

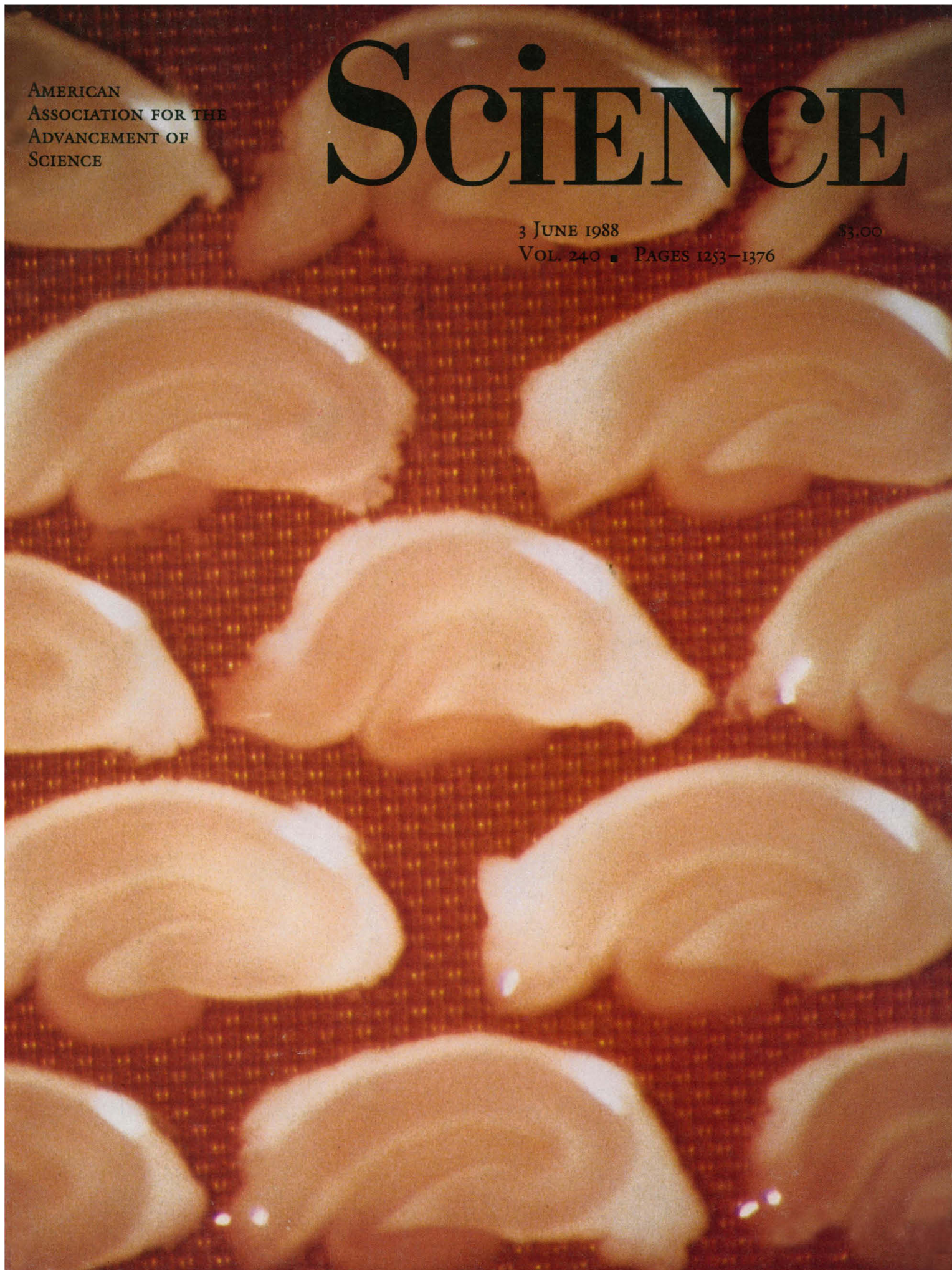
AMERICAN
ASSOCIATION FOR THE
ADVANCEMENT OF
SCIENCE

SCIENCE

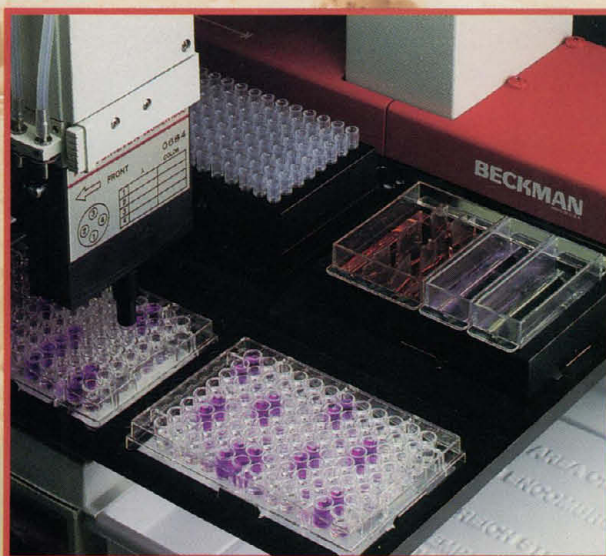
3 JUNE 1988

\$3.00

VOL. 240 ■ PAGES 1253-1376



Take the Tedium Out of ELISA and Hybridoma Methods...with the Biomek™ 1000.



Talk about tedious tasks.

A typical ELISA assay—including adding samples, enzyme-labelled antibody and substrate, diluting, washing, and transferring—requires approximately 2,000 pipettings per plate. A hybridoma fusion—including cell seedings, feedings, screening, recloning and aliquoting—represents from 65,000 to 130,000 pipettings! (Based on seeding 5-10 plates per fusion.) It all stacks up to time-consuming, error-prone tasks.

Enter the Biomek 1000.

For automation of ELISA and hybridoma methods, start to finish. Fast. Accurate. Flexible.

And Biomek goes where no other instrument has gone before. Past photometry. After Biomek takes absorbance readings, it can further manipulate samples for cell expansions, per your protocol. New ImmunoFit™ EIA/RIA Data Analysis Software can take data even further.

For applications data on ELISA and hybridoma automation, ask for SR169. Soon you'll say *"Remember the days when we spent hours, days, weeks PIPETTING???"*

To find out more, call toll-free (800) 742-2345, or write to Beckman Instruments, Inc., Spinco Division, 1050 Page Mill Rd., Palo Alto, CA 94304. Offices in major cities worldwide.

BECKMAN

A SMITHKLINE BECKMAN COMPANY

Circle No. 161 on Readers' Service Card



PREVIEWS FROM **Discount BOOK OF SOFTWARE™** AT LEAST **25% OFF!**

**EVERY DAY WE OFFER SOFTWARE AT THE LOWEST PRICES IMAGINABLE
THOUSANDS OF SOFTWARE TITLES AT BIG DISCOUNTS!
CALL US IF IT IS NOT LISTED HERE—WE HAVE IT!**

SOFTWARE FOR "IBM"

ACCOUNTING

Business Builder	\$596
DAC Easy Actg 2.0	63
Dollars and Sense 3.1	103
Information Management	146
Managing Your Money 4.0	123
One Write Plus	220
Quicken 2.0	34
Smart Money	59
Sylvia Porter Personal Finance	74

COMMUNICATION

Carbon Copy Plus	\$118
Crosstalk MK 4	128
Crosstalk XVI	93
IS Talk	37
Laplink	85
Relay Gold 2.0	138
Relay Silver 1.0	112
Slide Talk	90
Transporter 1.4	221

DATABASE

@Base	\$118
dBase III Plus	398
Data Manager PC	30
Database Manager 2	221
dBase 1.2	149
Enable 2.0	408
Microsoft Works 1.0	146
PC Converter Plus	60
PFS: First Choice 2.0	108
Q & A 3.0	208
Rapid File 1.2	221
R:Base For DOS	448
Reflex 1.14	86
Thinktank 2.4.1	146

GRAPHICS

Design CAD 3.0	168
Gem III Draw Plus	188
Generic CADD 3.0	58
Graph-in-the-box Rel. 2	57
Grasp 3.0	74
Harvard Graphics 2.1	371
In-A-Vision	298
Microsoft Chart 3.0	248
Newsroom Pro	49
PFS Graph	105
Print Shop	39
Print Shop Companion	30
Sign Master 6.2	158

LANGUAGES

Basic Compiler 5.36	\$268
Lattice C Compiler 3.2	249
Macro Assembler 5.0	96
Pascal Compiler 3.32	188
RM Basic	450
Smart Guide for DOS	22
Turbo Basic 1.1	60
Turbo C 1.5	60
Turbo Tutor 4.0	60

PROJECT MANAGEMENT

Gem Desk Top Publisher	\$238
Gem Desk Top	37
Harvard Total Project Manager	378
Timeline	288
Timelink Plus III	37

SPREADSHEET

Lotus 1-2-3 2.01	\$299
Microsoft Excel 2.0	318
Multiplan 3.04	118
PFS: Professional Plan	105
Quattro	128
Surpass	278
Swift & Easy	37
Swiftcalc PC w/Sideways	42
VP Planner	55

UTILITIES

Desqview	78
DOS Rx	\$60
Fastback 5.14	93
Genifer	213
Keyworks 3.0	74
Mace Utilities 4.10	55
Memory Mate 3.0	52
Norton Utilities-Advanced	83
PC Tools Deluxe 4.2	59
Quick Index III	111
Runtime	112
Sideways 3.2	41
SQZ Plus	59
Turbo Lightning	57
Windows 2.03	63

WORD PROCESSING

Bank St Writer Plus	\$49
Celebrity	67
Easy Extra 1.5	74
Microsoft Word 4.0	198
Multimate Adv. II	278
PFS: Prof. Write	118
Q & A Write	118
Samna Word IV	446
Volkswriter Dix Plus	74
WordPerfect 4.2	198
Word Finder	45
Zyindex (standard) 2.2	108

Software for "MACINTOSH"

dBASE MAC	\$298
Clickart Publications	37
Copy II Mac 7.1	30
Decision Map	108
Dollars & Sense 4.0	112
Draw It Again Sam	112
Easy 3D	112
Fastback 1.01	75
In Talk 3.0	146
Lazerstart 2.5	71
MAC Vision 2.0	299
Microsoft Chart 1.2	78
Microsoft Excel 1.06	296
Microsoft Works 1.1	198
Microsoft Multiplan 1.11	118
More 1.1c	221
Pixel Paint	371
Power Point 1.0	228
Printworks for MAC (Laser)	109
Ready Set go 4.0	371
Spellsweil 2.0	53
Superspool 4.0	75
Turbo Pascal	74
Turbo Tutor	52
Typing Tutor IV	44
Voila	75
Word Finder 2.0	44
Write Now 2.0	146

NEW! HOT! TITLES

SOFTWARE FOR "IBM"

Ability Plus 1.01	\$158
Fastback Plus 1.01	98
File Rescue Plus	37
Grandview	174
Networker Plus 2.0	194
Norton Guides for OS/2 API	88
Page Perfect	371
Quick Basic 4.0	68
VP Planner Plus 2.0	94

Software for "MACINTOSH"

Bookmark MAC 1.0	\$ 75
Lap Link MAC	105
MAC SQZ	60
Quicken (for MAC)	34
Timeslips III MAC	149

CALL TOLL FREE

1-800-222-Book™
1-800-222-2665

IN CT. CALL (203) 359-1660
8:00 am—5:30 pm, Mon. thru Fri.

**WHY YOU SHOULD ORDER FROM
THE BOOK OF DISCOUNT SOFTWARE:**

- ✓ **25% or MORE Off List Prices on All Software**
- ✓ **NO HIDDEN CHARGES**
- ✓ **No Shipping Charges on Credit Card or Pre-paid Orders**
- ✓ **No Handling Charges Ever**
- ✓ **Credit Card Convenience**



- ✓ **Your ONE SOURCE for Thousands of Software Titles—All at Discount Prices.**
- ✓ **No Membership Fee**

MAIL IN FOR FREE HANDBOOKS — —

PLEASE RUSH ME MY FREE COPY OF:

Discount BOOK OF SOFTWARE™

ALSO! NEW!

☐ **Book of Books™**

Cataloging 12,000 Scientific and Technical Books from 14 leading publishers.

Name

Company

Address

City State Zip

Or Send Business Card SC688

MAIL TO:

OMEGA PRESS
An OMEGA Technologies Company

Eight Omega Drive, P.O. Box 4182

Stamford, CT 06907

©COPYRIGHT 1988, OMEGA PRESS, INC. ALL RIGHTS RESERVED.
PRINTED IN USA



WE HAVE THEM ALL!

At OMEGA PRESS we strive to offer the very latest software packages, including version changes. At times however discontinued packages may affect our advertised programs.

Circle No. 24 on Reader Service Card

1259 This Week in *Science*

Editorial

1261 Random Samples

Letters

1263 AIDS Case Definition: H. H. IMREY; J. W. CURRAN, M. MORGAN ■ U.S. Observing Facilities: S. L. KEIL ■ Retirement Policy: L. M. FRIEDMAN; E. L. PATTULLO

News & Comment

1265 OTA Disputes U.S. Policy on Test Ban
1266 Cantor to Head LBL Genome Center
1267 The Coming Competition Among Clot-Busting Drugs
1269 A Prod to Productivity
1270 U.K. Earth Sciences: Some More Equal Than Others?
1271 A Fuel Shortage in Space?
1272 House Votes Ban on Low-Flying Missiles

Research News

1273 The Social Lives of Dolphins
1275 Fermat's Last Theorem Remains Unproved ■ When Good Proofs Go Bad
1277 Hotshots, Hotspots, and Female Preference
1278 Mapping by X-Ray Zapping
1279 *Random Samples*: Welcome, Engineers ■ The St. Louis Chinchillas? ■ Antiques at the NSF Dinner ■ Tell Me. Don't Tell Me

Articles

1285 Measuring the Accuracy of Diagnostic Systems: J. A. SWETS
1293 The El Niño Cycle: A Natural Oscillator of the Pacific Ocean-Atmosphere System: N. E. GRAHAM AND W. B. WHITE
1302 DNA Damage and Oxygen Radical Toxicity: J. A. IMLAY AND S. LINN

Research Articles

1310 Chimeric α_2 - β_2 -Adrenergic Receptors: Delineation of Domains Involved in Effector Coupling and Ligand Binding Specificity: B. K. KOBILKA, T. S. KOBILKA, K. DANIEL, J. W. REGAN, M. G. CARON, R. J. LEFKOWITZ

■ **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 © 1988 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 copies \$3.00 (\$3.50 by mail); back issues \$4.50 (\$5.00 by mail); Biotechnology issue, \$5.50 (\$6 by mail); classroom rates on request; Guide to Biotechnology Products and Instruments \$16 (\$17 by mail). **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*, 1333 H Street, NW, Washington, DC 20005. *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 Rat hippocampal slices supported on a nylon mesh laid over a polyethylene sheet in one compartment of a dual, linear flow, incubation and recording chamber. The 5-hour-old transverse slices (0.4 millimeter thick, 5 to 6 millimeters long, and 2 to 3 millimeters wide) are perfused with artificial cerebrospinal fluid and oxygenated with a humidified gas mixture of 95% oxygen and 5% carbon dioxide. See page 1326. [Robert D. Acland, School of Medicine, University of Louisville, Louisville, KY 40292]

Reports

- 1317 Seismic Slip and Down-Dip Strain Rates in Wadati-Benioff Zones: M. BEVIS
- 1319 Bacterial Manganese Reduction and Growth with Manganese Oxide as the Sole Electron Acceptor: C. R. MYERS AND K. H. NEALSON
- 1321 Potassium Salt Microinjection into *Xenopus* Oocytes Mimics Gonadotropin Treatment: Y.-T. LAU, R. R. YASSIN, S. B. HOROWITZ
- 1324 Epitopes Recognized by Human T Cells Map Within the Conserved Part of the GP190 of *P. falciparum*: A. CRISANTI, H.-M. MÜLLER, C. HILBICH, F. SINIGAGLIA, H. MATILE, M. MCKAY, J. SCAIFE, K. BEYREUTHER, *et al.*
- 1326 Lactate-Supported Synaptic Function in the Rat Hippocampal Slice Preparation: A. SCHURR, C. A. WEST, B. M. RIGOR
- 1328 Expression of c-fos Protein in Brain: Metabolic Mapping at the Cellular Level: S. M. SAGER, F. R. SHARP, T. CURRAN
- 1331 Familial Imprinting Determines H-2 Selective Mating Preferences: K. YAMAZAKI, G. K. BEAUCHAMP, D. KUPNIEWSKI, J. BARD, L. THOMAS, E. A. BOYSE
- 1333 A Model-Based Estimate of the Mean Incubation Period for AIDS in Homosexual Men: K.-J. LUI, W. W. DARROW, G. W. RUTHERFORD, III
- 1335 Location and Chemical Synthesis of a Binding Site for HIV-1 on the CD4 Protein: B. A. JAMESON, P. E. RAO, L. I. KONG, B. H. HAHN, G. M. SHAW, L. E. HOOD, S. B. H. KENT
- 1339 Expression of the β -Nerve Growth Factor Gene in Hippocampal Neurons: C. AYER-LELIEVRE, L. OLSON, T. EBENDAL, Å. SEIGER, H. PERSSON

AAAS News

- 1345 AAAS Annual Elections: Preliminary Announcement ■ *SB&F* Focuses on AIDS Education ■ Scientific Fraud and Misconduct Report Available ■ What's in a Name?

Book Reviews

- 1349 New Directions in Ecological Physiology, *reviewed by* F. H. POUGH ■ Perinatal Development, P. G. NELSON ■ Virulence Mechanisms of Bacterial Pathogens, A. B. ONDERDONK ■ Books Received

Software Reviews

- 1353 Equation-Solving Programs for the Personal Computer: K. R. FOSTER

Products & Materials

- 1359 Benchtop GC-MS-DS System ■ CCD Camera System ■ Microplate Reader ■ DNA Labeling Kit ■ Mammalian Cell Cultivation ■ Methyl Phosphonate DNA Oligonucleotides ■ Plant Tissue Culture Products ■ Literature

Board of Directors

Sheila E. Widnall
*Retiring President,
Chairman*
Walter E. Massey
President
Richard C. Atkinson
President-elect

Floyd E. Bloom
Mary E. Clutter
Eugene H. Cota-Robles
Mildred S. Dresselhaus
Beatrice A. Hamburg
Donald N. Langenberg
William T. Golden
Treasurer
Alvin W. Trivelpiece
Executive Officer

Editorial Board

Elizabeth E. Bailey
David Baltimore
William F. Brinkman
E. Margaret Burbidge
Philip E. Converse
Joseph L. Goldstein
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
James J. Bull
Charles R. Cantor
Ralph J. Cicerone
John M. Coffin
Bruce F. Eldridge
Paul T. Englund
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
Jiri Novotny
Gordon H. Orians
Carl O. Pabo
John S. Pearce

Yeshayau Pocker
Michael I. Posner
Jean Paul Revel
Russell Ross
James E. Rothman
Daniel V. Santi
Thomas C. Schelling
Ronald H. Schwartz
Vernon L. Smith
Otto T. Solbrig
Robert T. N. Tjian
Virginia Trimble
Geerat J. Vermeij
Harold Weintraub
Irving L. Weissman
George M. Whitesides
Owen N. Witte
William B. Wood

IMMUNOAFFINITY MEMBRANE

PALL

IMMUNODYNE™

Discover the highest level of accuracy, sensitivity, tensile strength and whiteness.

Immunodyne immunoaffinity membrane is a technological breakthrough for immunodiagnostic assays. This specially modified, optically pure white nylon 66 solid support membrane is ideal for immunofiltration, dot ELISA and other solid phase immunossay protocols.

Immunodyne membrane features a chemically preactivated surface offering a higher density of covalent binding sites than technologies of the past. It permanently immobilizes proteins on contact without loss of biological activity. The total internal and external pore surface area available for specific analyte detection provides almost a 1000-fold increase over non-porous solid phases. This high surface area and binding capacity

can serve to increase immunoassay rates and sensitivities in a wide variety of assay formats.

Protocols are available to ensure low background non-specific protein binding and optimize immunoassay procedures.

Immunodyne membrane also possesses two characteristics which are becoming increasingly more critical in assay development—pure whiteness and high tensile strength. Being pure white, it provides perfect color discrimination, *even when wet*. Through a special Pall process, this amazingly high microporous membrane has exceptional tensile strength. Its high tear resistance makes it ideal for engineering into fabricated devices on

the production line under the most stressful conditions.

Discover how Immunodyne immunoaffinity membrane and Pall's technical, engineering, and manufacturing support can help you successfully develop your immunoassay. For more information or technical assistance, contact Pall BioSupport 77 Crescent Beach Road, Glen Cove, NY 11542; 800-645-6246 (in NY State: 516-759-1900).



**Pall
BioSupport**



Solid Support Every Step Of The Way.

Circle No. 189 on Readers' Service Card

This Week in SCIENCE

Pacific turbulence

THE El Niño–Southern Oscillation (ENSO) is an irregular self-sustaining cycle of alternating warm and cool water episodes in the Pacific Ocean; despite reference to the baby (El Niño), powerful weather effects can be produced that sometimes have disastrous biologic consequences (page 1293). ENSO is governed by a natural oscillator that couples several ocean and atmosphere phenomena—the sea surface temperature, the surface wind stress, and the thickness of the ocean's warm upper layer of water. Each parameter shows its own quasi-periodicity but all are interrelated; together they maintain an oscillation with a 3- to 5-year periodicity. Graham and White provide a review and a new synthesis of numerical models and field observations of ENSO and emphasize the importance to the ENSO oscillator of wave motions in the ocean. Rossby waves travel slowly from east to west (taking, depending on latitude, from 9 months to 4 years to cross the Pacific basin); at the Pacific's western boundaries, faster moving Kelvin waves are reflected back toward the equator to reinitiate the cycle. Prospects for forecasting El Niño events continue to improve as more is understood about the interplay of ocean and atmosphere dynamics.

Adrenergic receptors: structure and function

CHIMERIC genes are helping to clarify how structure and function are related in adrenergic receptors (page 1310). Both α_2 and β_2 receptors bind various agonists and antagonists and both bind G proteins; however, when the β_2 receptor binds a G protein, the enzyme adenylyl cyclase is stimulated, but, when the α_2 receptors couple with G proteins, enzyme activity is inhibited. Because the α_2 and β_2 adrenergic receptors both have seven membrane-spanning domains, a panel of patchwork receptors could be produced from various combinations of genes encoding domains of the two

receptors. The ability of each chimera to bind with agonists and antagonists and to activate adenylyl cyclase in association with G protein binding was then evaluated and correlated with the domains making up the chimera. Kobilka *et al.* point out that a number of hormones, neurotransmitters, and drug receptors have structures that are homologous to those of the adrenergic receptors and that structure-function relations in these molecules might also be studied by constructing chimeras. This method is superior to mutagenesis and to cleavage analyses, in both of which loss of function rather than the acquisition of a new activity serves as the end point.

Plate subduction into the earth

A subducting oceanic tectonic plate apparently experiences significant deformation as it penetrates into the mantle of the earth at a subduction zone (page 1317). The rate of deformation or the strain rate of subducting slabs has been calculated from the magnitudes of deep earthquakes that have occurred in slabs at mantle depths of 75 to 175 kilometers. The slab strain rate turns out to be not much smaller than the strain rate of the surrounding mantle into which it is descending. Thus, subducting slabs are neither rigid nor strong. Bevis suggests that there may not be a barrier to subduction at 680 kilometers, an important seismic discontinuity in the mantle, because such a barrier would cause the weak slabs to buckle, and buckling is not evident.

Finding mates with good scents

AN explanation is at hand for the observation that, normally, inbred male mice choose to mate with female mice who have different tissue histocompatibility types (called H-2) than their own: the males are choosing a "non-self" partner and this is a negative response to their early family

experiences (page 1331). Litters of newborn mice were separated from their mothers and raised by foster parents; the genetic composition of the biologic and the foster parents differed only in the H-2 genetic region. At maturity, the fostered males (uncharacteristically for inbred mice) showed marked preferences for females of their own H-2 type rather than for the non-self choice that was the same as that of their foster parents. These experiments of Yamazaki *et al.* indicate that early chemosensory imprinting—the smell of the foster parents or siblings—directly guides the choice of a mate, probably helping the male mouse avoid mating with his closest kin.

AIDS incubation periods

FOR two AIDS risk groups, the incubation periods—the time from infection with HIV-1 (the AIDS virus) to diagnosis of the disease AIDS—have been determined, and they are very similar (page 1333). An 8.2-year incubation period was previously calculated for adults who had acquired AIDS through blood transfusions, but it has been unclear whether this figure would apply to other groups as well. Using serum data from a cohort of 84 homosexual and bisexual men, Lui *et al.* have developed a model from which an incubation period of 7.8 years for the homosexual-bisexual risk group was calculated; of all the adult AIDS cases in the United States, 74% occur among individuals in this risk group. All of the men in the cohort had developed serum antibodies to HIV-1 within 12 months of having had a negative blood test. Although the year of seropositivity in the homosexual-bisexual group was used as a proxy for the year during which exposure to the virus occurred (because the exact date of exposure to the virus could not be directly known), the true incubation period is not likely to be off by greater than 12 months; it is known from studies of adults who have contracted AIDS through blood transfusions that sera usually become positive for HIV-1 antibody within a few months of exposure to the virus.

The Clear Choice

Introducing **REFERENCE UPDATE™** — the enlightened approach to staying abreast of the scientific literature using your personal computer. This weekly service represents a whole new concept in keeping up with current publications in your field.

Each week subscribers will receive a single floppy disk containing the tables of contents from the current issues of more than 300 major journals of biology and medicine. Simply slip the disk into your computer and request any combination of authors, words in the title, and/or journal names. References that fit your retrieval request will immediately appear on the screen. *You pay no line charges* and retrieve only current references — not the ones that you already saw last week or last month.

If you wish, **REFERENCE UPDATE™** will automatically print reprint requests on special cards provided by RIS. Selected references may be entered directly into your *Reference Manager®* database or transferred into a disk file as a Medline formatted text file.

Of course we don't have a weekly cartoon, "Current Comments®", or a "Press Digest". But neither do we require thumbing through page after page of irrelevant journals, or moving awkwardly between cryptic index numbers in the back pages and titles in the body of a booklet. All we do is provide the information that you need, on time, and in a form that is easy to use.

And the biggest surprise is that the new, enlightened way costs less. Our introductory charter subscription price (through September 1, 1988) is only \$69.00 (plus \$20.00 postage and handling) for a 26 week trial. Our regular price will be \$250.00 a year — *less than \$5.00 a week*.

REFERENCE UPDATE™ is available for the IBM-PC and all compatibles as well as for the Apple Macintosh. Also available from RIS: *Reference Manager®* - the leading bibliographic management software, and *Grant Accountant™* - for more efficient management of grant funds.

REFERENCE UPDATE™

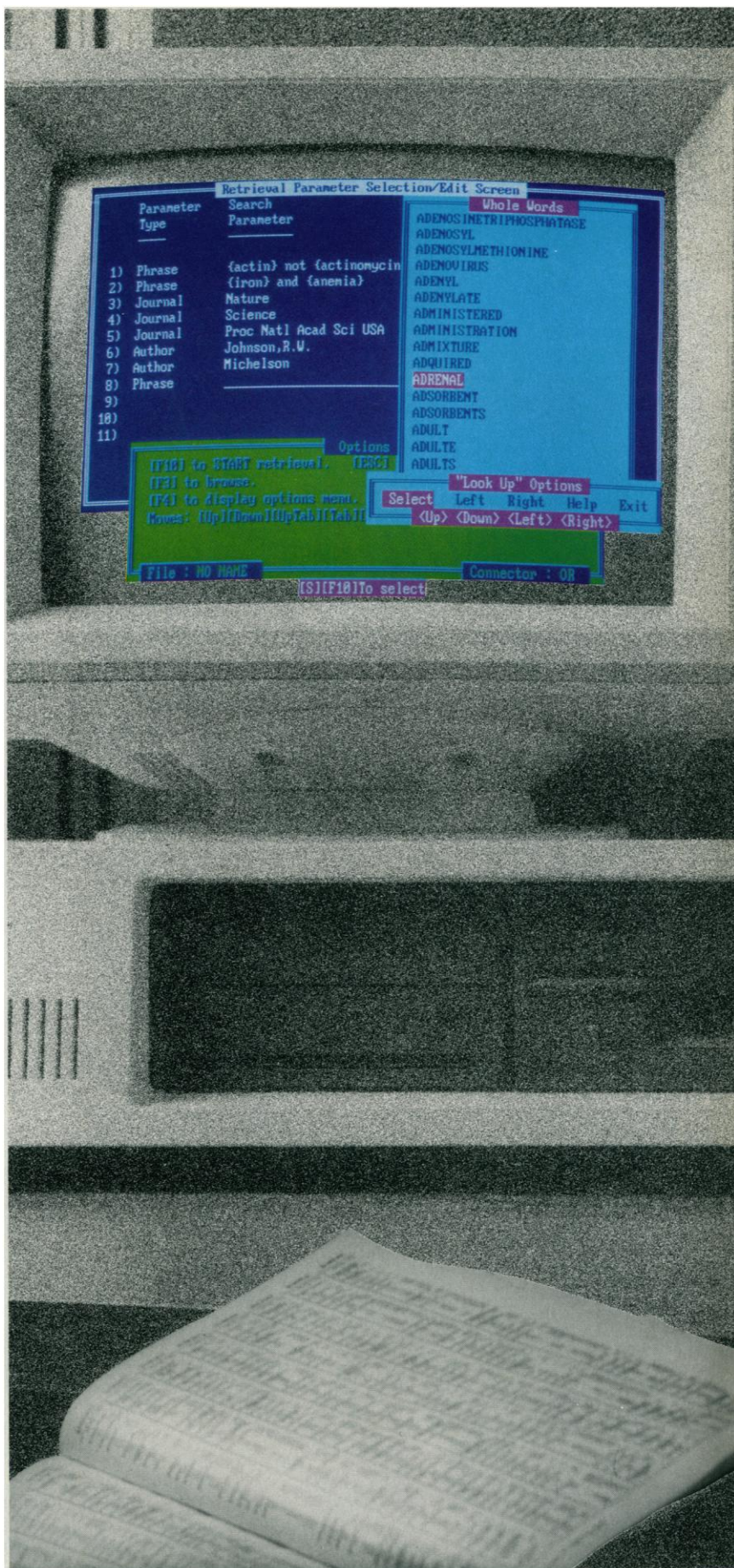
Research Information Systems, Inc.

1991 Village Park Way, Suite 205, Encinitas, CA 92024
(800) 722-1227 In California (619) 753-3914

In Western Europe: BILANEY Consultants GmbH Telefon: 02 11/37 60 91
In Australia: AMPL Software Pty., Ltd. Phone: (02) 884 019

Current Comments is a trademark of Institute for Scientific Information

Circle No. 187 on Readers' Service Card



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: Alvin W. Trivelpiece

Editor: Daniel E. Koshland, Jr.

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

EDITORIAL STAFF

Managing Editor: Patricia A. Morgan

Assistant Managing Editor: Nancy J. Hartnagel

Senior Editors: Eleanore Butz, Ruth Kulstad

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

Letters Editor: Christine Gilbert

Book Reviews: Katherine Livingston, *editor*; Deborah F. Washburn

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, Beverly Shields, Anna Victoreen, Barbara Wittig

Production Manager: Karen Schools

Assistant Production Manager: James Landry

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

Covers Editor: Grayce Finger

Manuscript Systems Analyst: William Carter

NEWS STAFF

News Editor: Barbara J. Culliton

News and Comment: Colin Norman, *deputy editor*; William Booth, Gregory Byrne, Mark H. Crawford, Constance Holden, Eliot Marshall, Marjorie Sun, John Walsh

Research News: Roger Lewin, *deputy editor*; Deborah M. Barnes, Richard A. Kerr, Jean L. Marx, Leslie Roberts, M. Mitchell Waldrop

European Correspondent: David Dickson

BUSINESS STAFF

Business Staff Manager: Deborah Rivera-Wienhold

Classified Advertising Supervisor: Karen Morgenstern

Membership Recruitment: Gwendolyn Huddle

Member and Subscription Records: Ann Ragland

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

Employment Sales Manager: Edward C. Keller

Marketing Manager: Herbert L. Burklund

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 60611: Jack Ryan, Room 2107, 919 N. Michigan Ave. (312-337-4973); San Jose, CA 95112: Bob Brindley, 310 S. 16 St. (408-998-4690); Dorset, VT 05251: Fred W. Dieffenbach, Kent Hill Rd. (802-867-5581); Damascus, MD 20872: Rick Sommer, 24808 Shrubbery Hill Ct. (301-972-9270); U.K., Europe: Nick Jones, +44(0647)52918; Telex 42513; FAX (0392) 31645.

Information for contributors appears on page XI of the 25 March 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, NY 10036. Telephone 212-730-1050 or WU Telex 968082 SCHERAGO.

Random Samples

Einstein once said, "Science can progress on the basis of error as long as it is not trivial." Farraday was once asked by a colleague, "Is Professor X always wrong?" "He's not that consistent," replied Farraday. Once when Philip Handler was chairman of the National Science Board and was defending the budget of the National Science Foundation, a hostile senator said, "I hear you biochemists want to adulterate bread by adding vitamin B to it. If the good Lord had wanted vitamin B in bread he would have put it there." Handler responded, "The good Lord did put vitamin B in bread. It was man who took it out in order to make white bread. The scientists who want to put it back are doing God's work." The NSF appropriation passed.

These vignettes are not the hard stuff of new scientific experiments or theories on which major scientific progress is based, but they are vignettes illustrating the processes and illuminating the people who create it. In this issue of *Science* we introduce a new feature in which incidents similar to those described above will be recorded (see page 1279). It will include testimony before Congress, quotations of scientists and of nonscientists about science, philosophical observations, and historical events. It is intended, like stroboscopic flashes, to highlight the insight and amusement that become visible transiently in the onward march of science. This column will be researched and written by Gregory Byrne, who will welcome your contributions.

One particular type of contribution will satisfy two needs. *Science* is deluged with requests to report prizes, obituaries, and promotions. We report little in this regard, not because the items are unimportant, but because to do a good job would require pages of sleep-inducing facts. Specialty journals can do this for one discipline, but *Science* covers the entire range of disciplines and there are innumerable prizes. If we wish to be fair to all disciplines, we would soon be swamped. However, anecdotes from award ceremonies frequently reveal little-known facts about how important discoveries were made or how scientific careers were formed. These and other amusing insights tell a great deal about the policies and history of science. *Science* readers should find that reporting of such information is worthier of space than a dry recital of the awards, promotions, and deaths. Those who provide us with interesting stories will be in the happy situation of giving our readers some ideas to ponder.

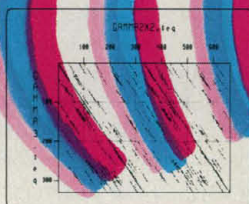
We have named the page "Random Samples." The dictionary defines "random" as "without definite aim, direction, rule or method, haphazard" and "sample" as "a part of anything shown as evidence of the quality of the whole." An individual anecdote is not evidence in science, and the items on this page will be collected with no large goal or message in mind. But often facts collected with one aim in mind can turn out to be useful in an unexpected connection. Space does not allow coverage of all the awards, all the testimony before Congress, or all the incidental items that occur each week. But if we are random enough, and our samples are representative, a picture of some of the fun and humanity of science may serendipitously emerge.

To believers in fairy tales, the good guys always win and the winners are always good guys. In the real world, including science, that is not always true. Some very important discoveries have been made by individuals whom one might not want to invite to dinner. And some extremely nice people just do not end up in the winner's circle. Character, however, is not irrelevant, since individuals who are generous with advice and materials to colleagues accelerate science by helping others, sometimes at sacrifice to their own advancement. The press is great at exposing unpleasant character flaws, but the person who is willing to play by the rules instead of cutting corners frequently gets short shrift. Scientists' attitudes, however, to new opportunities for inquiry, their insights into future directions of science, their eloquence in testimony before Congress, and their memories of how certain discoveries were made can provide insight, inspiration, or warning to others who are practitioners of the art. In some cases they may affect the research effort of the scientist in the laboratory. In other cases they may provide an epigram that will be useful to those trying to communicate more effectively with the public. Felicity in language and novelty in ideas deserve recognition whenever they occur. Those who notice such events should send them to us so that others may also enjoy and profit from the experience.—

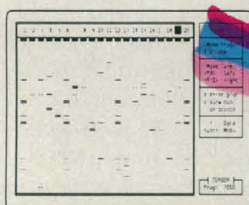
DANIEL E. KOSHLAND, JR.

LASERGENE

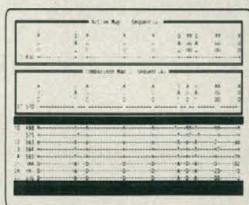
DNASTAR
Molecular Biology
Software on
Compact Disk



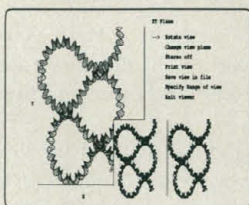
DOTPLOT



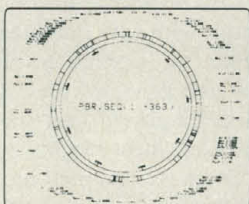
DIGIGEL



RMAP



BEND



MAPDRAW

DNASTAR now offers its comprehensive Molecular Biology software packages, including the complete GenBank® and NBRF-PIR® databases on **LASERGENE™** Compact Disk.

FULL DNA AND PROTEIN ANALYSIS The comprehensive system for processing nucleotide and amino acids sequences -- single programs to custom packages to turnkey systems.

UP TO DATE COMPLETE DATA Quarterly releases of **LASERGENE™** include the full GenBank® and NBRF-PIR® releases, not an abridged semi-annual release on floppies.

FAST DATABASE SEARCHES A full text search of GenBank® and NBRF-PIR® databases takes only seconds. Sequence pattern searches and homology searches take minutes. All words in the databases are indexed by DNASTAR, not just keywords and authors.

CONVENIENT USER INTERFACE All DNASTAR programs are accessible from a central menu. Files and programs can be selected by a simple point and pick method or by name. No computer commands to remember. Formulation of database queries, even complex relational ones can be done through a simple menu.

SAVES HARD DISK SPACE When used with **LASERGENE™**, the complete DNASTAR system including databases requires only a few megabytes of hard disk space.

FULLY INTEGRATED **LASERGENE™** uses Microsoft® DOS extension to seamlessly integrate the CD into the operating system as a standard drive. **LASERGENE™** is compatible with other CD products and does not interfere with your current software.

DIGITIZER DATA ENTRY Sequencing project and electrophoresis data entered directly using the **SEQ-EASY II™** digitizer with speech synthesizer. Use **DNASTAR PULSE™** for superior results in large fragment separation.

AVAILABLE FOR IBM PC/XT/AT, Compaq 386 and compatibles. Networks supported. IBM System 2 available second quarter 88.

DNASTAR continues to set the standard in
Molecular Biology Microcomputer Software Systems.

DNA*

DNASTAR 1801 University Ave, Madison WI 53705. (608) 233 5525 and 565 Chiswick High Rd, London W4 3AY, England. 1-994 0619
TELEX: London 934386 FAX: London 1-994 5578

Circle No. 181 on Readers' Service Card

AAAS Publications on

Science, Arms Control, and National Security

The Verification Challenge: Problems and Promise of Strategic Nuclear Arms Control Verification. By Richard A. Scribner, Theodore J. Ralston, and William D. Metz.

An authoritative examination of strategic nuclear arms control verification. Addresses principles and tasks of verification, technology and monitoring, compliance issues, and future verification needs. 1985; 249 pp.; softcover \$18.75 (\$15.00 for AAAS members); AAAS #85-31.

1986 Colloquium Reader— Science and Security: The Future of Arms Control. Edited by W. Thomas Wander, Richard A. Scribner, and Kenneth N. Luongo. More than 40 essays by leading experts. Examines key issues in arms control and national security. 1986; 205 pp.; softcover \$8.00 (\$6.40 for AAAS members); AAAS #86-16.

1986 Colloquium Proceedings— Science and Security: The Future of Arms Control. Edited by W. Thomas Wander and Kenneth N. Luongo. The edited proceedings from the first Annual AAAS Science, Arms Control, and National Security Colloquium. 1987; 326 pp.; softcover \$15.00 (\$12.00 for AAAS members); AAAS #87-17.

The Strategic Defense Initiative: Some Arms Control Implications. By Richard A. Scribner and Jeffrey Boutwell. A concise overview of topical SDI issues. 1987 (2nd ed.); 44 pp.; softcover \$2.50 (\$2.00 for AAAS members); AAAS #87-5.

Preventing Nuclear War: Steps That Can Be Taken Now. Edited by Richard A. Scribner. A survey of recent proposals for reducing the risk of nuclear war. It includes an extensive bibliography and glossary. 1987; 80 pp.; softcover \$4.00 (\$3.20 for AAAS members); AAAS #87-10.

Strategic Nuclear Arms Control Verification: An Annotated Bibliography, 1977–1984. By Richard A.

Scribner and Robert Travis Scott. A comprehensive guide to literature that is suitable for class or research use. Cross-referenced by subject. 1985; 90 pp.; softcover \$7.50 (\$6.00 for AAAS members); AAAS #85-8.

Strategic Nuclear Arms Control Verification Terms and Concepts: A Glossary. By Richard A. Scribner and Kenneth N. Luongo. A comprehensive glossary of weapons technology, arms control, and treaty terminology. 1985; 42 pp.; softcover \$2.50 (\$2.00 for AAAS members); AAAS #85-2.

Nuclear and Conventional Forces in Europe: Implications for Security and Arms Control. Edited by W. Thomas Wander. Original essays on major issues related to European security. 1987; 220pp.; softcover \$10.00 (\$8.00 for AAAS members); AAAS #87-18.

Emerging Technologies and the Conventional Defense of NATO. By Jonathan B. Tucker. Examines the broad range of issues in the debate over high technology conventional weapons and their implications for NATO defense. 1987; 74pp.; softcover \$7.00 (\$5.60 for AAAS members); AAAS #87-20.

Strategic Anti-Submarine Warfare: Technology and Strategy. By Tom Stefanick. An overview of the technologies, operations, and implications of strategic anti-submarine warfare. 1988; 60pp.; \$5.00 (\$4.00 for AAAS members); available in Fall 1988; AAAS #87-19.

Fear of Cheating, Fear of Spying: A Videotape and Companion Guide. Prepared by Richard A. Scribner and Shelley Alpern. This 40-minute videotape addresses the politics and technology of nuclear arms control verification with a special emphasis on the current compliance controversy. 1986; \$60.00 for VHS or Beta, \$75.00 for U-matic (please specify format); AAAS #86-10.

Order from: AAAS Marketing Dept. SG, 1333 H Street, NW, Washington, DC 20005. Please specify the appropriate AAAS #(s); add \$2.00 postage & handling per order; and allow 4–6 weeks for delivery. VISA and MasterCard accepted. For shipments to CA, add applicable sales tax.

Produced by the Program on Science, Arms Control, and National Security of the
American Association for the Advancement of Science

The Constrained Curve



The Constrained Curve

The geometric path traced by a robot arm is independent of time. Now a mathematician at the General Motors Research Laboratories has devised a simple, innovative way to relate the path to time so that the machine can track the path and meet specific performance objectives without exceeding its physical operating limits.

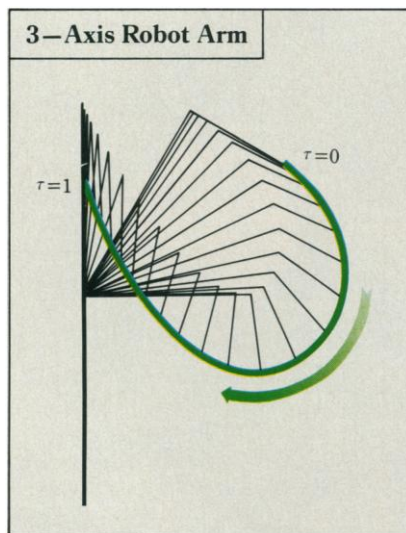
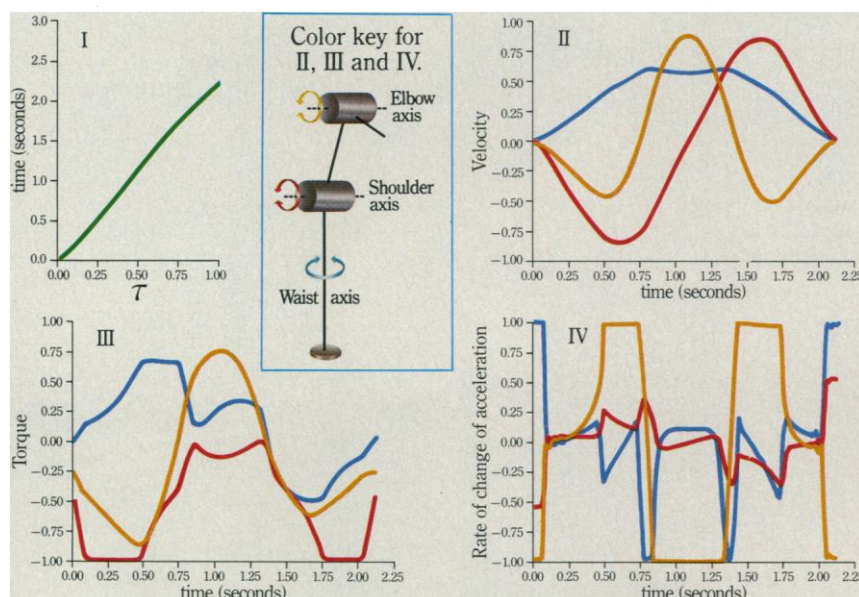


Figure 1: Schematic diagram of a 3-axis robot tracing a path in 3-space.

Figure 2: Results for Figure 1 path. I: Plot of the change of variables, $t=h(\tau)$. II, III, and IV: Normalized velocity, torque, and rate of change of acceleration for the waist, shoulder, and elbow (for any variable, a value of ± 1 indicates operation at a limit).



Industrial robot arms are very good at repeating a well defined motion with a high degree of accuracy. A robot with a welding tool, a paint sprayer, or a grasping device at its tip can weld in the right spot, spray a precise pattern, or locate a part in a given place time after time.

This untiring precision makes robots valuable in a quality-oriented manufacturing process such as the assembly of an automobile. That's why General Motors has installed so many robotic manipulators in its plants, and why GM is intent on developing technology and software to use these machines to their best advantage.

When a robot is to apply sealant to a windshield opening, or move a part from one point to another, its tip is positioned at points along a fixed geometric path, always maintaining the orientation needed to perform the task.

Mathematically, tip position along the path can be described as a func-

tion of a one-dimensional position parameter τ that ranges from 0 to 1 as the path evolves from beginning to end. Actually, for a robot having three joints, Figure 1 for example, tip position is determined by a set of three functions of τ , one for each joint of the arm. Each separate joint function relates a specific angle of rotation, θ , about that joint axis to a given value of τ .

To get the robot to perform a task, however, its computer controller must associate each point on the path with some value of time—in effect telling the robot to be in position A at a certain time, position B at another time, and so on, throughout the path.

Establishing an appropriate correspondence between time and the path position parameter is an important prerequisite to actually controlling the robot to follow the path.

Dr. Samuel Marin, a mathematician at General Motors Research Laboratories, has devised an effective and efficient means of computing the required correspondence. His work addresses productivity concerns. Dr. Marin's objective is to make cycle time (the time it takes the robot to trace the path from beginning to end) as small as possible, yet to respect at all times the physical operating limits of the robot.

Dr. Marin noted that by seeking a correspondence that gives time explicitly in terms of the path position parameter, $t=h(\tau)$, the problem's character changes. It appears not so closely associated with control theory, where the problem has also been studied, but more like a problem of nonlinear optimization.

Setting $g(\tau)=h'(\tau)$, the derivative of h with respect to τ , allowed Dr. Marin to pose the minimum time prob-

lem in the following way: minimize $\int_0^1 g(\tau) d\tau$, subject to some constraints dictated by the physical operating limits of the robot mechanism. These limits on the robot—limits on velocity, acceleration or torque, and on rate of change of acceleration (Fig. 2)—can all be formulated as differential inequality constraints and are all expressible in terms of the unknown function $g(\tau)$, as: $g(\tau) \geq G(\tau, g, g', g'') \tau \in [0, 1]$.

If the problem could be discretized, making it in some sense finite, it could be put on a computer and solved numerically. So Dr. Marin replaced the unknown function with a piecewise cubic approximation.

This allows the search for the unknown function to be confined to a class of functions that are completely characterized by a finite number of coefficients in a B-spline series.

He similarly discretized the constraints, replacing the infinite set of constraints with a finite dimensional subset that could be dealt with numerically.

He completed the formulation of the discrete problem by incorporating a grid-refinement strategy. Now the problem's dimension could be gradually increased to better approximate the continuous case.

What resulted was a classic nonlinear optimization problem, a finite dimensional problem in which it remained only to find the coefficients of the B-splines while satisfying the constraints.

A monotonicity property of this problem coupled with properties of the approximation method suggests that the simple technique of cyclic coordinate descent might best provide a solution.

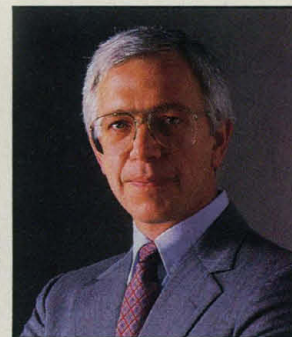
"While not so effective in other applications, a cyclic coordinate descent-based algorithm appears to be exactly what is needed in this class of problems," notes Dr. Marin. "With modifications introduced to ensure that the iterates are strictly feasible, this method has consistently and rapidly solved the problem."

Working closely with mathematicians at Rensselaer Polytechnic Institute, Dr. Marin is confirming this method's utility. In comparisons so far with several widely used, general-purpose optimization codes, the special method consistently shows itself to be superior.

"My work in path parametrization is just part of the story here at GM," emphasizes Dr. Marin. "Many aspects of this problem's formulation are rooted in deeper concerns about how robots can be made to move faster and more accurately. These concerns originated in the work of Dr. Robert Goor, my colleague in the Mathematics Department, and have motivated several significant advances in robot control and trajectory planning.

"Until all the pieces are put together in a production system, it's difficult to gauge the full value of this work. However it will help reduce our manufacturing costs and will enhance our product quality."

THE MAN BEHIND THE WORK



Dr. Sam Marin is a Senior Staff Research Scientist in the Mathematics Department of the General Motors Research Laboratories. He is also the Manager of the Department's Mathematical Analysis and Computation Section.

Dr. Marin received his undergraduate degree in mathematics from St. Vincent College in Latrobe, Pennsylvania, and holds both an M.S. and a Ph. D. in that discipline from Carnegie-Mellon University. Between graduate degrees, Sam was an officer in the U.S. Navy, teaching mathematics at the Naval Nuclear Power School.

Since joining General Motors in 1978, Dr. Marin has pursued interests in numerical analysis and approximation. He has published research relating these areas to a variety of applications, including robotics, geometric curve design, and acoustics.

Sam is a member of the Society for Industrial and Applied Mathematics. He lives in Rochester Hills, Michigan, with his wife and two children.

General Motors



REAL TIME CONFOCAL MICROSCOPY

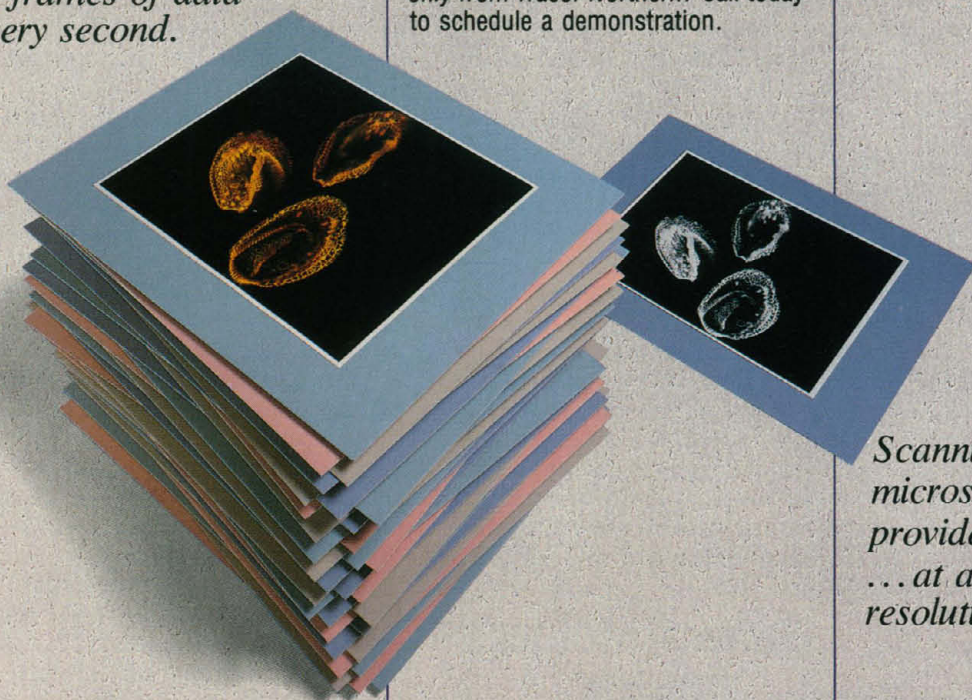
Only the TSM™ from Tracor Northern provides real time direct viewing at a rate in excess of 30 frames per second and at a resolution of greater than 4000 lines. This allows acquisition using any camera — or by direct viewing with the naked eye.

TSM™ is not restricted to any single light source. Tungsten/halogen, xenon or mercury sources are all available.

TSM™ is ideal for fluorescence microscopy. Rather than slow scan frame capture, the real time optical sectioning capability of the TSM™ allows rapid location and inspection of various planes within the labelled sample.

Real time confocal microscopy — only from Tracor Northern. Call today to schedule a demonstration.

TSM™ real time confocal imaging provides over 30 frames of data every second.



Scanning laser microscopy provides 1 frame ... at a much lower resolution.



Tracor Northern

TRACOR NORTHERN 2551 WEST BELTLINE HIGHWAY MIDDLETON, WISCONSIN 53562-2697
TEL: (608) 831-6511, FAX: (608) 836-7224, TWX: 910-280-2521
TRACOR EUROPA B.V. P.O. BOX 333 3720 AH BILTHOVEN THE NETHERLANDS
TEL: 030-78 08 55, FAX: 030-78 15 64, TELEX: 70775
TRACOR NORTHERN JAPAN 1-18-13 HAMAMATSU-CHO MINATO-KU TOKYO 105, JAPAN
TEL: 81 3 434 4866, FAX: 81 3 434 4897, TELEX: 7812423879 (23879 TRACOR J)
TRACOR NORTHERN CANADA 116 GALAXY BLVD. REXDALE, ONTARIO M9W 4Y6 CANADA
TEL: (416) 674-4600, FAX: (416) 674-4658, TELEX: 06989179

Circle No. 138 on Readers' Service Card

Why are laboratories switching from
Ficoll[®]/Hypaque[®]?

Sepracell-MN™.

Sepracell-MN™ is now used in hundreds of laboratories to separate mononuclear cells. It's a chemically modified colloidal silica medium (patents pending worldwide) that separates cells with continuous density gradients formed during centrifugation.

Separations are *better*. Routinely obtain 35% more and 15% purer lymphocytes. (Results available upon request).

Separations are *easy*. No layering. Use any size tube. Mix equal volumes of Sepracell-MN™ and whole blood, then centrifuge.

Separations are *versatile*. Use buffy coat or leukopak. Separate mononuclear cells further to monocytes and lymphocytes.

Separations are *affordable*. Sepracell-MN™ **costs 50% less** per ml than Ficoll-Paque®[®], LSM®[®], or Histopaque®[®].

Sepracell-MN™ is conveniently packaged in six non-breakable plastic bottles. One liter is \$50, five liters is \$200. Why not try Sepracell-MN™ in your laboratory? To place an order or to receive literature call toll free 1-800-222-0924.

Sepratech
CORPORATION

Circle No. 227 on Readers' Service Card

305 North MacArthur Boulevard . Suite 100 . Oklahoma City, OK 73127 . 1 (405) 789-0577
Hypaque®[®], LSM®[®] and Histopaque®[®] are trademarks of respectively, Winthrop Laboratories, Organon Teknika Corp. and Sigma Chemical Co. Ficoll®[®] and Ficoll-Paque®[®] are trademarks of Pharmacia LKB Biotechnology Inc.



Workshop on Molecular Evolution September 18-30, 1988

The workshop will consist of a series of lectures and discussions exploring multiple approaches to molecular evolution. This program is designed for established investigators, postdoctoral fellows, and advanced graduate students. The theoretical basis of comparative sequence analysis and phylogenetic tree construction will be presented. The evolution of mutation rates, introns, transposable elements, and multigene families will be examined. Model systems for the study of micro-evolution and the applicability of molecular phylogeny data towards understanding the ecology and evolutionary history of living systems will be described.

Enrollment limited to 60 students.

Director: Mitchell L. Sogin, National Jewish Center for Immunology and Respiratory Medicine

Cost: \$300 includes Tuition, Room/Board

Deadline August 1, 1988.

For further information contact Office of Sponsored Programs, Marine Biological Laboratory, Woods Hole, MA 02543 (617) 548-3705, ext. 216.

NEW!

Grant Manager II

The Leading Software Package
For Grant And Lab Management
Just Got Better!

Scientists and administrators in more than 500 university departments use our software to manage their grant spending. Now there is an even easier way! Grant Manager II will give you more time for science. It will manage your grant accounting, print orders, and update balances automatically.

Grant Manager II will give you total control over your money. It keeps updated balances to prevent overspending or underspending. It will help you detect errors in university ledgers. There's much more! Call or write for a free brochure, and start using your IBM PC to manage grants and orders.



Niles & Associates

2200 Powell, Suite 765s

Emeryville, CA 94608

FREE
brochure!

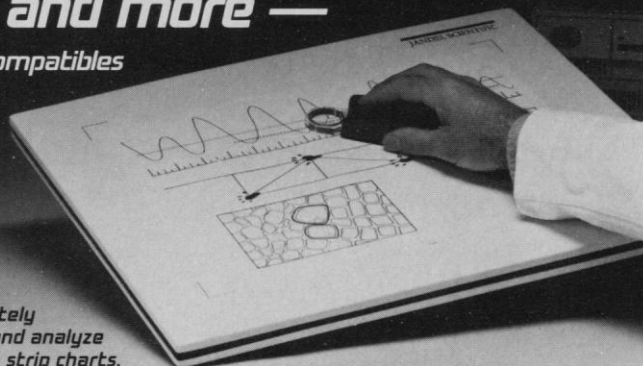
write, or call (415)
655-6666

Circle No. 152 on Readers' Service Card

SigmaScan™

*measures areas, lengths
coordinates, angles,
slopes, and more —*

IBM PC and Compatibles



Quickly and accurately
digitize, measure and analyze
photomicrographs, strip charts,
X-rays, maps, and more — using
your own PC.

- Areas, lengths, angles, and slopes
- X,Y digitizing
- User-defined units
- Standard ASCII data output
(use in Lotus, dBase, etc.)
- Keyboard macros
- User-defined data transforms

Save hundreds of hours annually over
manual measurement techniques.
Automate complex analyses. Comes
complete with software, choice of
digitizing tablet, money-back guarantee
and full year hardware warranty.

*Sigma-Scan™ software is also
available separately.*

Free brochure **800-874-1888**
In CA **415-924-8640**

FAX: 415-924-2850 / Telex: 4931977
In Europe: R.J.A. Handers, Germany
Ph #02101/666268

Jandel
SCIENTIFIC

"Microcomputer Tools
for the Scientist"

■ 65 Koch Road ■ Corte Madera, CA 94925

Circle No. 252 on Readers' Service Card

Astronomy & Astrophysics

Edited by
Morton S. Roberts

Selected from articles published in *Science* between 1982-1984, these 24 papers are divided into four parts: Solar System, Structure and Content of the Galaxy, Galaxies and Cosmology, and Instrumentation. The volume reveals a broad, coherent, and contemporary picture of our astronomical universe. Includes two Nobel Prize lectures. Fully indexed and illustrated. 1985; 384 pages.

Hardcover \$29.95

Softcover \$17.95

(AAAS members deduct 20%)

Order from AAAS Marketing,
Dept. Q, 1333 H Street, NW,
Washington, DC 20005.

Add \$1.50 postage and handling.

**American Association for the
Advancement of Science**

Book Reviews

Evolutionary Physiology

New Directions in Ecological Physiology.

MARTIN E. FEDER, ALBERT F. BENNETT, WARREN W. BURGGREN, and RAYMOND B. HUEY, Eds. Cambridge University Press, New York, 1988. x, 364 pp., illus. \$49.50; paper, \$19.95. Based on a symposium, Washington, DC, May 1986.

The ecological physiology of animals is a relatively new area of specialization. It can in part be traced to comparative physiology, but intellectually it is closely tied to natural history and studies of animal behavior. The classic study of thermoregulation of desert reptiles by R. B. Cowles and C. M. Bogert, published in 1944, showed that physiology could be related directly to the behavior of animals in the wild and that laboratory techniques could be taken into the field. Subsequently, the development of biophysical models of the mass and energy exchange of organisms has strongly influenced ecological physiology. The prominent role that terrestrial ectotherms, especially lizards, have played reflects the historical origins of the discipline as well as the conspicuous effects that interactions with the physical environment have on the minute-to-minute behavior of ectotherms.

Much work with birds and mammals had its origin in the pioneering studies of the allometry of energetics by S. Brody, F. R. G. Benedict, and M. Kleiber, and many studies of endotherms have emphasized those relationships in contexts somewhat different from those addressed in recent work with ectotherms. Plant physiological ecology has developed almost independently of work with animals, although biophysical modeling, which is now an important component of animal ecological physiology, originated with David M. Gates's studies of plants. These historical considerations help to explain the distribution of topics in this book: Plants are excluded, and the allometric approach to energetics that characterizes, for example, the work of Brian K. McNab is conspicuously absent.

At its best, ecological physiology has offered the opportunity to integrate specializations as diverse as physiology, ecology, morphology, behavior, and evolutionary biology. The most successful studies have combined reductionist and synthetic approaches to define both mechanisms and patterns. This perspective has allowed a diversity of information to be integrated into a coherent picture of how organisms work. For example, the differences in exercise physiology of

lizards in the spectrum from widely foraging to sit-and-wait predators provides a context for interpreting parallel differences in body shape, color, predator avoidance mechanisms, diet, daily energy intake, and reproduction. This integrative approach provides insights that are not apparent from more restricted perspectives.

Of course, no discipline always realizes its potential, and ecological physiology has been no exception. The disparaging comment that ecological physiologists show that "organisms can live where they do live" has some foundation. Many studies have contributed only further examples of already well-documented phenomena. In an introduction, Albert F. Bennett suggests that one problem in ecological physiology has been its reliance on the study of novel organisms in novel environmental situations. That strategy was initially productive, but the fact of adaptation to specific environments has been so well documented that additional examples will contribute little to our understanding. Further progress will depend on asking new and more sophisticated questions.

New Directions in Ecological Physiology responds to this perception of stagnation by attempting to initiate a discussion of the questions, contexts, and goals that should define the future of the discipline. In 1986, 26 biologists—all senior, all male—were assembled for three mornings of presentations and afternoons of discussion. The book is the product of that conference. As such, it is a social document as much as a scientific one, and many of the most interesting parts are to be found in the edited transcripts of discussions among the participants.

Following Bennett's introduction, the book is divided into three parts: Comparisons of Species and Populations, Interindividual Comparisons, and Interacting Physiological Systems. An opening chapter by George A. Bartholomew sets the historical scene. Interspecific comparisons have been the mainstay of ecological physiology, and Bartholomew (whose first- and second-generation students are represented among the participants) has been a pioneer in the field. Bartholomew is particularly associated with the recognition that animals in extreme environments are likely to provide the clearest examples of adaptive specialization. His fascinating chapter reviews the development of ecological physiology from a personal perspective and argues that interspecific comparisons do not yield trivial results when the

NEW FROM SINAUER ASSOCIATES

FROM MESSAGE TO MIND:

Directions in Developmental Neurobiology
Edited by S. S. Easter, K. F. Barald,
and B. M. Carlson

"Of the several collections of papers in developmental neurobiology published during the last ten or so years, this one--because of the broad focus and the generally high quality of the reviews--may be the best."

William A. Harris, *Science*

1988 368 pp. \$35.00 (paper) \$55.00 (cloth)

FOUR BILLION YEARS:

*An Essay on the Evolution of
Genes and Organisms*

W. F. Loomis

Four Billion Years discusses the evolution of life on the primitive planet Earth and the subsequent generation of complex cells. This essay is directed at all those interested in biochemistry, molecular biology, and evolutionary biology.

1988 286 pp. \$22.95 (paper) \$39.95 (cloth)

THE EVOLUTION OF SEX:

An Examination of Current Ideas

Edited by R. E. Michod and B. R. Levin

Contributors include: G. Bell, H. Bernstein, L. Brooks, J. Crow, R. Devoret, J. Felsenstein, M. Ghiselin, W. Hamilton, D. Hickey, R. Holliday, F. Hopf, B. Levin, D. Lloyd, J. Maynard Smith, R. Michod, M. Rose, J. Seger, W. Shields, R. Trivers, M. Uyenoyama, and G. Williams.

1988 384 pp. \$29.95 (paper) \$55.00 (cloth)



Sinauer Associates, Inc., Publishers
Sunderland, MA 01375
(413) 665-3722

For information circle reader service number 631

NEW!

Protecting Biotechnology Inventions

A Guide for Scientists

by Roman Saliwanchik

- An authoritative, easy-to-follow handbook by a noted patent attorney.
- Every researcher should read this book.
- Covers patents vs. trade secrets, documenting research, confidential relationships, effects of publication, approved culture depositories, and more.
- Author, formerly senior patent attorney for Upjohn, has over 20 years of patent experience in biotechnology.

160 pages, 24 illustrations. 6 × 9 inches, 1988
ISBN 0-910239-20-7. Paper, \$22.00 (prepaid)



Science Tech Publishers
701 Ridge St. Madison, WI 53705
(608) 238-8664

species are chosen with an appreciation of their whole biology and when appropriate questions are asked.

The contrast between traditional and new directions is illustrated by the discussion following Bartholomew's presentation—evolutionary questions, some commentators suggest, are not usefully addressed by studies of novel species. Developing this theme in the next chapter, Martin E. Feder expands on the views presented by Bennett to suggest that enough is enough: "Ecological physiologists have assembled an enormous number of case studies that establish 'equilibrium' beyond any reasonable doubt," and further studies "will not appreciably augment the overwhelming mass of evidence already assembled to demonstrate 'equilibrium.'" Instead, Feder suggests that general questions can profitably be addressed. The most basic of these is whether individual variation in physiological characters is related to individual variation in Darwinian fitness. Feder's chapter proposes a significant reformulation of the perspective of ecological physiology, from an attempt to understand the biology of organisms to a way of asking questions about evolution. Most of the remaining chapters continue this theme, and the final chapter (also by Feder) concludes that "For me, the central question of

organismal biology, and the one that expresses the essence of the potential new directions of ecological physiology, is, 'How can we explain the evolution of diverse complex organisms?'"

If we assume that this new direction is the right one (and not all ecological physiologists will accept that premise), how successful is it likely to be? Physiologists have long recognized the existence of individual variation in physiological characteristics, but, as Bennett points out, they have usually treated it as noise in the search for a mean value to characterize a species. In fact, that variation is the raw material of evolution. In this respect, evolutionary physiology is taking its cue from evolutionary morphology and the study of animal behavior, which came to similar realizations some time ago.

Can measurements of individual physiological variation be related to individual differences in Darwinian fitness as *New Directions* proposes? Productive attempts have originated with the observation of genetic variation and have pursued the significance of that variation at higher levels of biological organization. Most complete is the work of Ward Watt and his associates on the significance of genetic variation at the phosphoglucose isomerase locus of *Colias* butterflies. (Surprisingly, these studies are not repre-

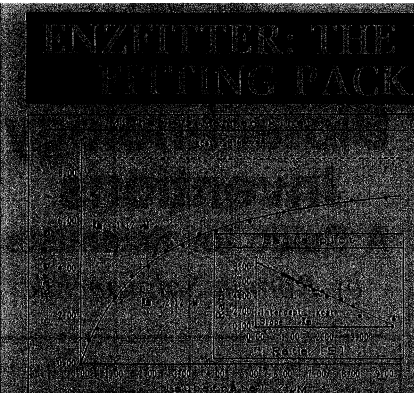
sented in *New Directions*.) Watt has demonstrated mechanistic links that extend from the different functional properties of electromorphs of the enzyme through the flight times of male butterflies, and he has shown in the field that males with the isozymes that are predicted to be favored do, in fact, sire a disproportionately large number of broods. A similar approach to the functional significance of physiological variation is represented in *New Directions* in chapters by Richard K. Koehn (the leucine aminopeptidase locus of mussels) and Dennis A. Powers (the lactic dehydrogenase locus of killifish). Another approach to relating physiological variation to fitness rests on correlations of the multiple-locus heterozygosity of individuals with physiological characters such as metabolism and growth rate. Correlations of this sort have been reported for trees, grasses, invertebrates, and vertebrates. Their widespread occurrence is intriguing, but they do not suggest a mechanistic basis for a link between physiological variation and fitness.

Demonstrating an effect of any characteristic on fitness is difficult, and demonstrating an effect on evolution is harder still. Even the most successful studies have revealed stabilizing selection and thus cases in which evolution is *not* occurring. The goal of demonstrating a role for physiological variation in directional selection remains elusive. One of the difficulties we will encounter in attempting to establish a discipline of evolutionary physiology lies in the phenomena that ecological physiologists study. Complex functions do not readily lend themselves to genetic analysis. Sprint speed, endurance, oxygen consumption, salt or water flux, and temperature tolerance are the sorts of phenomena traditionally measured by ecological physiologists, and these characteristics are almost certainly controlled by multiple genetic loci.

Given the magnitude of the difficulties, is it realistic to hope to trace mechanistic links between heritable physiological variation and whole-organism performance under natural conditions and thereby demonstrate the importance of physiological variation for evolutionary biology? That goal is certainly not going to be achieved quickly, and a clear understanding of what we must accomplish is needed to avoid unproductive searches for simple answers to complex questions.

Attempts to relate individual physiological variation to fitness have focused so far on the middle levels of the chain of evidence, especially on the relationship of physiological characteristics to locomotor performance. From this point the links must be extended downward to tissue and molecular mechanisms and upward to the effects of variation in locomotion on fitness. A reduc-

SOFTWARE



ENZITTER: THE ULTIMATE CURVE-FITTING PACKAGE FOR IBM PC

ENZITTER fits sets of experimental data by non-linear least-squares regression. It is one of several different programs provided in the ENZFITTER package. You can select the program that best fits your data. You can also use the integrated equation editor and graphing package.

The ENZFITTER package includes a graphical user interface with a menu-driven system. It is available on IBM PC compatible hardware. It is also available on other hardware. It is also available on other hardware.

ENZITTER can be used to perform robust weighting (removal of outliers), and to run in batch mode (performing several analyses automatically without user intervention). All results can be sent to a printer or to disk. ENZFITTER provides sophisticated entry and editing facilities for data and it will also read ASCII files including DOFUS 1-2-3 PRN.

ENZITTER is presented in menu form, with windows and context-sensitive help. It supports Hercules, Color and enhanced graphics cards.

Equations fitted: Linear regression Non-linear regression Michaelis-Menten Hill equation Michaelis-Menten with 2 sites Single double or triple exponential decay 1st order rate equation Hill equation	Transformed/derivative plots fitted: Residuals Scatchard Eadie Lineweaver-Burk Semi-logarithmic Lineweaver-PK
---	--

Package includes comprehensive manual (4.5/25 floppy disk) or 1MB/100KB RAMmin DOS 2.0 or later.

Payment with order please. Checks payable to BIOSOFT in US dollars or pounds sterling.

P.O. Box 580, Milltown, New Jersey 08850. Telephone (201) 613 9013.