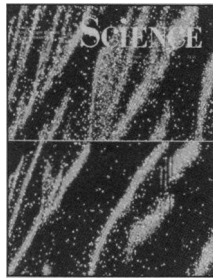


	7	This Week in <i>Science</i>
Editorial	9	Sensors, Computers, and Actuators
Letters	10	The Overhead Question: P. E. GRAY; S. C. BEERING AND R. M. ROSENZWEIG; R. BARKER; R. ELDRIDGE; A. E. SEIGMAN; J. J. ALEO; J. M. SCHURR; P. D. BOYER; R. SEEBASS; D. E. KOSHLAND, JR.
News & Comment	14	Science Beyond the Pale
	17	Researchers Declare Crisis, Seek Funding Solutions ■ Planning a Budget: In God We Trust?
	18	Multidisciplinary Look at a Finite World
	20	<i>Briefings</i> : AID Aids AIDS Efforts with New Syringes ■ Director Contenders Just Say No to NIH ■ How to Save Endangered Species ■ Primate Find Surprises Biologists ■ Three Mile Island "Turns Around" ■ Weed Genes ■ English Physics Hits the Fat Farm ■ The NASA Vegematic ■ Advanced Photons
Research News	22	Bad News from the Bacteria ■ The Policy Response: In Limbo
	25	Hubble's Managers Start to Survey the Damage
	26	DORIS Gets a Face-Lift Mount Graham Observatory on the Brink
	27	Diamond Films Sparkle as They Come to Market ■ Ultra Diamond from Pure Carbon-12
Articles	31	The CFC-Ozone Issue: Progress on the Development of Alternatives to CFCs: L. E. MANZER
	36	The Z Boson: M. S. CHANOWITZ
Research Articles	42	Evidence That the Head of Kinesin Is Sufficient for Force Generation and Motility in Vitro: J. T. YANG, W. M. SAXTON, R. J. STEWART, E. C. RAFF, L. S. B. GOLDSTEIN
Reports	48	Television Image of a Large Upward Electrical Discharge Above a Thunderstorm System: R. C. FRANZ, R. J. NEMZEK, J. R. WINCKLER

■ **SCIENCE** is published weekly on Friday, except the last week in December, and with a supplement in March by the American Association for the Advancement of Science, 1333 H Street, NW, Washington, DC 20005. Second-class Non-profit postage (publication No. 484460) paid at Washington, DC, and at an additional entry. Copyright © 1990 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): \$80. Domestic institutional subscription (51 issues): \$150. Foreign postage extra: Canada \$46, other (surface mail) \$46, air mail 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, \$20 (for postage and handling add per copy \$1.00 U.S., \$1.50 Canada, \$2.00 other foreign). Bulk rates on request. **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, 27 Congress Street, Salem, Massachusetts 01970. The identification code for *Science* is 0036-8075/83 \$1 + .10. **Change of address:** allow 6 weeks, giving old and new addresses and 11-digit account number. **Postmaster:** Send Form 3579 to *Science*, P.O. Box 1723, 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 objectives 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, to advance education in science, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.



COVER Chirp entrainment by the katydid *Mecopoda* to periodic acoustic stimulation at two different stimulus intensities: plots obtained by iteration of the Poincaré map. The abscissa represents input stimulus rate and the ordinate, phase. At each stimulus rate the map was iterated 50 times: the first 10 iterations are represented by yellow dots while the last 40 iterations (steady-state) are shown in red. The plots identify regions of phase-locked response. See page 55.

- 51 Seawater Strontium Isotopic Variations from 2.5 Million Years Ago to the Present: R. C. CAPO AND D. J. DEPAOLO
- 55 Synchronous, Alternating, and Phase-Locked Stridulation by a Tropical Katydid: E. SISMONDO
- 58 The Role of Ocular Muscle Proprioception in Visual Localization of Targets: G. M. GAUTHIER, D. NOMMAY, J.-L. VERCHER
- 61 Mediation of Cardioprotection by Transforming Growth Factor- β : A. M. LEFER, P. TSAO, N. AOKI, M. A. PALLADINO, JR.
- 64 An Insulin-Stimulated Protein Kinase Similar to Yeast Kinases Involved in Cell Cycle Control: T. G. BOULTON, G. D. YANCOPOULOS, J. S. GREGORY, C. SLAUGHTER, C. MOOMAW, J. HSU, M. H. COBB
- 67 Recognition of a Peptide Antigen by Heat Shock-Reactive $\gamma\delta$ T Lymphocytes: W. BORN, L. HALL, A. DALLAS, J. BOYMEL, T. SHINNICK, D. YOUNG, P. BRENNAN, R. O'BRIEN
- 70 Intercalation Complex of Proflavine with DNA: Structure and Dynamics by Solid-State NMR: P. TANG, C.-L. JUANG, G. S. HARBISON
- 73 Site-Specific Cleavage of a Yeast Chromosome by Oligonucleotide-Directed Triple-Helix Formation: S. A. STROBEL AND P. B. DERVAN

Inside AAAS

- 76 Entries for Behavioral Science Research Prize ■ Trilateral Science Summit Held in Budapest ■ Elements of Chaos ■ Arctic Division Call for Papers ■ SWARM Division Meeting ■ AAAS Handbook ■ Westinghouse Award for Public Understanding of Science ■ AAAS Environmental Fellows

Book Reviews

- 78 Mesoamerica After the Decline of Teotihuacan, A.D. 700-900, AND Tula of the Toltecs, *reviewed by*: D. FREIDEL ■ *Astronomer by Chance*, J. V. EVANS ■ *Evolutionary Phenomena in Galaxies*, V. TRIMBLE ■ *Books Received*

Products & Materials

- 82 Computer for Measuring Geological Resistance ■ Chromatography Storage Cabinets ■ Thermal Cycler for DNA Sequencing ■ Containment Vacuum Cleaner ■ Software for Drawing Figures ■ Protein Purification System ■ Literature

Board of Directors

Richard C. Atkinson
*Retiring President,
Chairman*

Donald N. Langenberg
President

Leon M. Lederman
President-elect

Mary Ellen Avery
Francisco J. Ayala
Eugene H. Cota-Robles
Robert A. Frosch
Joseph G. Gavin, Jr.
John H. Gibbons
Beatrix A. Hamburg
Florence P. Haseltine

William T. Golden
Treasurer

Richard S. Nicholson
Executive Officer

Editorial Board

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

Board of Reviewing Editors

John Abelson
Don L. Anderson
Stephen J. Benkovic
Gunter K.-J. Blobel
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
Harry A. Fozzard

Theodore H. Geballe
Roger I. M. Glass
Stephen P. Goff
Corey S. Goodman
Stephen J. Gould
Eric F. Johnson
Stephen M. Kosslyn
Konrad B. Krauskopf
Charles S. Levings III
Richard Losick
Joseph B. Martin
John C. McGiff
Anthony R. Means
Mortimer Mishkin
Roger A. Nicoll
William H. Orme-Johnson III
Carl O. Pabo
Yeshayau Pocker

Dennis A. Powers
Erkki Ruoslahti
Thomas W. Schoener
Ronald H. Schwartz
Terrence J. Sejnowski
Robert T. N. Tjian
Virginia Trimble
Emil R. Unanue
Geerat J. Vermeij
Bert Vogelstein
Harold Weintraub
Irving L. Weissman
Zena Werb
George M. Whitesides
Owen N. Witte
William B. Wood
Keith Yamamoto

Sensors, Computers, and Actuators

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: Richard S. Nicholson

Editor: Daniel E. Koshland, Jr.

News Editor: Ellis Rubinstein

Managing Editor: Patricia A. Morgan

Deputy Editors: Philip H. Abelson (*Engineering and Applied Sciences*); John I. Brauman (*Physical Sciences*); Thomas R. Cech (*Biological Sciences*)

EDITORIAL STAFF

Assistant Managing Editor: Monica M. Bradford

Senior Editors: Eleanore Butz, Martha Coleman, Barbara Jasny, Katrina L. Kainer, Phillip D. Szurumi, David F. Voss

Associate Editors: R. Brooks Hanson, Pamela J. Hines, Kelly LaMarco, Linda J. Miller

Letters Editor: Christine Gilbert

Book Reviews: Katherine Livingston, *editor*; Teresa Fryberger

Contributing Editor: Lawrence I. Grossman

Chief Production Editor: Ellen E. Murphy

Editing Department: Lois Schmitt, *head*; Patricia L. Moe, Barbara P. Ordway

Copy Desk: Joi S. Granger, Margaret E. Gray, MaryBeth Shartle, Beverly Shields

Production Manager: James Landry

Assistant Production Manager: Kathleen C. Fishback

Art Director: Yolanda M. Rook

Graphics and Production: Holly Bishop, Julie Cherry, Catherine S. Siskos

Systems Analyst: William Carter

NEWS STAFF

Correspondent-at-Large: Barbara J. Culliton

Deputy News Editors: John M. Benditt, Jean Marx, Colin Norman

News and Comment/Research News: Ann Gibbons, David P. Hamilton, Constance Holden, Richard A. Kerr, Elliot Marshall, Joseph Palca, Robert Pool, Leslie Roberts, M. Mitchell Waldrop

European Correspondent: Jeremy Cherfas

West Coast Correspondent: Marcia Barinaga

Contributing Correspondents: Joseph Alper, Barry A. Cipra, Robert Crease

BUSINESS STAFF

Circulation Director: Michael Spinella

Fulfillment Manager: Marlene Zendell

Business Staff Manager: Deborah Rivera-Wienhold

Classified Advertising Supervisor: Amie Charlene King

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); Hoffman Estates, IL 60195: Jack Ryan, 525 W. Higgins Rd. (708-885-8675); 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 29 June 1990 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.

The continuing trend to cheaper and more powerful computer chips opened the path to a great revolution in process controls. When sensors are available to provide information about phenomena, microcomputers can analyze the data and issue commands to actuators to respond appropriately. The processes that are now being beneficially monitored include manufacturing and operations of aircraft, automobiles, and electric power plants. Use of computer-based controls has proceeded unevenly with respect to various applications. Where expensive capital equipment is in place, such as in electric power plants, widespread exploitation of new sensors and microcomputers has been slow. In automobiles, where new models frequently appear and competition is great, the use of microcomputers has been growing rapidly.

Coal-fired electric generating plants are subject to many modes of forced outages. When a large unit becomes suddenly inoperable, costs of replacement electricity alone may amount to \$500,000 per day. Such lapses can be avoided if incipient failures can be detected. Principal causes of forced outages are leaks in boiler tubes and failures of rotating machinery. Often the problems have small beginnings and expand with time. Signals from equipment may have mechanical frequencies ranging from a few hertz through ultrasonic; optical signals may be infrared, ultraviolet, and higher. With appropriate sensors, data collection, and computer analysis, plant diagnostics can be achieved and a predictive maintenance strategy can be formulated.

The automotive industry has been faced with the necessity of cutting pollution while improving mileage. It is also highly competitive. Initially computers were introduced on models as add-on features. But lately the sensor-computer-actuator systems have come to have important roles in the engineering of cars. More than one expert has estimated that at the end of this decade, average automobiles will contain electronic components costing \$2000. As many as two to three dozen sensors could then be employed. At present most cars have computers to control a number of functions including the power train. A typical system contains eight power-train sensors that monitor variables such as air change temperature, heater exhaust gas oxygen, vehicle speed, and manifold absolute pressure.

A manifold pressure device is of special interest because it employs an advanced silicon and glass sensing element to convert air pressure values into a variable frequency output. The crucial part of the sensing element is a silicon diaphragm whose electroresistive properties are modified when deformed by changes in pressure. The crystalline silicon wafers serving as blanks for the diaphragms are products available from the semiconductor industry. Much of the silicon sensor-chip manufacturing process can be highly automated, leading to cost-effective mass production of dependable components.

Experts state that various forms of silicon sensors will have many additional roles in the future of automobiles. Silicon is a strong material that can withstand corrosion and the high air temperatures under the hood. Technology pioneered by the semiconductor industry is some of the most advanced anywhere. Some of the know-how can be used in making sensors. In addition, silicon can be micro-machined by chemical etching to exacting standards. Both sensor and computer capabilities might be included in a single chip.

The automobile companies conduct R&D on silicon sensors and actuators. But they depend to a considerable extent on outside vendors. One of these is Honeywell. A recent communication from Norm A. Foss of that company had this to say: "...the revolution now going on in the manufacture of silicon microstructure sensors and actuators is truly amazing." He listed nine of Honeywell's microstructure sensors, including mass airflow, accelerometers, pressure, and gas composition. The airflow sensor has a dynamic range greater than 10,000:1. Actuators included electrical to pressure transducers, microvalves, and microswitches and relays.

Substantial efforts at University of California, Berkeley, Massachusetts Institute of Technology, Cornell, and other universities are devoted to exploiting micro-machining of silicon to produce very tiny microdynamical systems. A goal is to develop the engineering science base and technology for the design, analysis, fabrication, and operation of devices and systems that have components that measure less than 1 mm³. Already a microgear has been fabricated that has the diameter of a human hair. The new technology has the possibility of fabricating systems that can perform entirely new functions.

—PHILIP H. ABELSON