

987 This Week in *Science*

## Editorial

989 Scientific Competency Through Fun

## Letters

991 Fenfluramine Studies: M. DEROME-TREMBLAY AND C. NATHAN ■ Climatic Change and Forests: C. S. BINKLEY ■ Financial Benefit from Research: D. K. GRAYSON ■ Narrow Corridors Stop Falling Soda Machines: C. K. OMOTO ■ Broad Training for Social Scientists: J. H. BARKOW ■ Cost of Electricity: A. A. BARTLETT

## News & Comment

999 Landsats: Drifting toward Oblivion?  
1000 Hospital Faulted on Dry Eye Study  
NIH Probes Researcher's Fundraising  
1001 CBO Lists Options for Cutting R&D  
Fertile Ground for Arms Control  
Sakharov Declines to Run for Moscow Seat  
1002 Europe Tries to Untangle Laws on Patenting Life  
■ No Patent for Harvard's Mouse?  
Lederman to Leave Fermilab  
1004 A Global Supercomputer Race for High Stakes

## Research News

1007 Arctic Ozone Is Poised for a Fall  
1009 New Look at Turtle Migration Mystery  
1009 Lift-Off Laser: GaAs on Glass  
1010 Keck Telescope Mirror Is in Production  
1012 How DNA Viruses May Cause Cancer

## Articles

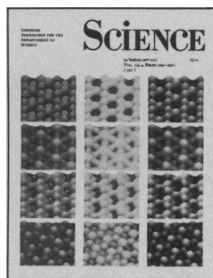
1017 Combining Cognitive and Statistical Approaches to Survey Design:  
S. E. FIENBERG AND J. M. TANUR  
1023 Polymers, Fractals, and Ceramic Materials: D. W. SCHAEFER  
1027 Genetic Control of Differentiation of the *Caenorhabditis elegans* Touch Receptor  
Neurons: M. CHALFIE AND M. AU

## Research Articles

1033 Reverse Transcriptase in a Clinical Strain of *Escherichia coli*: Production of  
Branched RNA-Linked msDNA: B. C. LAMPSON, J. SUN, M.-Y. HSU,  
J. VALLEJO-RAMIREZ, S. INOUE, M. INOUE

■ **SCIENCE** is published weekly on Friday, except the last week in December, and with an extra issue in February by the American Association for the Advancement of Science, 1333 H Street, NW, Washington, DC 20005. Second-class postage (publication No. 484460) paid at Washington, DC, and at an additional entry. Now combined with **The Scientific Monthly**® Copyright © 1989 by the American Association for the Advancement of Science. The title **SCIENCE** is a registered trademark of the AAAS. Domestic individual membership and subscription (51 issues): \$70. Domestic institutional subscription (51 issues): \$110. Foreign postage extra: Canada \$32, other (surface mail) \$32, air-surface via Amsterdam \$85. First class, airmail, school-year, and student rates on request. **Single copy sales:** Current issue, \$3.50; back issues, \$5.00; Biotechnology issue, \$6.00 (for postage and handling, add per copy \$0.50 U.S., \$1.00 all foreign); Guide to Biotechnology Products and Instruments, \$18 (for postage and handling add per copy \$1.00 U.S., \$1.50 Canada, \$2.00 other foreign). Bulk rates on request. **Change of address:** allow 6 weeks, giving old and new addresses and 11-digit account number. Authorization to photocopy material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by AAAS to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$1 per copy plus \$0.10 per page is paid directly to CCC, 21 Congress Street, Salem, Massachusetts 01970. The identification code for *Science* is 0036-8075/83 \$1 + .10. **Postmaster:** Send Form 3579 to *Science*, P.O. Box 1722, Riverton, NJ 08077. *Science* is indexed in the *Reader's Guide to Periodical Literature* and in several specialized indexes.

■ 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** Scanning tunneling microscope images (25 angstroms by 25 angstroms) of iodine atoms adsorbed on a platinum(III) substrate. Four structural geometries of the adsorbed iodine are presented (*top to bottom*), each displayed in three color schemes (*left to right*). The structures provide information about the iodine—platinum bonding forces. See page 1050. [B. C. Schardt *et al.*, Department of Chemistry, Purdue University, West Lafayette, IN 47907; color images photographed directly from the computer screen of a Nanoscope II tunneling microscope manufactured by Digital Instruments, Santa Barbara, CA]

## Reports

- 1043 Chemico-Viscous Remanent Magnetization in the  $\text{Fe}_3\text{O}_4\text{-}\gamma\text{Fe}_2\text{O}_3$  System: Ö. ÖZDEMİR AND D. J. DUNLOP
- 1047 Epitaxial Growth of Diamond Films on Si(111) at Room Temperature by Mass-Selected Low-Energy  $\text{C}^+$  Beams: J. L. ROBERTSON, S. C. MOSS, Y. LIFSHITZ, S. R. KASI, J. W. RABALAI, G. D. LEMPERT, E. RAPOPORT
- 1050 Atomic Resolution Imaging of Adsorbates on Metal Surfaces in Air: Iodine Adsorption on Pt(111): B. C. SCHARDT, S.-L. YAU, F. RINALDI
- 1053 Uranium-Series Dated Authigenic Carbonates and Archeulian Sites in Southern Egypt: B. J. SZABO, W. P. MCHUGH, G. G. SCHABER, C. V. HAYNES, JR., C. S. BREED
- 1056 Specific Recognition of Cruciform DNA by Nuclear Protein HMGI: M. E. BIANCHI, M. BELTRAME, G. PAONESSA
- 1059 A *Salmonella* Locus That Controls Resistance to Microbicidal Proteins from Phagocytic Cells: P. I. FIELDS, E. A. GROISMAN, F. HEFFRON
- 1062 Reciprocal Effects of Hyper- and Hypoactivity Mutations in the *Drosophila* Pattern Gene *torso*: T. R. STRECKER, S. R. HALSELL, W. W. FISHER, H. D. LIPSHITZ
- 1066 Macrophage Inflammatory Protein-1: A Prostaglandin-Independent Endogenous Pyrogen: G. DAVATELIS, S. D. WOLPE, B. SHERRY, J.-M. DAYER, R. CHICHEPORTICHE, A. CERAMI
- 1068 Block of Stretch-Activated Ion Channels in *Xenopus* Oocytes by Gadolinium and Calcium Ions: X.-C. YANG AND F. SACHS
- 1071 Neuroanatomical Correlates of Anticipatory Anxiety: E. M. REIMAN, M. J. FUSSELMAN, P. T. FOX, M. E. RAICHLER
- 1074 Structure and Function of Human Amphiregulin: A Member of the Epidermal Growth Factor Family: M. SHOYAB, G. D. PLOWMAN, V. L. McDONALD, J. G. BRADLEY, G. J. TODARO

## Book Reviews

- 1085 Beamtimes and Lifetimes, reviewed by S. E. COZZENS ■ Nucleus, J. S. WALKER ■ Divide and Prosper, M. WALKER ■ The War of Invention, J. H. MORROW, JR. ■ Books Received

## Products & Materials

- 1089 System for Probe Synthesis and Hybridization ■ Drawing Utility for Chemical On-Line Searches ■ Modular Environmentally Controlled Chamber ■ Columns for Amino Acid Analysis ■ Antibodies ■ Six-Vessel Culture System ■ Vibrating Microtome ■ Literature

### Board of Directors

Walter E. Massey  
*Retiring President,  
Chairman*

Richard C. Atkinson  
*President*

Donald N. Langenberg  
*President-elect*

Mary Ellen Avery  
Francisco J. Ayala  
Floyd E. Bloom  
Mary E. Clutter  
Eugene H. Cota-Robles  
Joseph G. Gavin, Jr.  
John H. Gibbons  
Beatrix A. Hamburg  
William T. Golden  
*Treasurer*

Philip H. Abelson  
*Executive Officer, Acting*

### Editorial Board

Elizabeth E. Bailey  
David Baltimore  
William F. Brinkman  
E. Margaret Burbidge  
Philip E. Converse  
Joseph L. Goldstein  
Mary L. Good  
F. Clark Howell  
James D. Idol, Jr.  
Leon Knopoff  
Oliver E. Nelson  
Helen M. Ranney  
David M. Raup  
Howard A. Schneiderman  
Larry L. Smarr  
Robert M. Solow  
James D. Watson

### Board of Reviewing Editors

John Abelson  
Qais Al-Awqati  
Don L. Anderson  
Stephen J. Benkovic  
Floyd E. Bloom  
Henry R. Bourne  
James J. Bull  
Kathryn Calame  
Charles R. Cantor  
Ralph J. Cicerone  
John M. Coffin  
Robert Dorfman  
Bruce F. Eldridge  
Paul T. Englund  
Fredric S. Fay  
Theodore H. Geballe

Roger I. M. Glass  
Stephen P. Goff  
Robert B. Goldberg  
Corey S. Goodman  
Jack Gorski  
Stephen J. Gould  
Richard M. Held  
Gloria Heppner  
Eric F. Johnson  
Konrad B. Krauskopf  
Charles S. Levings III  
Richard Losick  
Karl L. Magleby  
Philippa Marrack  
Joseph B. Martin  
John C. McGiff  
Mortimer Mishkin  
Gordon H. Orians  
Carl O. Pabo

Yeshayau Pocker  
Michael I. Posner  
Dennis A. Powers  
Russell Ross  
James E. Rothman  
Erkki Ruoslahti  
Ronald H. Schwartz  
Vernon L. Smith  
Robert T. N. Tjian  
Virginia Trimble  
Emil R. Unanue  
Geerat J. Vermeij  
Bert Vogelstein  
Harold Weintraub  
Irving L. Weissman  
George M. Whitesides  
Owen N. Witte  
William B. Wood

## American Association for the Advancement of Science

*Science* serves its readers as a forum for the presentation and discussion of important issues related to the advancement of science, including the presentation of minority or conflicting points of view, rather than by publishing only material on which a consensus has been reached. Accordingly, all articles published in *Science*—including editorials, news and comment, and book reviews—are signed and reflect the individual views of the authors and not official points of view adopted by the AAAS or the institutions with which the authors are affiliated.

**Publisher:** Philip H. Abelson, *Acting*

**Editor:** Daniel E. Koshland, Jr.

**Deputy Editor:** John I. Brauman (*Physical Sciences*)

## EDITORIAL STAFF

**Managing Editor:** Patricia A. Morgan

**Assistant Managing Editor:** Nancy J. Hartnagel

**Senior Editor:** Eleanore Butz

**Associate Editors:** Keith W. Brocklehurst, Martha Coleman, R. Brooks Hanson, Barbara Jasny, Katrina L. Kelner, Edith Meyers, Linda J. Miller, Phillip D. Szuroni, David F. Voss

**Letters Editor:** Christine Gilbert

**Book Reviews:** Katherine Livingston, *editor*

**This Week in Science:** Ruth Levy Guyer

**Contributing Editor:** Lawrence I. Grossman

**Chief Production Editor:** Ellen E. Murphy

**Editing Department:** Lois Schmitt, *head*; Mary McDaniel, Patricia L. Moe, Barbara E. Patterson

**Copy Desk:** Joi S. Granger, Jane Hurd, MaryBeth Shartle, Beverly Shields

**Production Manager:** Karen Schools Colson

**Assistant Production Manager:** James Landry

**Graphics and Production:** Holly Bishop, James J. Olivari, Yolanda M. Rook

**Covers Editor:** Grayce Finger

**Manuscript Systems Analyst:** William Carter

## NEWS STAFF

**News Editor:** Barbara J. Culliton

**Deputy News Editors:** Roger Lewin, Colin Norman

**News and Comment/Research News:** William Booth, Gregory Byrne, Mark H. Crawford, Constance Holden, Richard A. Kerr, Eliot Marshall, Jean L. Marx, Robert Pool, Leslie Roberts, Marjorie Sun, M. Mitchell Waldrop

**European Correspondent:** David Dickson

**Contributing Writer:** John Walsh

## BUSINESS STAFF

**Circulation Director:** John G. Colson

**Fulfillment Manager:** Ann Ragland

**Business Staff Manager:** Deborah Rivera-Wienhold

**Classified Advertising Supervisor:** Karen Morgenstern

**Guide to Biotechnology Products and Instruments:** Shauna S. Roberts

## ADVERTISING REPRESENTATIVES

**Director:** Earl J. Scherago

**Traffic Manager:** Donna Rivera

**Traffic Manager (Recruitment):** Gwen Canter

**Advertising Sales Manager:** Richard L. Charles

**Marketing Manager:** Herbert L. Burklund

**Employment Sales Manager:** Edward C. Keller

**Sales:** New York, NY 10036: J. Kevin Henebry, 1515 Broadway (212-730-1050); Scotch Plains, NJ 07076: C. Richard Callis, 12 Unami Lane (201-889-4873); Chicago, IL 60914: Jack Ryan, 525 W. Higgins Rd. (312-885-8675); San Jose, CA 95112: Bob Brindley, 310 S. 16th St. (408-998-4690); Dorset, VT 05251: Fred W. Dieffenbach, Kent Hill Rd. (802-867-5581); Damascus, MD 20872: Rick Sommer, 11318 Kings Valley Dr. (301-972-9270); U.K., Europe: Nick Jones, +44(0647)52918; Telex 42513; FAX (0647) 52053.

**Information for contributors** appears on page XI of the 23 December 1988 issue. Editorial correspondence, including requests for permission to reprint and reprint orders, should be sent to 1333 H Street, NW, Washington, DC 20005. Telephone: 202-326-6500.

Advertising correspondence should be sent to Tenth Floor, 1515 Broadway, New York, NY 10036. Telephone 212-730-1050 or WU Telex 968082 SCHERAGO, or FAX 212-382-3725.

## Scientific Competency Through Fun

Concern for the scientific education of the children of the United States is much in the news. Recent test scores of American children in comparison with those of their Japanese and European counterparts have created part of the alarm, and lower enrollments in science programs at college and graduate levels have added fuel to the fire. The argument that global competitiveness requires more scientists is being used to add pressure for expanded mathematics and science programs. But there should be a second reason for expansion: fairness, which requires that all children start out with an equal chance for a good education. Part of the reason for the low American test scores is that many schools are underfunded, and most of these are located in regions where the underprivileged and recently arrived immigrants tend to accumulate. Those are precisely the groups who most desperately need the education system to provide the basis for equality of opportunity.

Fortunately, producing an adequate supply of scientists and giving scientific literacy to the nonscientists can be accomplished by the same means—teaching excellent science to every child at the elementary school level. Expanding the base of the pyramid in this way will increase the number of students who emerge from their academic training as the scientists of the future. It will also provide vital background for those who never go on to scientific careers. Voters, judges, and insurance salesmen can have an understanding of the complexity of the scientific world, as well as the ability to operate the computers and sophisticated equipment that even the most menial jobs will require in the future.

If scientific competence is to be extended to all, then the teaching of mathematics in the elementary schools will have to be a fundamental target. Although mathematics may become a minor tool for many adults, even some in science, almost invariably scientists say they did well in mathematics in elementary school; those intimidated by science say, in disproportionate numbers, “I was never good at math.” The myth that mathematics must be difficult lends its study an element of Greek tragedy, in which catastrophic failure inevitably lurks somewhere down the road. It seems essential, therefore, that programs in elementary school mathematics be made to be fun and be taught in an atmosphere of leisure to remove the anxiety that is so often self-fulfilling. Gambling in elementary school may sound like the ultimate in degradation, but playing with cards and rolling dice can introduce principles of probability; flipping coins can be associated with Gaussian distribution; cutting through spheres and cones and squares can teach solid geometry on personal computer screens. A recent report of the National Academy of Sciences\* supports such programs and gives excellent advice on how to improve the teaching of science. Studies indicate that there are a higher number of men than women among computer enthusiasts, suggesting a possible bias of many early computer games, which tend to be oriented toward conventional male interests—war, sports strategy, and car races. So it appears that mathematics must be developed as fun before it can be required as an essential.

To those who argue that such programs would mean more time spent on mathematics than on other subjects, such as English, history, and social studies, the answer is, yes, because mathematics is different and intrinsically more difficult. This difficulty arises not necessarily because of higher conceptual challenges but because the skills of mathematics are cumulative. If one learns the history of Greece poorly, that has a minor effect on learning the history of Rome. But if one fails to understand fractions, the ability to complete more advanced calculation, such as algebra or trigonometry, is fatally impaired.

It is time to recognize that the smokestack industry, with its large manual labor force, is disappearing. To be fair to our youth who will not be scientists, and to provide a broader base for future personnel in science, we must develop excellent programs at the elementary level. This improvement requires more money for schools, better salaries for teachers, and more demanding curricula. But all of that may not help unless there are imaginative changes in instruction that will make science fun and build confidence while helping students to a real understanding of scientific approaches. We have tried money without imagination, and it has failed. We have provided imagination without money, and it has failed. Perhaps this time, by analyzing the problem deeply, we can provide both ingredients simultaneously. It might be fair, effective, and fun all at the same time.—DANIEL E. KOSHLAND, JR.

\*National Research Council, *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (National Academy Press, Washington, DC, 1989).