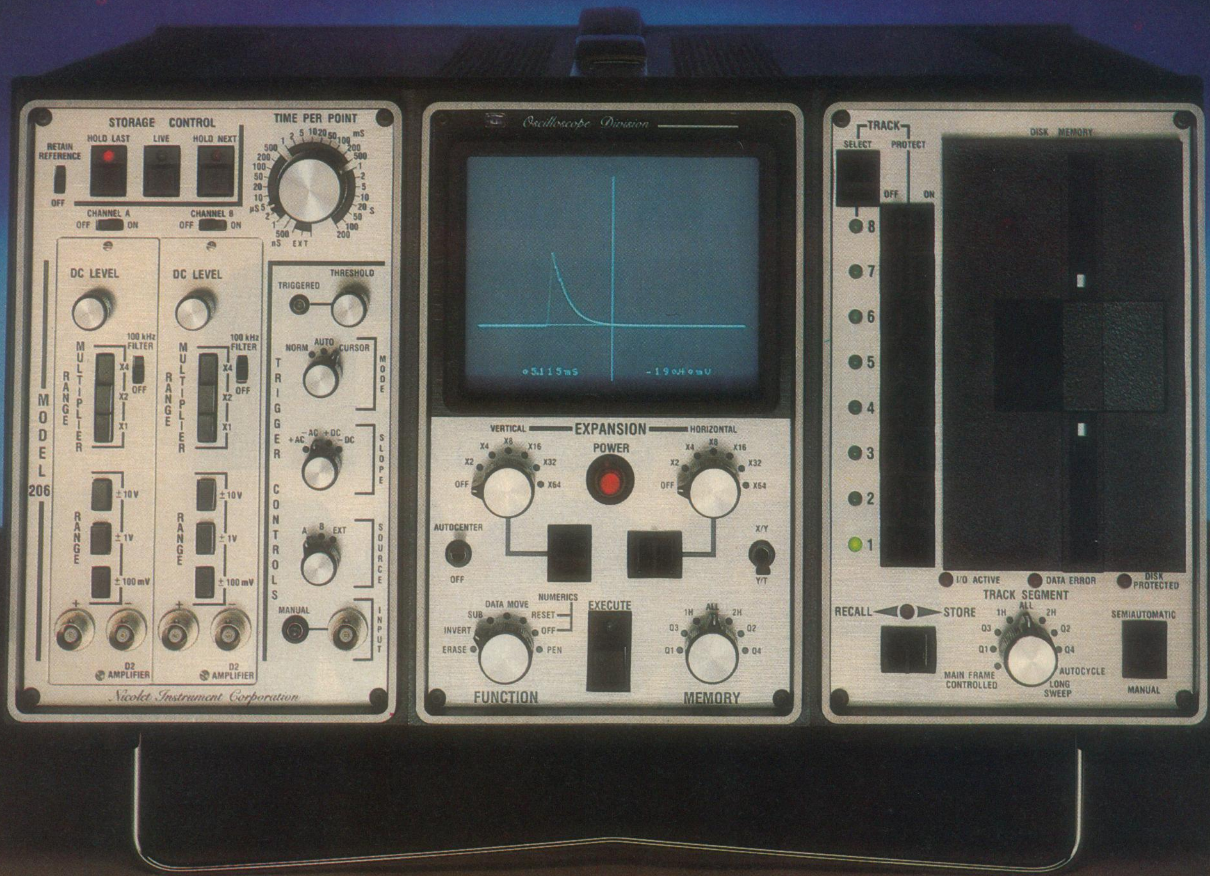

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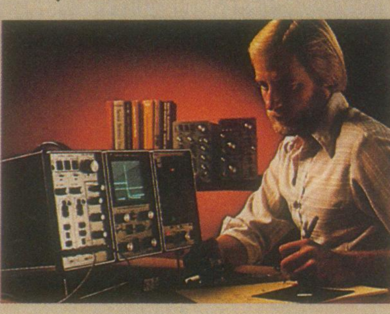

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Superconducting Magnets

The article "Magnet failures imperil new accelerator" by William J. Broad (News and Comment, 21 Nov. 1980, p. 875) deals with the Isabelle project at Brookhaven, a cornerstone of the national program in high energy physics. Unfortunately the article contains many misleading statements and errors. The author did not visit Brookhaven, relying instead on phone calls and reports, nor did he refer any part of his article back to the laboratory for checking of facts. In a matter as complex and important as this, more careful procedures might have been in order.

I limit my comments to the parts of the article directly involving Brookhaven. In summary, it is true that getting the Isabelle superconducting magnets ready for production has presented us with serious and unanticipated difficulties and that we have had to mount strenuous efforts to overcome them. These efforts are very much still in progress. However, it is simply not true that, as asserted in the article, the Isabelle project is "teetering on the brink of a technological failure."

The article describes inaccurately the history of magnet development at Brookhaven and casts discredit unfairly on the many able people involved. Most important it denies the progress that has occurred since the magnets with Westinghouse coils were tested nearly a year ago. As a result of this progress we expect to be able to use magnets of the present basic design in Isabelle. Such use will entail some delay, and it is possible that it will require a reduction in the peak energy by as much as 10 percent. The article is wrong in asserting that these magnets could only be used up to 300 GeV, a 25 percent reduction in energy. At its last meeting in Washington (9–12 November), the High Energy Physics Advisory Panel, an independent group of distinguished scientists, reviewed the project and went on record with the conclusion that a reduction of 10 percent in energy would be acceptable because it would not significantly impair the capability of the machine to do its job.

The article states (on no authority) that the production of magnets could fall 3 to 4 years behind if a different magnet design is selected. A different design is the most extreme option, and we estimate that would involve a delay of 2 years.

The article refers repeatedly to "little model magnets" and leaves the clear impression that the Isabelle project was launched after only very small model magnets had been built. This is a damaging assertion, and it is simply wrong. The size was increased by only about 10 percent in going from the Mark series of magnets, started in 1975, to the Isabelle design.

In discussing the Westinghouse magnets, the article says, "In addition, tests showed that the quality of the magnetic field was not suitable for use in a particle accelerator." In fact, it is well known that these magnets were meant to explore industrial production and the systematics of training and were never designed to have ultimate field qualities. The contract with Westinghouse was not canceled, as stated in the article, but *extended* from 6 magnets to 12.

The article states that "under federal pressure, Brookhaven officials this spring called together a ten-person panel of scientists and engineers not directly connected with the Isabelle project to evaluate the magnet problems." The fact is that the panel consisted of five persons; it was set up by the Project Head, James Sanford, in the summer of 1979; and it made its first report to him in November 1979. Sanford again activated the panel in the summer of 1980, asking, as a precaution, for specific evaluation of alternative magnet designs for Isabelle. The panel was not created because of federal pressure but because of decisions made entirely within the laboratory.

The article states, "In October 1978, just days after the start of the fiscal year, ground for Isabelle was broken." The implication is of reckless haste to get on with the project. In fact, Congress had authorized and appropriated $5 million in the preceding fiscal year for the start of the project. Hence groundbreaking took place about 1 year after the initiatory congressional action.

The article avoids mentioning the many other aspects of this very large project, all of which are proceeding well. At this time there are no other major critical technical problems. In any state-of-the-art endeavor on the scale of Isabelle, unforeseen technical problems will arise; we expected this and are prepared to tackle them.

Although superconducting magnets for Isabelle are a problem, there is no reason to believe they are an "intractable problem." Successful superconducting magnets have been made at Brookhaven, at Fermilab, in Europe, and in Japan. We are pushing the state of the art, but that is appropriate for scientific projects and will allow us to achieve better performance and lower cost than if only well-understood and demonstrated technologies were employed.

Moreover the advancement of superconducting magnets will benefit numerous areas of technology outside of high energy physics. The approach we used was a responsible one, as completion of the machine will show.

G. H. VINEYARD
Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York 11973

I have no detailed knowledge of the Isabelle or ESCAR projects, but statements made by William J. Broad concerning Fermilab are misleading.

Broad misrepresents the record of the Fermilab R & D program when he says that we built 130 superconducting magnets that were not "acceptable for use" in our accelerator and that "many went up in smoke." We indeed constructed about 100 full-scale superconducting magnets as part of an R & D program to learn how to mass produce these 7-meter-long, precision-wound devices. We started and aborted an additional 60 magnets in the various phases of uncovering and solving technical problems. Four magnets were deliberately tested to destruction in order to provide crucial data for the final design. It is appropriate to note that the Fermilab magnets differ from Isabelle magnets in several important design parameters because of the differences in injection energy and final field strength.

Our R & D program was obviously successful. Fermilab is now well underway in the construction of the Energy Saver Accelerator. We have assembled more than 250 magnets and measured their properties at room temperature; more than 95 percent have passed rigid tests for accelerator-grade magnetic field quality. More than 60 of these magnets have been assembled in cryostats, cooled to the superconducting state, and have undergone a rigorous set of mechanical and thermal tortures followed by more precise measurements of field strength and quality. We have conducted successful tests of strings of magnets—20 in an above-ground test facility and two strings of 40 magnets in the accelerator tunnel. More than 90 of the original R & D magnets are in use or scheduled for use in beam lines where the acceptance criteria are less rigid. Many of the incomplete magnets provide a stockpile of salvageable parts.

All of the above are ascertainable facts. Broad did not contact anyone at Fermilab about these issues.

It is certainly true that superconducting accelerator magnet technology has proved to be enormously difficult. Indeed, the Fermilab approach to R & D through extensive production (devised by R. R. Wilson) was successful in permitting solutions to be found to a myriad of difficult and unanticipated technical problems—solutions which were compatible with mass production techniques. This is the essential reason why R & D is needed. As Broad states, the superconducting accelerator program is at the edge of novel technology, and we still face formidable obstacles such as the assembly, commissioning, and operation of very large cryogenic systems and of 4 miles of superconducting magnets carrying intense beams of high energy particles. The risks are high, but the scientific payoff is enormous.

The combined experience gained at Fermilab and Isabelle will provide the nation with a heritage of mastered superconducting magnet technology. This is one area where we are comfortably ahead of the Soviet Union, Western Europe, and Japan. The knowledge obtained in the accelerator laboratories has already played an important role (and will continue to do so) in a vast array of applications, not only to future generations of accelerators but also in fields as disparate as fusion, magnetohydrodynamics, motor generators, mass transportation, and power transmission. In this way the dedicated and anxiety-ridden labor of many scientists and engineers and the expenditure of large amounts of public funds will continue to pay off in large social as well as scientific benefits.

LEON M. LEDERMAN
Fermi National Accelerator Laboratory, Batavia, Illinois 60510

. . . a few matters of record, in the order Vineyard raises them. I did not deny progress, saying instead "peformance of the magnets is getting better." The Brookhaven panel itself urged a reduction to 300 GeV, calling such a move "sober and realistic." It also estimated that a new design could entail a 3-year delay, which added to the current 1-year delay comes to 4 years. The Westinghouse magnets were indeed meant for use in Isabelle, being called the "000" series (001, 002, and so forth), so that all 732 dipole magnets could be counted. It is true that the Brookhaven panel initially had five members, but for its second report (the only one I referred to) the panel had ten members. Lederman omits to mention that the field strength Fermilab is aiming for is not the 5 tesla needed for Isabelle but 4.3 tesla, a strength even the Isabelle Mark 5 surpassed in 1976.—WILLIAM J. BROAD

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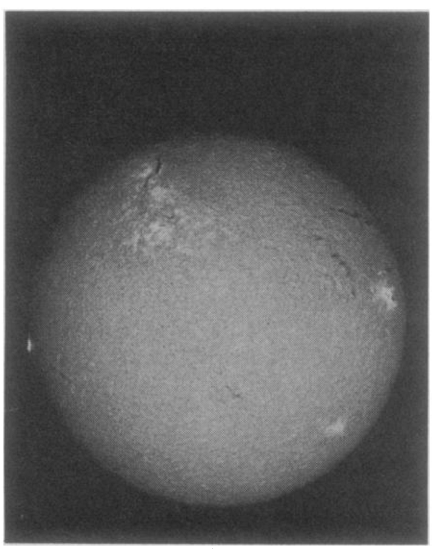
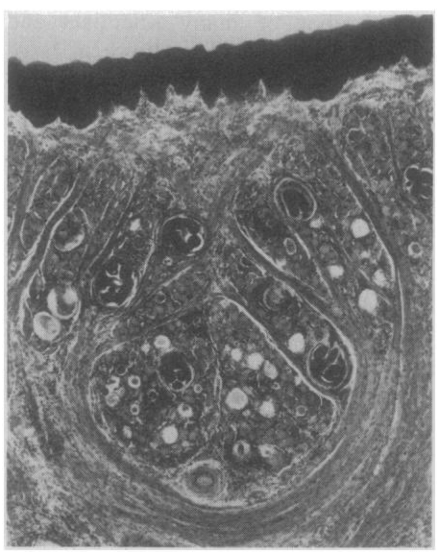
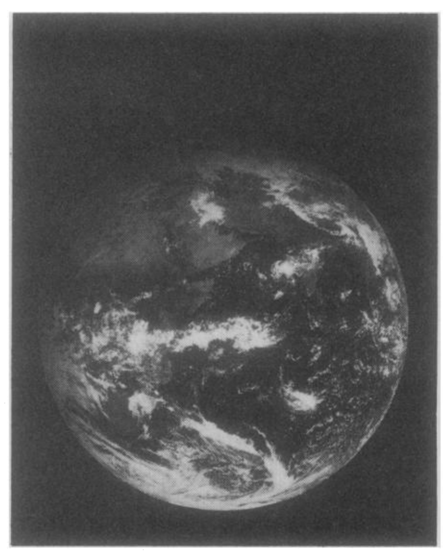


Hydrogen-alpha photograph of solar flares. Sacramento Peak Observatory, Sunspot, N.M.



Photomicrograph of *trichinella spiralis* in muscle, 175×. Tungsten-halogen source (3200 K) with KODAK WRATTEN Filter No. 58.



Meteorological imagery from geostationary satellite. VIZIR laser-beam recording by Société Européenne de Propulsion (France).

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9 January 1981, Volume 211, Number 4478

SCIENCE

Shortages of Scientists and Engineers

For the next decade this nation will have great needs for scientists and engineers. Already there are shortages in such fields as petroleum and chemical engineering and computer science. The shortages are likely to spread to other fields and to worsen. Faculty members are being recruited by industry, and fewer students are seeking the Ph.D. degree in some disciplines.

There is a particularly acute shortage in computer science. Advances in electronics have made computation and memory comparatively cheap. Many companies perceive attractive opportunities to apply the new hardware. These applications require development of systems of software by computer scientists. Eager bidding for computer scientists has pushed salaries to $30,000 per year for students at the baccalaureate level.

We are also experiencing an expanding need for scientists and engineers brought on by the decreasing availability of oil and by its higher price. Merely to maintain our limited production rate of petroleum will require employment of more experts for planning exploitation of the new wells and for tertiary recovery. Research, development, and engineering entailed in synthetic fuel plants will employ an even larger number of trained people.

As prices for energy escalate, most of the nation's existing processes, equipment, plants, and buildings are becoming obsolete. As prices for oil go even higher, there will be great incentives for research, development, and design and construction of new facilities. In the chemical industry, the need to minimize the hazards of toxic substances is also leading to major efforts involving highly trained personnel, including toxicologists.

The United States has lagged in achieving standards of quality control. The Japanese, who have been exemplary in this regard, employ a much higher ratio of engineers to blue-collar workers than do we. To identify and correct the factors that lead to manufacturing defects often requires unusual skill and ingenuity. Restoration of the reputation of American products will demand the deployment of more scientists and engineers in production facilities.

There will be other major demands for trained personnel. This country has lost its lead in many areas of technology. Who is to innovate? Who will create and develop alternative energy sources? The world will face terrible shortages of food, and we will need to change our style of agriculture to slow soil erosion. Who will develop more productive and pest-resistant plants? Who will exploit the opportunities of the revolution in biology based on recombinant DNA?

The universities, traditionally a source of new knowledge and trained people, will try very hard to fulfill their function. However, they are in relatively poor shape to do so. In most schools, equipment for training and research is antiquated or absent. Opportunities for young faculty members have become limited. At the public universities, state funds for support of research and teaching have diminished. Flexibility in the use of funds has been curtailed. The gross total of federal research funds in constant dollars has remained about the same. But federal intervention in universities has entailed substantial costs. For this and other reasons, the net sums actually available for research in universities have declined substantially.

One of the few bright spots in the situation is an improving relationship between industry and the universities. Leaders of industrial research are enthusiastic about the quality of the young people they are hiring. An increasing number of companies are supporting fellowships and research at the schools. They could and should do more. They could serve their long-term interests by helping to improve the level of equipment for teaching and research. They should be more emphatic in expressing their admiration for the training that young people are receiving. They should be prepared to intervene if federal budget cutters should propose to deal another blow to universities by chopping federal research funds.—PHILIP H. ABELSON

Information for Contributors

The Editors of *Science*

Papers published in *Science* often receive far more attention than papers published in specialty journals. As a consequence, the rate of submission of papers is high—about 5000 manuscripts are submitted each year. The rejection rate of about 80 percent contrasts with that of most specialty journals, which is usually about 30 percent. Most of the material submitted to *Science* is of good quality and worthy of publication, and virtually all the scientific papers are eventually published somewhere. In selecting papers for *Science*, the editors must consider the needs of a broad audience. Insofar as the input of manuscript permits, preference is given to items that seem to be of general significance.

General Information

Four types of signed papers are considered: Articles, Reports, Letters, and Technical Comments. The author's membership in the AAAS is not a factor in selection. Papers are considered with the understanding that they have not been published and are not under consideration elsewhere. Authors will usually be notified of acceptance, rejection, or need for revision in 6 to 8 weeks (Reports) or 8 to 10 weeks (Articles).

Outside reviews. Almost all Articles and Reports, including those solicited by the editor, are sent to two or more outside referees for evaluation. Referees suggested by authors are used at the discretion of the editors. Papers that depend on statistical inferences for their conclusions may be sent to statisticians (in addition to other referees) for review.

Length limits. Papers that exceed the length limits cannot be handled expeditiously and in some cases will be returned without review. The limits are stated below in number of pages based on standard-size pages ($8^1/_2$ by 11 inches) typed with double spacing throughout (including the references and notes) and with 1-inch margins.

1) Articles: Up to 20 pages of text, including the references and notes, and one table or figure for approximately every three manuscript pages.

2) Reports: Up to seven pages of text, including references and notes, and two tables or figures that together will occupy no more than half a printed page.

3) Letters: Up to 250 words.

4) Technical Comments: Up to two pages of text, including references and notes.

Selection of Manuscripts

1) Articles: About half the Articles published in *Science* are solicited by the editor. Both solicited and unsolicited Articles undergo outside and in-house review. Articles are expected to (i) provide a review of new developments in one field that will be of interest to readers in other fields, (ii) describe a current research problem or a technique of interdisciplinary significance, or (iii) present a study of some aspect of the history, logic, philosophy, or administration of science or a discussion of science and public affairs. Readers should be able to learn from a technical Article what has been firmly established and what are significant unresolved questions; speculation should be kept to a minimum. Preference is given to Articles that are well written, well organized, and within the length limit. Balance of subject matter in *Science* is an important consideration when a choice is made between acceptable Articles.

2) Reports: Reports are selected on the basis of reviewers' comments and an in-house review. Reports are expected to contain solid research results or reliable theoretical calculations. Preference is given to those that describe departures or discoveries that will be of broad interdisciplinary interest or of unusual interest to the specialist. In making the final selection, the editors take into consideration (i) the reviewers' comments: reports most likely to be accepted are those that receive persuasive outside reviews favoring publication; (ii) clarity of presentation within the prescribed length limit; and (iii) subject matter in relation to that of other papers on hand. An attempt is made to balance the subjects of Reports so that one discipline is not overrepresented to the exclusion of others.

3) Letters: Letters are selected for their pertinence to material published in *Science* or because they discuss significant problems of interest to most scientists. Letters of a highly technical nature are usually transferred to the Technical Comments section. Letters pertaining to material published in *Science* may correct errors, provide support or agreement, offer different points of view, clarify, or add information. Outside reviewers may be consulted on questions of accuracy. Insinuations and conjecture about another author's motives, abilities, or intelligence are considered inappropriate for publication. The selection of letters is intended to reflect the range of opinions received.

4) Technical Comments: Technical Comments may be selected for publication if they express significant criticisms of papers published in *Science* or offer useful additional information. Technical Comments are usually sent for an opinion to the authors of the original papers before being reviewed. Discussions of minor issues or priority claims are not deemed appropriate, nor are questions that can be resolved by correspondence between the critic and the original authors.

5) Book Reviews: The selection of books to be reviewed and of reviewers is made by the editors.

Submission of Manuscripts

Submit an original and two duplicates of each manuscript together with a letter of transmittal giving:

1) the name(s) and telephone number(s) of the author(s);

2) the title of the paper and a statement of its main point;

3) the names, addresses, telephone numbers, and fields of interest of four to six persons in North America but outside your institution who are qualified to referee your paper;

4) the names of colleagues who have reviewed your paper; and

5) the fields of interest of readers who may want to read your paper.

Manuscript Preparation

Typing. Use double spacing throughout the text, tables, figure legends, and references and notes.

Units of measure. Use metric units. If measurements were made in English units, give metric equivalents.

Symbols and abbreviations. Define all symbols, abbreviations, and acronyms.

References and notes. Number references and notes in the order in which they are cited in the text. Place references cited only in tables or figure legends after the text references. Gather all acknowledgments into a single, brief statement at the end. Use *Bibliographic Guide for Editors & Authors* (American Chemical Society, Washington, D.C.) for abbreviations of journal titles. For journals not listed there provide the full title. Use the following forms:

For a journal paper: H. Smith, *Am. J. Physiol.* **98**, 279 (1931).

For a book: F. Dachille and R. Roy, *Modern Very High Pressure Techniques* (Butterworth, London, 1961), pp. 163-180.

For a paper in a compilation: F. Dachille and R. Roy, in *Reactivity of Solids*, J. H. de Boer, Ed. (Elsevier, Amsterdam, 1960), p. 502.

For unpublished material: A. Giraud, paper presented at the American Nuclear Society Conference, Washington, D.C., November 1976.

Illustrations. For each illustration submit three copies of a quality suitable for reproduction. Label each on the back with the name of the author and the figure number. Plan figures for the smallest printed size consistent with clarity. Color may be used if necessary but authors are billed accordingly. Cite all illustrations in the text and provide a brief legend for each.

Tables. Type each table on a separate sheet, give it a number and title, and cite it by number in the text. Give each column a heading. Indicate units of measure in parentheses in the heading for each column, and do not change the unit of measure within a column.

Equations and formulas. Use quadruple spacing around equations and formulas that are to be set off from the text. Define all symbols.

Special Requirements and Procedures

1) Articles: Provide a title of one or two lines of not more than 26 characters and spaces each; a brief author note giving your position and address; and a summary of 50 to 100 words. The summary should convey to the general reader the main point of the paper and outline the results or conclusions. The introduction should portray the broad significance of the work, and the whole text should be intelligible to scientists in different disciplines. Explain all technical terms likely to be known in only one field. Insert short subheadings at appropriate places in the text to mark your main ideas. Provide a reference list in accord with *Science* style. Reference lists should not be exhaustive; citation of a single review article can often replace many references. A maximum of 40 references is suggested.

2) Reports: Provide a title of one or two lines of not more than 54 characters and spaces each, and an abstract of 50 to 75 words. The abstract and the first portion of the report should portray for the general reader the results described and their significance. The body of the report should be intelligible to scientists in other fields of expertise. Complete documentation need not be presented but should be available in cited references.

3) Letters: Letters should be short (up to 250 words) and to the point; they should be carefully phrased, free of technical jargon, and nonrepetitive. When a Letter refers to an Article published in *Science* the original author is usually given an opportunity to reply. Letters are frequently shortened and edited. Letters are acknowledged by postcard; authors are notified if their letters are accepted for publication. Letters must be typed with double spacing.

4) Technical Comments: Technical Comments on Reports or Articles are published at the end of the Reports section. When a Technical Comment is accepted for publication the authors of the original paper are usually given an opportunity to reply.

5) Book Reviews: Instructions accompany review copies when they are sent to reviewers.

Printing and Publication

Editing. Before being sent to the printers, papers are edited to improve accuracy and effectiveness of communication. When changes are needed because the author's meaning is not clear, the editor may consult the author by telephone; when the editing is extensive, the manuscript may be returned to the author for approval or further adjustment before the type is set.

Proofs. One set of galley proofs is provided for each paper. Alterations should be kept to a minimum and marked only on the proofs. Extensive alterations may delay publication.

Scheduling. Papers are not scheduled for publication until *Science* has received corrected galley proofs from the authors. The median delay between acceptance of papers and mailing of galley proofs to authors is 4 to 8 weeks (allowing for editing and typesetting); the median delay between receipt of authors' galley proofs by *Science* and publication is 4 to 6 weeks (allowing for proofreading, layout, and paging). There may be additional delays in publication for papers with tables or figures that present problems in layout and for papers accompanying cover pictures.

Reprints. An order blank for reprints accompanies proofs.

Cover Photographs

Particularly good photographs that pertain to a paper being submitted will be considered for use on the cover. Submit prints (*not* slides, negatives, or transparencies) together with the manuscript, and indicate in the letter of transmittal that a possible cover picture is enclosed.