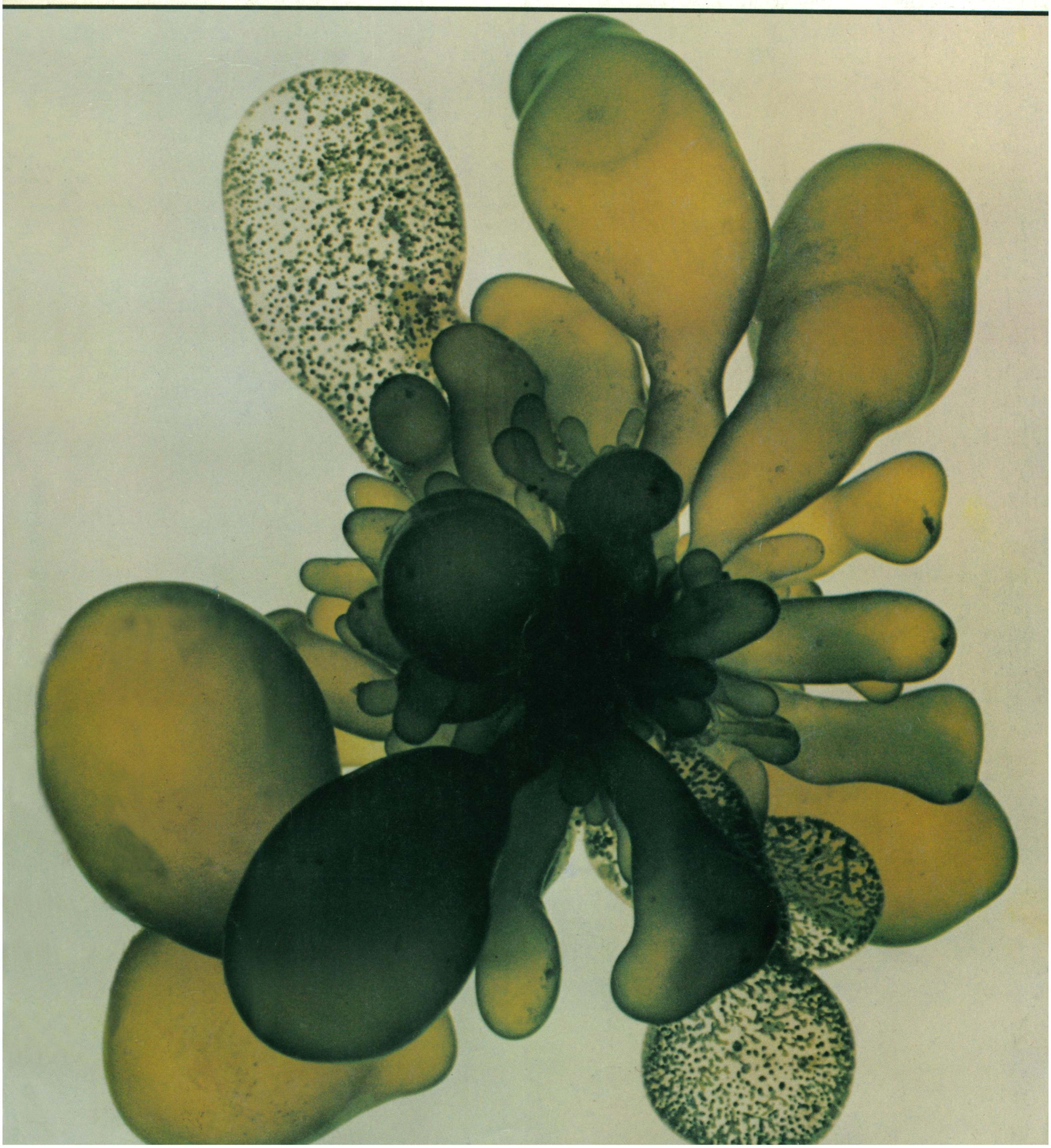
20 July 1984 • Vol. 225 • No. 4659 $2.50

SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



Now:

TWO WAYS TO IMPROVE YOUR PEPTIDE SYNTHESIS.

THE FIRST ONE'S NEW.

It's the System 990 Peptide Synthesizer with new microprocessor control for greater ease of operation. This is the versatile synthesizer with reliability proven in more than a dozen years of operation, worldwide.

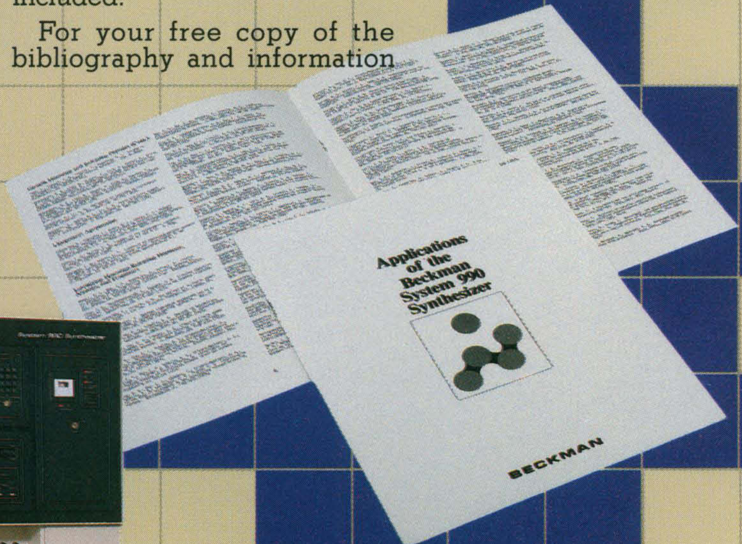
With the new 990, you have increased programming flexibility and the freedom to choose from different synthesis methodologies. Like using such protecting groups as *t*-Boc, or Fmoc. Or, resins like polyamide and polystyrene.

Regardless of the method or strategy, what you select is easy to program, modify or run on a System 990. It's no wonder scientists the world over have made Beckman Synthesizers their number one choice.

THE SECOND IS FREE.

If you're interested in the synthesis of peptides, you'll appreciate our latest bibliography. It's yours for the asking. This handy publication lists more than 200 references of published work using Series 990 synthesizers. References are divided by peptide type from Acyl Carrier Protein through Troponin and a lengthy Methods section is included.

For your free copy of the bibliography and information on our latest System 990, simply contact your local Beckman Representative. Or, drop us a line: Beckman Instruments, Inc., Spinco Division, 1050 Page Mill Road, Palo Alto, California 94304.



BECKMAN

Circle No. 60 on Readers' Service Card

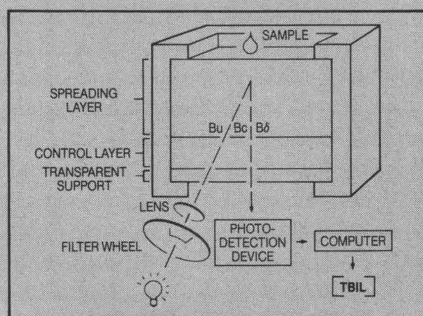
Making headway against jaundice a fraction at a time.

Kodak scientists have isolated what may be the first true human "biliprotein." The existence of this bilirubin fraction may lead to an advance in the diagnosis and treatment of jaundice-related disorders.

This important verification came to light during product-improvement testing procedures for Kodak Ektachem clinical chemistry slides. In the process of separating and identifying different bile pigments in serum, a fourth bilirubin fraction, delta (B_δ), was rediscovered. It is distinct from unconjugated bilirubin and is strongly linked (possibly covalently) to albumin.

Not only have we isolated and characterized this virtually unknown fourth fraction, we have developed a new assay procedure which enables labs to measure the delta fraction simply, rapidly, and accurately.

Last year we introduced an Ektachem chemistry slide to measure neonatal bilirubin. By means of dry film layers, this slide measures both unconjugated bilirubin (Bu) and mono- and diconjugated bilirubin (Bc) together. But the delta bilirubin fraction, which is tightly bound to a serum protein believed to be albumin, is not detected by the BuBc slide.

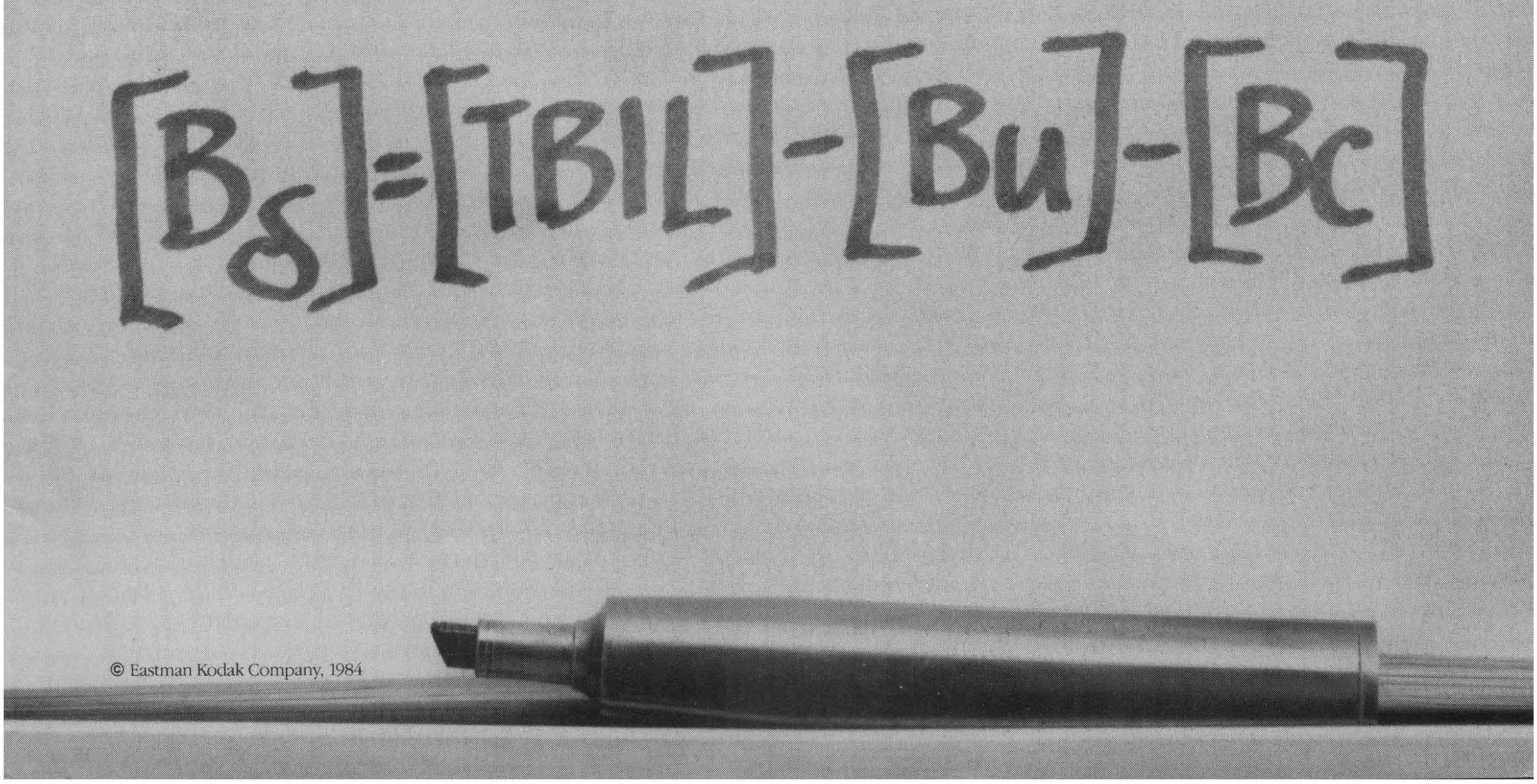


This year we are introducing a Kodak Ektachem fractionated bilirubin panel composed of BuBc and TBIL (Total Bilirubin), from which estimates of B_δ can be calculated. The new TBIL slide quantitates all three bilirubin fractions ($Bu + Bc + B_\delta$) while the BuBc slide now measures Bu and Bc as individual fractions. The difference in bilirubin quantitated by the two slides is B_δ.

We think the fractionated bilirubin panel may lead to a better understanding of the molecular basis of jaundice. This, in turn, can make it easier for health care professionals to diagnose biliary atresia and cytomegalovirus in newborn infants. And to screen for hepatobiliary disease, make differential diagnoses, indicate therapeutic strategies, and support prognoses.

For more information, write for "Bilirubin—Its Components in Serum and the Kodak Assay" to: Eastman Kodak Company, Dept LCSM-1, 343 State Street, Rochester, NY 14650.

Kodak. Where technology anticipates need.



© Eastman Kodak Company, 1984

ISSN 0036-8075
20 July 1984
Volume 225, No. 4659

SCIENCE

BOARD OF DIRECTORS
ANNA J. HARRISON, Retiring President, Chairman
DAVID A. HAMBURG, President
GERARD PIEL, President-Elect
ROBERT W. BERLINER
LAWRENCE BOGORAD
WALTER E. MASSEY
DOROTHY NELKIN

CHAIRMEN AND SECRETARIES OF AAAS SECTIONS
MATHEMATICS (A): Gail S. Young, Lynn Arthur Steen
PHYSICS (B): Chen Ning Yang, Rolf M. Sinclair
CHEMISTRY (C): Fred W. McLafferty, Jean'ne M. Shreeve
ASTRONOMY (D): Patrick Palmer, Donat G. Wentzel
PSYCHOLOGY (J): Gregory A. Kimble, William N. Dember
SOCIAL, ECONOMIC, AND POLITICAL SCIENCES (K): Robin M. Williams, Jr., David L. Sills
HISTORY AND PHILOSOPHY OF SCIENCE (L): Wesley C. Salmon, David L. Hull
ENGINEERING (M): Raymond L. Bisplinghof, W. Edward Lear
EDUCATION (Q): Marvin Druger, Joseph D. Novak
DENTISTRY (R): Robert J. Fitzgerald, Harold M. Fullmer
PHARMACEUTICAL SCIENCES (S): Stuart Feldman, David A. Knapp
INFORMATION, COMPUTING, AND COMMUNICATION: Joseph Becker, Madeline M. Henderson

DIVISIONS
ARCTIC DIVISION: John Davies, President; Gunter E. Weller, Executive Secretary
PACIFIC DIVISION: Barbara Wright, President; Alan E. Leviton, Executive Director
SOUTHWESTERN AND ROCKY MOUNTAIN DI: Charles E. Holley, Jr., President; M. Michelle Bal, Executive Direc

SCIENCE is published weekly on Friday, except the last week in December, by the American Association for the Advancement of Science, 1515 Massachusetts Avenue, NW, Washington, D.C. 20005. Second-class postage (publication No. 484460) paid at Washington, D.C., and at an additional entry. Now combined with **The Scientific Monthly®** Copyright © 1984 by the American Association for the Advancement of Science. Domestic individual membership and subscription (51 issues): $56. Domestic institutional subscription (51 issues): $93. Foreign postage extra: Canada $24, other (surface mail) $27, air-surface via Amsterdam $65. First class, airmail, school-year, and student rates on request. Single copies $2.50 ($3 by mail); back issues $3 ($3.50 by mail); Biotechnology issue, $5 ($5.50 by mail); classroom rates on request. **Change of address:** allow 6 weeks, giving old and new addresses and seven-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*, 1515 Massachusetts Avenue, NW, Washington, D.C. 20005. *Science* is indexed in the *Reader's Guide to Periodical Literature* and in several specialized indexes.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

ɴ B. SLAUGHTER SHEILA E. WIDNALL WILLIAM T. GOLDEN WILLIAM D. CAREY
ɴ E. SAWYER LINDA S. WILSON Treasurer Executive Officer

LOGY AND GEOGRAPHY (E) BIOLOGICAL SCIENCES (G) ANTHROPOLOGY (H)
m W. Hay Dorothy M. Skinner Priscilla Reining
omas Dutro, Jr. Walter Chavin

ICAL SCIENCES (N) AGRICULTURE (O) INDUSTRIAL SCIENCE (P)
rt A. Good John Pesek J. Kenneth Craver
than E. Rhoads Ralph J. McCracken Robert L. Stern

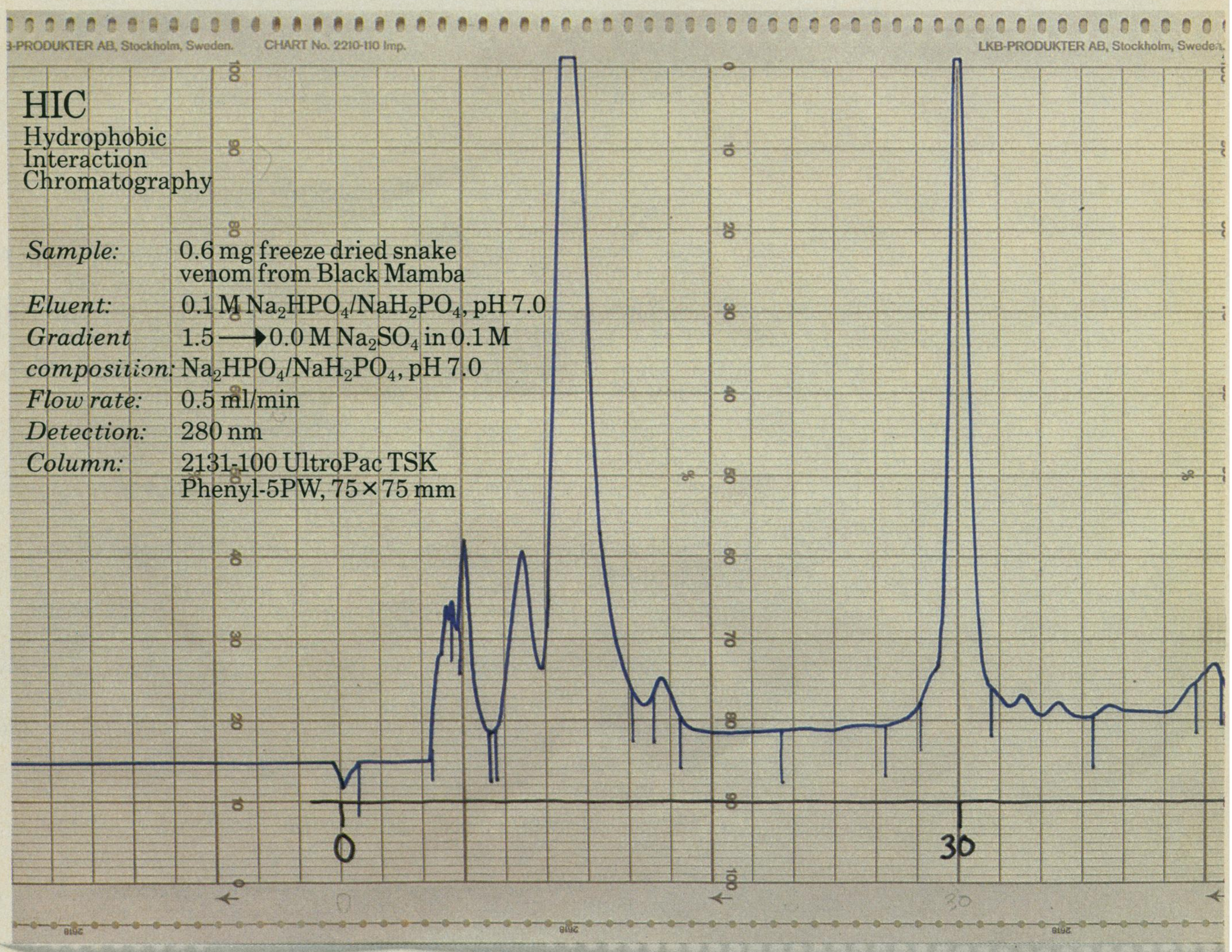
'ISTICS (U) ATMOSPHERIC AND HYDROSPHERIC (W) GENERAL (X)
ara A. Bailar William W. Kellogg George C. Sponsler
ird J. Wegman Bernice Ackerman Rodney W. Nichols

American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, prove the effectiveness of science in the promotion of human welfare, and to increase public understanding and eciation of the importance and promise of the methods of science in human progress.

COVER

Cluster of *Boergesenia forbesii* cells. The giant, balloon-like cells of this marine green alga produce hundreds of viable protoplasts within 90 minutes when they are wounded (protoplasts visible in two cells). This phenomenon is accompanied by the appearance of numerous coated pits and vesicles near the plasma membrane (about ×9). See page 331. [John W. La Claire II, Department of Botany, University of Texas, Austin 78712, with cooperation of the Cell Research Institute and Dennis T. Brown]

A new prot
High biological activi



The problem

Purification of proteins, peptides and nucleic acids still presents the biochemist with the problem of how to preserve high biological activity, get good resolution, and do it fast.

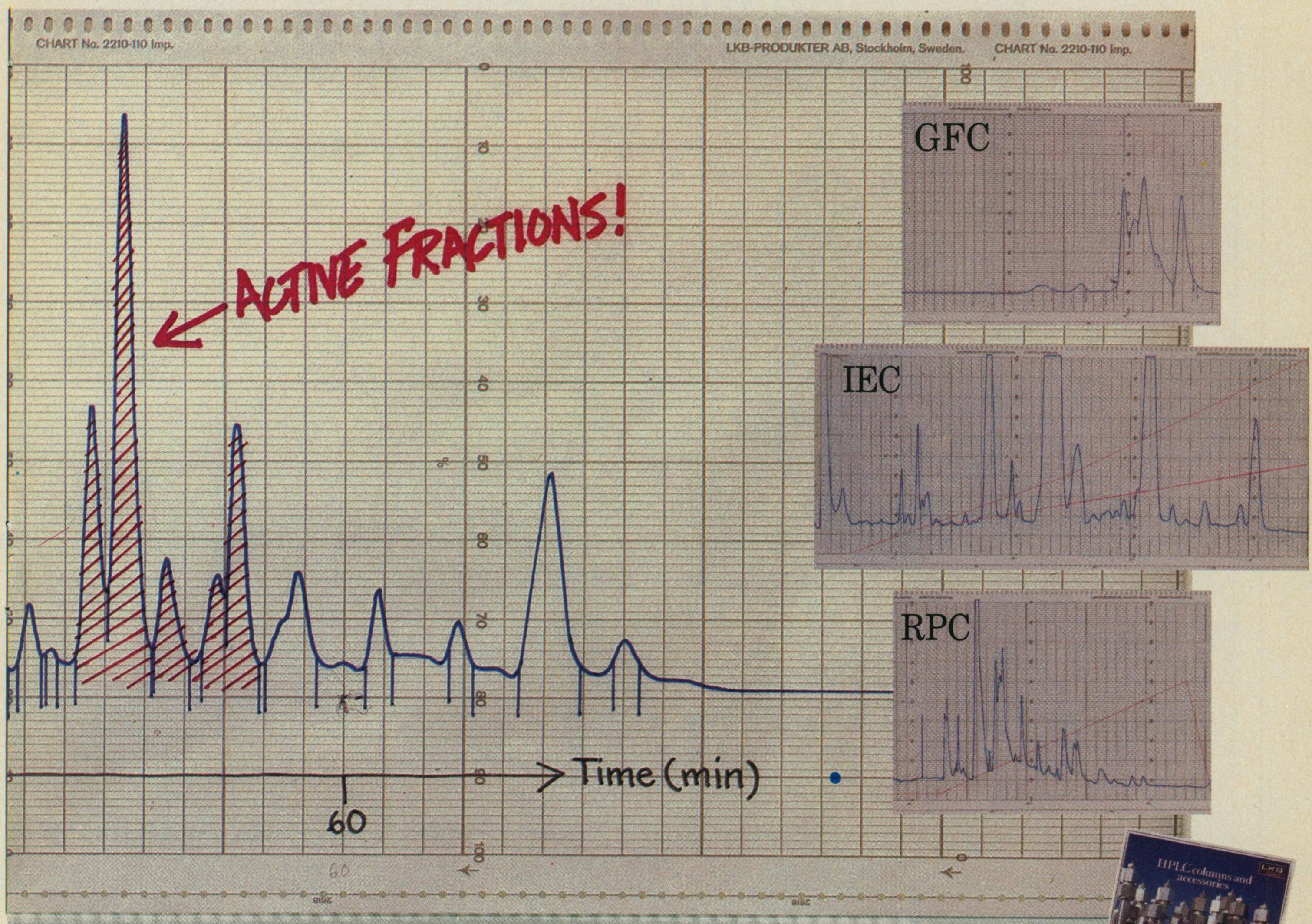
The answer

A new separation mode – Hydrophobic Interaction Chromatography (HIC)–an aqueous system where *salt gradients* regulate the ability of the column matrix to retain biomacromolecules, *and* keep them active. Control interaction between the hydrophobic sites of a protein with the hydrophobic ligands of your packing material, and you've got the answer – HIC.

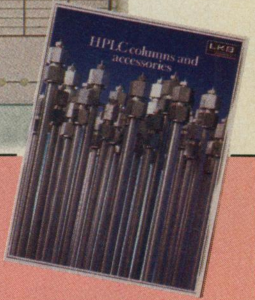
The facts

LKB now introduces a new HPLC column that's engineered to meet the special demands of hydrophobic chromatography. The UltroPac® Phenyl-5PW column eliminates all the problems caused by organic solvents, provides mild separating conditions and ensures complete accessability even for biomacromolecules up to 10^6. The result is outstandingly high biological activity, very fine resolution and fast chromatography. Whatever your separation method, be it GFC, IEC, RPC and now HIC, LKB's comprehensive range of prepacked columns lets you select the technique most suitable for your sample. A complete choice.

ein HPLC
ty with fine resolution



And you'll find it all in our new catalogue of HPLC columns and accessories. Get yourself a copy– and get the facts.



YES, please send me the new catalogue of HPLC columns and accessories.

Name

Company/institution

Department

Address

Telephone

LKB
BROMMA

Head office: LKB-Produkter AB, Box 305, S-161 26 Bromma, Sweden Tel 08-98 00 40, telex 10492

Main US sales office: LKB Instruments, Inc. 9319 Gaither Road, Gaithersburg, Maryland 20877. Tel 301-963-3200, telex 909870 (dom.), 64634 (intern.)

UK sales office: LKB Instruments Ltd., 232 Addington Road, S. Croydon, Surrey CR2 8YD, England. Tel 01-657 8822, telex 264414

Other sales offices in: Antwerp, Athens (for Middle East), Bangkok, Copenhagen, Lucerne, Madras, Moscow, Munich, Paris, Rome, Turku, Vienna, Zoetermeer

Circle No. 29 on Readers' Service Card

AAAS Report IX
Research and Development
FY 1985
Intersociety Working Group

This timely document analyzes major budget and policy issues relating to R&D in the FY 1985 budget, presents data on federal agency and industry support for R&D, and discusses trends in R&D funding in light of current policy issues. The report looks in detail at the R&D programs of major federal agencies and provides cross-cutting analyses of the budget by several scientific and engineering disciplines.

284 pp. Paperback $10.00

Also Available:

R&D in FY 1985: Budgets, Policies, Outlooks. Proceedings of the 1984 AAAS Colloquium on R&D Policy.

Approx. 175 pp. Paperback $7.00

Congressional Action on R&D in the FY 1985 Budget. Willis H. Shapley, Albert H. Teich, and Jill H. Pace. Fall 1984

Approx. 50 pp. Paperback $3.00

Books may be purchased by writing to the **AAAS Sales Department, 1515 Massachusetts Avenue, NW, Washington, DC 20005.** Please allow 6-8 weeks for delivery. All orders under $10 must be prepaid. Visa and MasterCard customers include account number, expiration date, and signature. Past reports in the series are available; contact the Sales Department for more information.

SCIENCE/SCOPE

In designing and making a satellite part entirely via computer, Hughes Aircraft Company developed what may be a first in computer-aided design/computer-aided manufacturing. The part is a launch lock pivot plate for the Intelsat VI communications satellite. (The plate keeps the inner and outer sections of the spacecraft together until it is time to begin the spun/despun operation in space. This operation stabilizes the satellite in orbit.) The plate was designed on a CADAM system and made on a computerized milling machine driven by a ComputerVision system. Because CADAM lacks the ability to run milling machines without extensive manual manipulation, engineers developed a custom translator. This new programming allowed CADAM data to be understood by ComputerVision and, in turn, by the milling machine. The use of CADAM and ComputerVision in tandem is believed to be an industry first.

Heat pictures are screening printed circuit boards for such defects as open or short circuits and failed components. The Automatic Infrared Test & Inspection System (AITIS) uses a cooled, 60-element infrared detector to create a high-resolution thermogram. A computer isolates faults by comparing a tested board with a master thermogram stored in computer memory. Components that appear too warm or too cool are shown in color-coded temperatures on a video monitor. As a complement to automatic test equipment, AITIS saves time and money. Hughes developed AITIS under its independent research and development programs and contracts with the U.S. Army Missile Command and U.S. Air Force.

An advanced military communications satellite network will let U.S. bombers and airborne command posts remain in continuous contact with designated ground and naval stations anywhere in the world. The new MILSTAR network will consist of satellites in various orbits and hundreds of terminals aboard aircraft, ships, submarines, and in ground units and command centers. Hughes is designing survivable, secure, and jam-resistant terminals for B-1 and B-52 bombers, E-3A Airborne Warning and Control System (AWACS) early-warning aircraft, E4 command post aircraft, VC-137 "Air Force 1," and other aircraft involved in the Air Force portion of the joint services network.

Some of the fastest digital integrated circuits yet built have been demonstrated at Hughes. The circuits, made of gallium arsenide, are biphase clock flip-flops configured to perform frequency division. They were operated at frequencies up to 5.77 GHz, the highest division speed yet reported for integrated circuits operating at room temperature. The circuits were fabricated by electron-beam lithography (using a Hughes system) to produce gate lengths of 0.5 micrometers in the MESFET switching transistors. These gallium arsenide devices could be used in very-high-frequency signal processing or as interfaces to more complex chips, including Very High Speed Integrated Circuits.

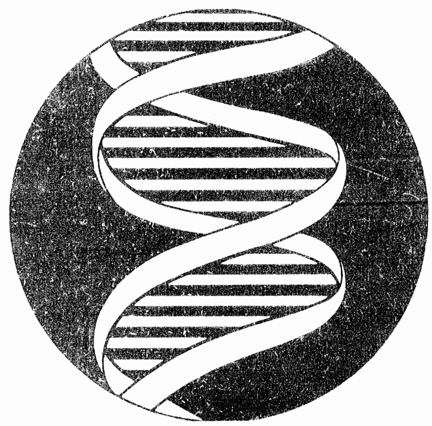
Career growth opportunities exist at Hughes Support Systems for a variety of engineers qualified by degree or extensive work experience. They include systems engineers, radar engineers, and software and hardware design engineers for major simulation and test equipment programs. Also, field engineering posts throughout the U.S. offer travel, autonomy, and responsibility for the life cycle of Hughes electronics systems. Please send your resume to Lowell Anderson, Professional Employment, Dept. S2, Hughes Aircraft Company, P.O. Box 9399, Long Beach, CA 90801-0463. Equal opportunity employer. U.S. citizenship required.

For more information write to: P.O. Box 11205, Marina del Rey, CA 90295

HUGHES
AIRCRAFT COMPANY

One-shot biotechnology

One place, one time – a complete up-date on the commercial applications of biotechnology. Biotech '84 USA in Washington in September.



This Conference is the world forum for industry leaders and the latest, most controversial biotechnology topics.

This Exhibition is a unique international marketplace for the products, systems and services of major industry organizations.

Biotech 84

September 10 - 12, 1984

International Conference & Exhibition
Sheraton Washington Hotel, Washington DC

online
presenting technology to
the business world

For more information call Online (212) 279-8890 – or clip your business card to this advertisement and return to:-

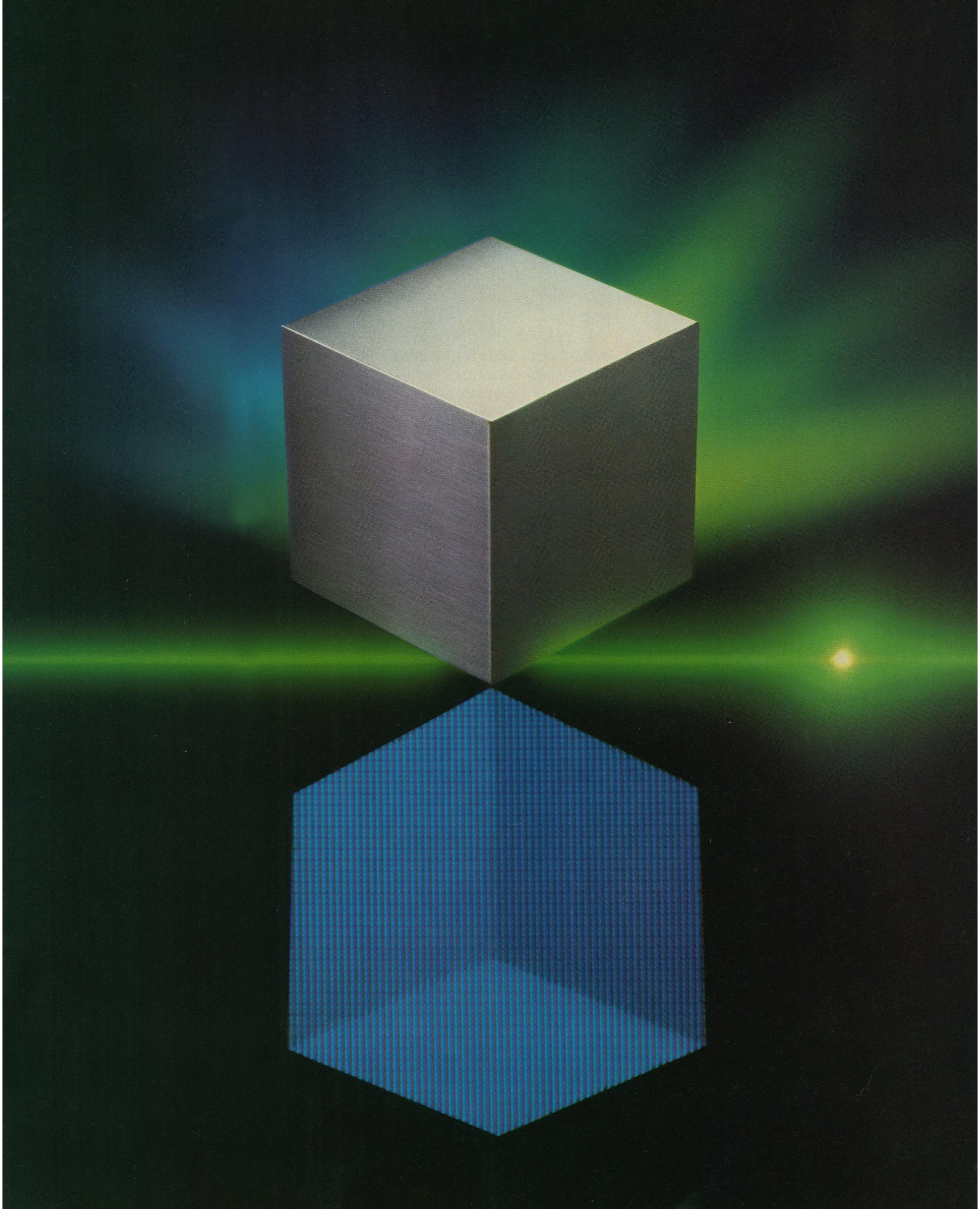
Online Conferences Inc.
Suite 1190, 2 Penn Plaza, New York, NY 10121.

Please indicate your interest – Exhibitor ☐ Delegate ☐ Visitor ☐

BU84 S100.3

Circle No. 4 on Readers' Service Card

The Robot Abstraction



The Robot Abstraction

Until now, matching robots to specific industrial tasks has been done by trial and error, requiring the creation of expensive prototypes. Recent advances at the General Motors Research Laboratories have produced a computer system that can be used not only to select the right robot, but also to program it to perform the task in the most efficient way.

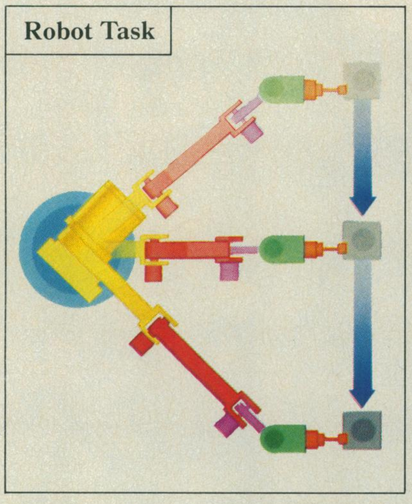
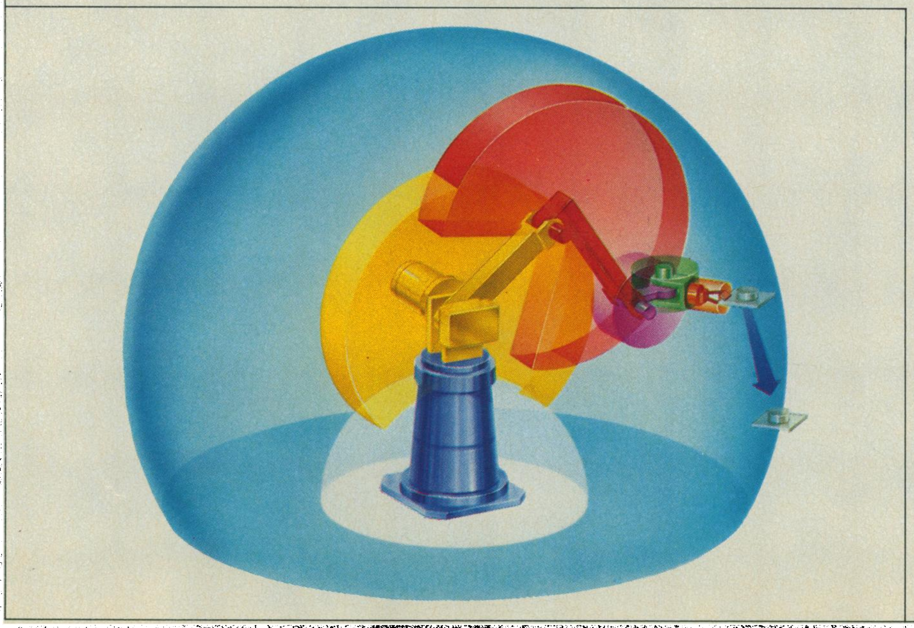


Figure 1: Two-dimensional overhead view of a robot task—the straight path trajectory of a solid.

Figure 2: Three-dimensional illustration of the robot work cell layout, showing reach capability for the task in Figure 1. Areas of color show total reach as well as the joint limits stored in the robot model.



THE DECISION to use robots to automate a manufacturing facility introduces the need for more decisions. There are several dozen kinds of robots, each with different capabilities. Thus far, choosing the right robot for a given set of tasks has been largely a manual process, involving great expenditures of time and money. By combining previously separate disciplines in a single computer system, two General Motors researchers have made the introduction of robots to the factory floor a more rational, less costly undertaking.

RoboTeach is the first computer system which integrates robotics, solid modeling, and simulation. It was designed and developed by Dr. Robert Tilove and Mary Pickett, both members of the Computer Science Department.

The use of powerful programming languages for manipulating robots is a major new development in the discipline of robotics. The languages specify desired robot motions, but they have no way of describing the robot's environment. Hence, they cannot automatically take into account physical obstacles or anticipate collisions. With only robot programming languages at one's disposal, assuring proper interaction with the environment requires testing with actual robots and parts.

Solid modeling, on the other hand, provides geometrically complete representations of environmental components and their spatial relations. But solid modeling cannot represent processes, because it has no way of representing temporal relations. Traditional solid modeling deals only with static relationships. While robot programming is without physical context, solid modeling is nothing but physical context. Neither by itself is adequate.

Nor are they satisfactory together. Only by simulation of both the robot and its environment can the sequence of discrete steps in a robot task be converted into the continuous motion of a process. Also without simulation, there is no way to represent accurately the robotic process as it unfolds in its environment.

RoboTeach, by combining all three disciplines, provides computer representations of the environment, the robot, and the task. Consequently, it helps users reach high-level decisions about the real world without the investment of time or money in actual robots, actual parts, or the factory setting.

One key RoboTeach abstraction is a mathematical robot model. Solid modeling techniques represent the geometric form of each link of the robot. Then constraints are imposed on the relative positions of mating links to produce a mathematical abstraction of a mechanical joint. By insisting that the joint constraints always be satisfied, RoboTeach insures that the abstract robot model corresponds to a physically realizable geometric configuration.

OTHER representational facilities in RoboTeach handle robot task definitions. The representation of any task can be matched with the representation of any robot. In this way, RoboTeach helps users to determine the optimal robot for the task. Once a robot has been selected, RoboTeach can be used to program the robot off-line.

Not only are robots proliferating, but the tasks assigned to them are becoming more complex, making the need for off-line programming more urgent. When there are only a half dozen robots in a factory, the prospect of reprogramming them all by conventional show-and-teach methods for every new task is not overwhelming. But when there are hundreds of robots, the value of being able to reprogram without interaction with each robot becomes more apparent. Without off-line programming, the savings which justified the initial robot investment may quickly vanish.

RoboTeach distinguishes between two kinds of off-line programming: at the task level (what to do) and at the robot level (how to do it). For example, in the creation of a mechanical assembly, task-level instructions would include what components to assemble, the alignment of the components for the assembly process, and criteria for verifying that the final assembly is correct. Typically, there is a one-to-many relationship between task-level instructions and robot-level instructions.

"RoboTeach is currently in use," says Robert Tilove, "to study robot reach capabilities and to simulate simple robot-level tasks."

"Future research," adds Mary Pickett, "will explore the possibility of using RoboTeach to approach problems from the more abstract task level, with the user defining the task at a high level and RoboTeach filling in the details."

General Motors

MARK OF EXCELLENCE

THE PEOPLE BEHIND THE WORK

Dr. Robert Tilove and Mary Pickett are Staff Research Scientists in the Computer Science Department at the General Motors Research Laboratories.

Mary Pickett received her B.S. in mathematics from Iowa State University and her Master's in computer science from Purdue University. She was a member of the team that developed GMSOLID, an interactive geometric modeling system. Her research at GM has also included the design of real-time programming languages. She joined GM in 1971.

Robert Tilove received his undergraduate and graduate degrees in electrical engineering from the University of Rochester. His Ph.D. thesis concerned the design and analysis of geometric algorithms for solid modeling. His current research interests also include the application of geometric modeling to computer vision and robot control. He joined GM in 1981.

DRAWING YOUR OWN CONCLUSIONS

. . . Is Easy With The Versatile HIPAD™ DT-114 From Houston Instrument.

Enter a whole new universe of graphics, made possible by programs tailored to the HIPAD digitizer.

Exciting new applications in computer-aided drafting are now available, allowing you to create subdivision plats, machine drawings, schematics, architectural elevations and circuit-board artwork . . . with your microcomputer . . . at your desk . . . with no training as a draftsman.

Use of the HIPAD in medicine is increasing. With currently available software, physicians and dentists can prepare graphics of anatomical features for diagnosis and correction.

Artistic efforts are complemented by the HIPAD. With customized software, free-form renditions can be created quickly and precisely. Colors to fit the moment can be selected . . . and easily changed at a later time. The HIPAD provides access to the realm of high technology graphics.

The HIPAD features a full-size 11″ x 11″ digitizing area, and is both UL listed and FCC approved.

The Conclusions You Draw Are Clearly Correct. The HIPAD will open the door to a universe of form and color . . . and creativity.

For the name, address and phone number of your nearest representative, write Houston Instrument, P.O. Box 15720, Austin, TX 78761. Phone 512-835-0900, or 800-531-5205 if outside Texas for the name and location of your nearest representative. In Europe contact Houston Instrument, Belgium NV., Rochesterlaan 6, 8240 Gistel, Belgium. Tel. 059-27-74-45, Tlx. 846-81399.

houston instrument

houston instrument 25th Anniversary 1959-1984

Visit us at the NCC, Booth A1334.

Circle No. 42 on Readers' Service Card

HIPAD is a trademark of Houston Instrument

4P013A

20 July 1984, Volume 225, Number 4659 SCIENCE

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.

Editorial Board

FREDERICK R. BLATTNER, BERNARD F. BURKE, ARNOLD DEMAIN, CHARLES L. DRAKE, ARTHUR F. FINDEIS, E. PETER GEIDUSCHEK, GLYNN ISAAC, NEAL E. MILLER, FREDERICK MOSTELLER, ALLEN NEWELL, RUTH PATRICK, BRYANT W. ROSSITER, VERA C. RUBIN, WILLIAM P. SLICHTER, SOLOMON H. SNYDER, PAUL E. WAGGONER, JOHN WOOD

Publisher: WILLIAM D. CAREY

Editor: PHILIP H. ABELSON

Editorial Staff

Assistant Managing Editor: JOHN E. RINGLE
Production Editor: ELLEN E. MURPHY
Business Manager: HANS NUSSBAUM
News Editor: BARBARA J. CULLITON
News and Comment: COLIN NORMAN (deputy editor), JEFFREY L. FOX, CONSTANCE HOLDEN, ELIOT MARSHALL, R. JEFFREY SMITH, MARJORIE SUN, JOHN WALSH
European Correspondent: DAVID DICKSON
Contributing Writer: LUTHER J. CARTER
Research News: ROGER LEWIN (deputy editor), RICHARD A. KERR, GINA KOLATA, JEAN L. MARX, THOMAS H. MAUGH II, ARTHUR L. ROBINSON, M. MITCHELL WALDROP
Administrative Assistant, News: SCHERRAINE MACK; *Editorial Assistant, News*: FANNIE GROOM
Senior Editors: ELEANORE BUTZ, MARY DORFMAN, RUTH KULSTAD
Associate Editors: MARTHA COLLINS, SYLVIA EBERHART, CAITILIN GORDON, WILLIAM GREAVES, LOIS SCHMITT
Assistant Editors: STEPHEN KEPPLE, LISA MCCULLOUGH, EDITH MEYERS
Book Reviews: KATHERINE LIVINGSTON, *Editor*; LINDA HEISERMAN, JANET KEGG
Letters: CHRISTINE GILBERT
Copy Editor: ISABELLA BOULDIN
Production: JOHN BAKER; HOLLY BISHOP, ELEANOR WARNER; JEAN ROCKWOOD, SHARON RYAN, BEVERLY SHIELDS
Covers, Reprints, and Permissions: GRAYCE FINGER, *Editor*; GERALDINE CRUMP, CORRINE HARRIS
Guide to Scientific Instruments: RICHARD G. SOMMER
Editorial Administrator: SUSAN ELLIOTT
Assistant to the Associate Publisher: ROSE LOWERY
Assistant to the Managing Editor: NANCY HARTNAGEL
Membership Recruitment: GWENDOLYN HUDDLE
Member and Subscription Records: ANN RAGLAND

EDITORIAL CORRESPONDENCE: 1515 Massachusetts Avenue, NW, Washington, D.C. 20005. Area code 202. General Editorial Office, 467-4350; Book Reviews, 467-4367; Guide to Scientific Instruments, 467-4480; News and Comment, 467-4430; Reprints and Permissions, 467-4483; Research News, 467-4321. Cable: Advancesci, Washington. For "Information for Contributors," write to the editorial office or see page xi, *Science*, 29 June 1984.
BUSINESS CORRESPONDENCE: Area Code 202. Membership and Subscriptions: 467-4417.

Advertising Representatives

Director: EARL J. SCHERAGO
Production Manager: GINA REILLY
Advertising Sales Manager: RICHARD L. CHARLES
Marketing Manager: HERBERT L. BURKLUND

Sales: NEW YORK, N.Y. 10036: Steve Hamburger, 1515 Broadway (212-730-1050); SCOTCH PLAINS, N.J. 07076: C. Richard Callis, 12 Unami Lane (201-889-4873); CHICAGO, ILL. 60611: Jack Ryan, Room 2107, 919 N. Michigan Ave. (312-337-4973); BEVERLY HILLS, CALIF. 90211: Winn Nance, 111 N. La Cienega Blvd. (213-657-2772); SAN JOSE, CALIF. 95112: Bob Brindley, 310 S. 16 St. (408-998-4690); DORSET, VT. 05251: Fred W. Dieffenbach, Kent Hill Rd. (802-867-5581).
ADVERTISING CORRESPONDENCE: Tenth floor, 1515 Broadway, New York 10036 (212-730-1050).

Freedom of Inquiry: An Endangered Species

A series of events in recent months signals the need for attention and action by the scientific community. On the surface, the events appear unrelated, but viewed collectively, the ramifications of each have substantial impact on the future of scientific inquiry.

First, an active campaign has been launched by various individuals and groups to reduce, or ban altogether, the use of animals in scientific research. Initially, these factions rally against the sale and distribution of pound animals. This is an emotionally charged issue—the public readily identifies with the homeless animals because of attachments to their own pets. Legislation introduced to curtail the use of animals in research passed into law in Massachusetts in February. Although a similar measure was detected in the California legislature, the proponents may seek a public referendum. They may also seek to establish provisions for external review boards to make judgments concerning which research proposals involving animal experimentation are justified and which are not. Evidence thus far indicates that once the objective of banning the use of pound animals has been met, the advocates push on toward banning the use of animals from any source and for any scientific purpose.

The second concern involves the suit filed by Jeremy Rifkin to block the release of genetically engineered organisms into the environment. The case in question centers on a bacterium which, in its native state, serves as a nucleus for ice crystal formation. The removal of a single gene eliminates this characteristic. The next step was to have been the introduction of the modified bacteria into the environment of crop plants, replacing the native strain and reducing the potential for frost injury to plants. The restraining order against this, obtained by Rifkin *et al.*, is based on allegations that a National Institutes of Health review committee failed to conduct an adequate study and submit a satisfactory environmental impact statement. However, the basic issue is that many supporters of the litigation are fundamentally opposed to genetic engineering and seek to block application of the new technology.

Third is a suit brought by California Rural Legal Assistance, representing the California Agrarian Action Project, to block mechanization research in agriculture. One objective is to require the University of California to submit social impact statements on proposed research projects before they can be approved. This suit illustrates again the ways in which special interest groups attempt to regulate scientific research which they perceive is not beneficial to them. They do not accept the evidence that overall social and economic benefits far outweigh the costs.

Each case is individually controversial and each decision sets a precedent. Considered collectively, the impact can be overwhelming. It is essential, therefore, that members of the scientific community become active participants in the debates. Highly committed and articulate individuals and groups are presenting their cases to the public and the lawmakers without equally articulate rebuttal from scientists. Since litigation has become the method by which policy to constrain scientific research is decided, scientific societies may well need to invest—individually and collectively—in legal representation to present their views in opposition to such constraints.

As the National Science Board Commission on Pre-College Education recently concluded, it is critical that all students return not only to the fundamentals of reading, writing, and arithmetic, but also to scientific and technological literacy. In the interest of free inquiry and the advances that science has brought—and must continue to bring—to civilization, we must invest our energies on all fronts. To allow these and other antiscience activities to go uncontested would be unconscionable.—CHARLES E. HESS, *Vice Chairman, National Science Board, and Dean, College of Agricultural and Environmental Sciences, University of California, Davis 95616*

If an Eppendorf® Pipette could pipette a sample up to 48 times without refilling, it would look like this.

Imagine an Eppendorf Pipette that dispenses up to 48 times without refilling.

Imagine a pipette that makes serial pipetting at 1-second intervals as easy as pressing a small lever.

Imagine a pipette that eliminates cleaning, contamination and carry-over error problems with interchangeable Combitips, disposable plastic sample reservoirs available in 3 sizes (0.5, 2.5 and 12.5ml capacity).

Imagine a pipette with foolproof 'click-set' volume adjustment dial to select among 5 volume increments for each size Combitip, giving you a choice of 13 different volumes from 10 to 1,250 µl.

Only one pipette can do all this with traditional Eppendorf accuracy, precision and operating ease. Only Eppendorf makes it... The Repeater, the new repetitive pipette with disposable Combitips.

For literature, write: Eppendorf Division, Brinkmann Instruments, Inc., Subsidiary of Sybron Corporation, Cantiague Road, Westbury, N.Y. 11590, or call 516/334-7500. In Canada: Brinkmann Instruments (Canada), Ltd., or call 416/675-7911.

Eppendorf Repeater

SYBRON | Brinkmann

For literature circle reader service number 55
For a demonstration circle reader service number 56