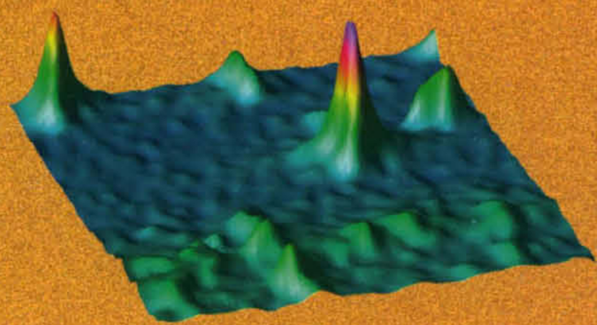
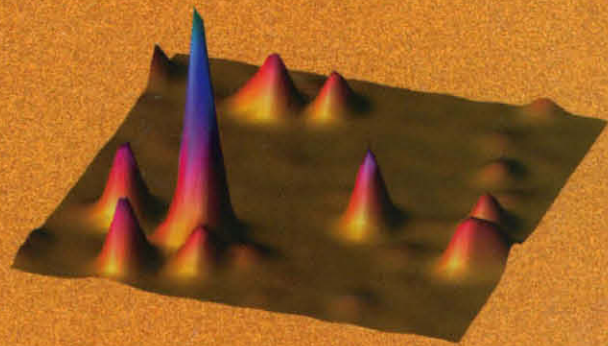
12 March 1999

Science

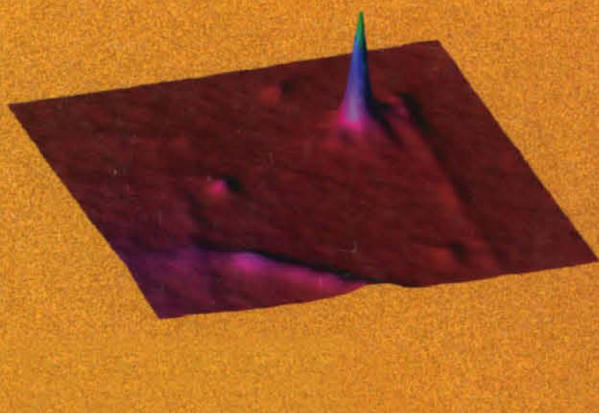
Vol. 283 No. 5408
Pages 1593–1804 $8

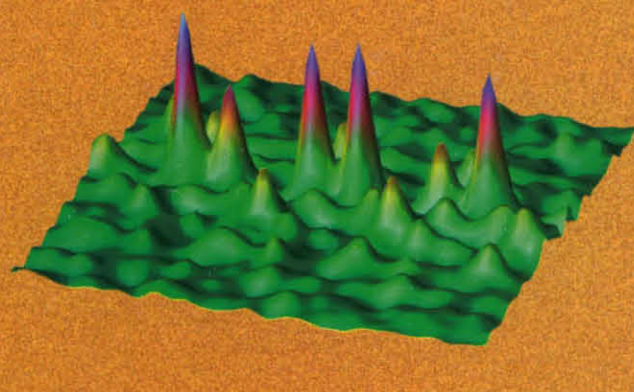




Frontiers in Chemistry

Single Molecules





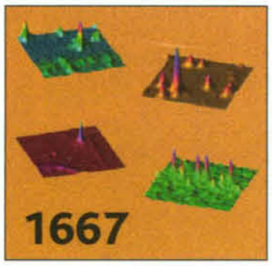
American Association for the Advancement of Science


Eagle Eye® II
STILL VIDEO SYSTEM
New Tools to Expand Your Imaging Horizons...
Cool New Tools
-20°C cooled CCD camera
Light-tight Mini Darkroom Cabinet
UV-white light conversion screen for any transilluminator
Windows95 EagleSight® image analysis software
UNITED STATES AND CANADA
(800) 424-5444
INTERNET
techservices@stratagene.com
STRATAGENE EUROPE:
Austria: 017 956 7036
Belgium: 027 13 12 11
Germany: 0699 509 6197
Netherlands: 0800 023 0448
Switzerland: 01 800 9045
United Kingdom: 0171 365 1056
DISTRIBUTORS
For a list of worldwide distributors, please visit the Stratagene Web site at www.stratagene.com
Circle No. 72 on Readers' Service Card
Stratagene... the Future of Scientific Imaging.
www.stratagene.com
STRATAGENE

VOLUME 283 12 MARCH 1999 NUMBER 5408

Science

www.sciencemag.org



COVER Optical images of single molecules. Clockwise from upper left. Frequency-space: pentacene in *p*-terphenyl at 2 kelvin (K). Confocal: protein kinase A regulatory subunit in agarose gel, 295 K (room temperature). Total internal reflection: green fluorescent protein in polyacrylamide gel, 295 K. Far-field epifluorescence: terrylene in *p*-terphenyl, 2 K. Special section topics begin on p. 1667. [Images: W. E. Moerner, W. P. Ambrose, S. Brasselet, J. Deich, R. M. Dickson, D. J. Norris, S. S. Taylor]

1626
Storing nuclear waste in salt

NEWS

NEWS OF THE WEEK

1610 **SCIENTIFIC PUBLICATIONS: NIH Weighs Bold Plan for Online Preprint Publishing**

▼1611 (1706) **ATOMIC PHYSICS: Atom Lasers Get More Laserlike**

1614 **ATOM OPTICS: Attractive Wire Guides Atoms Out of Trap**

1614 **BIOPROSPECTING: Model Indian Deal Generates Payments**

▼1615 (1736) **DEVELOPMENTAL BIOLOGY: New Findings Reveal How Legs Take Wing**

1616 **MATH EDUCATION: Videotapes Expose Classroom Faults**

▼1617 (1752) **NEUROBIOLOGY: Memory for Order Found in the Motor Cortex**

1619 **GRAND STAIRCASE MONUMENT: Proposed Access Rules Split Community**

NEWS FOCUS

1620 **SCIENTIFIC COMMUNITY: Eastern Europe's Social Science Renaissance**
Bright Spots in a Bleak Russian Landscape

1623 **ECOLOGY: Scientists—and Climbers—Discover Cliff Ecosystems**

1625 **BIOTECHNOLOGY: Engineering Metabolism for Commercial Gains**

1626 **RADIOACTIVE WASTE DISPOSAL: For Radioactive Waste From Weapons, a Home at Last**
Yucca Mountain: A Hotter Case to Handle

1629 **KOREA: Subsidy Helps New Grads Find First Science Jobs**

FRONTIERS IN CHEMISTRY: SINGLE MOLECULES

1667 **Special Section Introduction**

NEWS

1668 **Watching DNA at Work**
Deconstructing DNA for Faster Sequencing

REVIEWS

1670 **Illuminating Single Molecules in Condensed Matter** W. E. Moerner and M. Orrit

1676 **Fluorescence Spectroscopy of Single Biomolecules** S. Weiss

1683 **Nanoscale Science of Single Molecules Using Local Probes** J. K. Gimzewski and C. Joachim

1689 **Single-Molecule Biomechanics with Optical Methods** A. D. Mehta, M. Rief, J. A. Spudich, D. A. Smith, R. M. Simmons

See related reports on pp. 1724 and 1727.

DEPARTMENTS

NETWATCH 1599

THIS WEEK IN *SCIENCE* 1601

SCIENCESCOPE 1613

RANDOM SAMPLES 1631

CONTACT *SCIENCE* 1639

NEW PRODUCTS 1759

RESEARCH

RESEARCH ARTICLE

▼1699 (1652) **Mantle Values of Thermal Conductivity and the Geotherm from Phonon Lifetimes** A. M. Hofmeister

REPORTS

▼1706 (1611) **A Well-Collimated Quasi-Continuous Atom Laser** E. W. Hagley, L. Deng, M. Kozuma, J. Wen, K. Helmerson, S. L. Rolston, W. D. Phillips

▼1709 (1655) **Quantum-Well States as Fabry-Pérot Modes in a Thin-Film Electron Interferometer** J. J. Paggel, T. Miller, T.-C. Chiang

1712 **Ice Core Records of Atmospheric CO_2 Around the Last Three Glacial Terminations** H. Fischer, M. Wahlen, J. Smith, D. Mastroianni, B. Deck

1714 **Present-Day Deformation Across the Basin and Range Province, Western United States** W. Thatcher, G. R. Foulger, B. R. Julian, J. Svarc, E. Quilty, G. W. Bawden

1718 **A Search for Companions to Nearby Brown Dwarfs: The Binary DENIS-P J1228.2-1547** E. L. Martín, W. Brandner, G. Basri

1720 **"Debye-Scherrer Ellipses" from 3D Fullerene Polymers: An Anisotropic Pressure Memory Signature** L. Marques, M. Mezouar, J.-L. Hodeau, M. Núñez-Regueiro, N. R. Serebryanaya, V. A. Ivdenko, V. D. Blank, G. A. Dubitsky

1724 **Single-Polymer Dynamics in Steady Shear Flow** D. E. Smith, H. P. Babcock, S. Chu

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SCIENCE (ISSN 0036-8075) is published weekly on Friday, except the last week in December, by the American Association for the Advancement of Science, 1200 New York Avenue, NW, Washington, DC 20005. Periodicals Mail postage (publication No. 484460) paid at Washington, DC, and additional mailing offices. Domestic individual membership and subscription (51 issues): $110 ($62 allocated to subscription). Domestic institutional subscription (51 issues): $325; Foreign postage extra: Mexico, Caribbean (surface mail) $55; other countries (air assist delivery) $90. First class, airmail, student, and emeritus rates on request. Canadian rates with GST available upon request, GST #1254 88122. Publications Mail Agreement Number 1069624. **Printed in the U.S.A.**

SCIENCE'S COMPASS

EDITORIAL

1639 **Congress and U.S. Research** E. Bloch and C. M. Vest

LETTERS

1641 **Confidence in Nuclear Deterrence** J. H. McNally. **DNA: Uncooked, *al Dente*, or *Scotti*?** A. Stasiak, J. Dubochet, P. Furrer, O. Gonzalez, J. Maddocks. ***Response*** D. Mackenzie. **Whale Origins** M. A. O'Leary. ***Response*** J. E. Heyning. **Edison's Laboratory** P. Israel. ***Response*** B. H. Kevles. **Journal Prices** R. A. Hites. **Breast Implant Safety** D. L. Davis and R. F. Garry

POLICY FORUM

1647 **MEDICINE: IRB Review and Consent in Human Tissue Research** J. F. Merz, D. G. B. Leonard, E. R. Miller

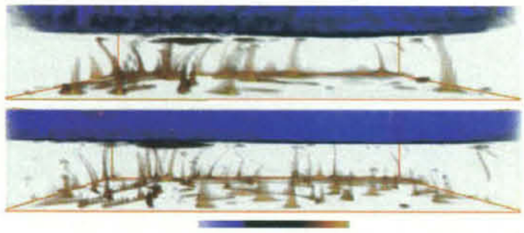
BOOKS *ET AL.*

1649 **COMMUNICATION: *Avatars of the World*** *From Papyrus to Cyberspace* J. J. O'Donnell, reviewed by M. A. Keller

1649 **ANTHROPOLOGY: *The Fateful Hoaxing of Margaret Mead*** *A Historical Analysis of Her Samoan Research* D. Freeman, reviewed by M. Orans

PERSPECTIVES

▼1651 1742 **GENETICS: Unmasking a Cheating Gene** J. F. Crow



1652
Heat flow in the mantle

▼1652 1699 **MANTLE CONVECTION: A Thermal Balancing Act** O. L. Anderson

▼1655 1709 **APPLIED PHYSICS: Mirrors for Electrons** F. J. Himpsel

1656 **RETROSPECTIVE: Martin Rodbell (1925–1998)** L. Birnbaumer

REVIEW

1657 **NEUROSCIENCE: Storage and Executive Processes in the Frontal Lobes** E. E. Smith and J. Jonides

SCIENCE ONLINE
www.scienceonline.org

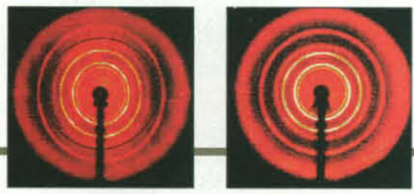
SCIENCE
THE JOURNAL
www.sciencemag.org

***SCIENCE*NOW**
DAILY NEWS SERVICE
www.sciencenow.org

NEXT WAVE
WEEKLY CAREER UPDATES
www.nextwave.org

GRANTSNET
RESEARCH FUNDING DATABASE
www.grantsnet.org

NEUROAIDS
EXPERIMENTAL WEB SITE
www.sciencemag.org/NAIDS



1720
Pressure leaves a mark on C60 molecules

1727 **How Strong Is a Covalent Bond?** M. Grandbois, M. Beyer, M. Rief, H. Clausen-Schaumann, H. E. Gaub

1730 **Adaptation of Bulk Constitutive Equations to Insoluble Monolayer Collapse at the Air-Water Interface** J. P. Kampf, C. W. Frank, E. E. Malmström, C. J. Hawker

1733 **Abnormal Spindle Protein, Asp, and the Integrity of Mitotic Centrosomal Microtubule Organizing Centers** M. do Carmo Avides and D. M. Glover

▼1736 1615 **Role of Pitx1 Upstream of Tbx4 in Specification of Hindlimb Identity** M. Logan and C. J. Tabin

1739 **Negative Regulation of Wingless Signaling by D-Axin, a *Drosophila* Homolog of Axin** F. Hamada, Y. Tomoyasu, Y. Takatsu, M. Nakamura, S.-i. Nagai, A. Suzuki, F. Fujita, H. Shibuya, K. Toyoshima, N. Ueno, T. Akiyama

▼1742 1651 **Truncated RanGAP Encoded by the *Segregation Distorter* Locus of *Drosophila*** C. Merrill, L. Bayraktaroglu, A. Kusano, B. Ganetzky

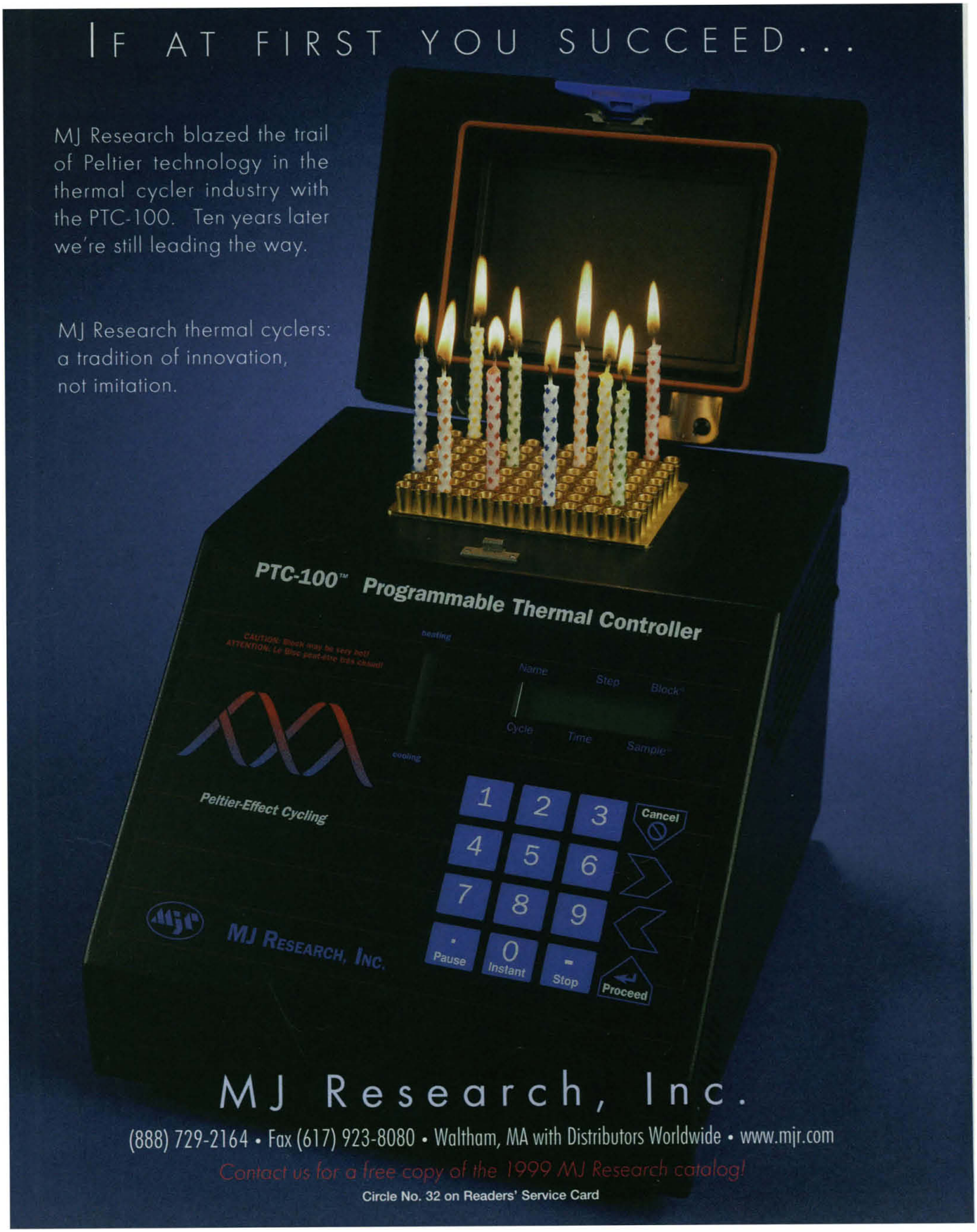
1745 **Linear Differentiation of Cytotoxic Effectors into Memory T Lymphocytes** J. T. Opferman, B. T. Ober, P. G. Ashton-Rickardt

1748 ***HLA* and HIV-1: Heterozygote Advantage and *B*35-Cw*04* Disadvantage** M. Carrington, G. W. Nelson, M. P. Martin, T. Kissner, D. Vlahov, J. J. Goedert, R. Kaslow, S. Buchbinder, K. Hoots, S. J. O'Brien

▼1752 1617 **Motor Cortical Encoding of Serial Order in a Context-Recall Task** A. F. Carpenter, A. P. Georgopoulos, G. Pellizzer

1736
Wings become legs

Change of address: allow 4 weeks, giving old and new addresses and 8-digit account number. **Postmaster:** Send change of address to *Science*, P.O. Box 1811, Danbury, CT 06813–1811. **Single copy sales:** $8.00 per issue prepaid includes surface postage; bulk rates on request. **Authorization to photocopy** material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by AAAS to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that $4.00 per article is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923. The identification code for *Science* is 0036-8075/83 $4.00. *Science* is indexed in the *Reader's Guide to Periodical Literature* and in several specialized indexes.



IF AT FIRST YOU SUCCEED...
MJ Research blazed the trail of Peltier technology in the thermal cycler industry with the PTC-100. Ten years later we're still leading the way.
MJ Research thermal cyclers: a tradition of innovation, not imitation.
PTC-100™ Programmable Thermal Controller
heating
cooling
Name
Step
Block
Cycle
Time
Sample
Peltier-Effect Cycling
MJ RESEARCH, INC.
1 2 3
4 5 6
7 8 9
Pause
0 Instant
Stop
Cancel
Proceed
MJ Research, Inc.
(888) 729-2164 • Fax (617) 923-8080 • Waltham, MA with Distributors Worldwide • www.mjr.com
Contact us for a free copy of the 1999 MJ Research catalog!
Circle No. 32 on Readers' Service Card

HOTTER THAN EXPECTED

How hot is Earth's interior? Heat flow from Earth can be measured accurately, but only rough estimates of its internal temperatures have been made; for example, some estimates of temperatures at the base of the mantle differ by 500 to 1000 kelvin. Internal temperatures depend both on the heat flow and the thermal conductivity, which varies greatly with mineralogy, pressure, and temperature. Because there are only a few experimental determinations of the thermal conductivity at the relevant conditions, theoretical estimates must fill the gap. Hofmeister (p. 1699; see the Perspective by Anderson) develops a new theory for determining thermal conductivity at high pressures and temperatures based on consideration of the lattice phonon and radiative contributions. The theoretical measurements fit available infrared data of relevant minerals and imply that Earth's interior is hotter by about 500 kelvin than most current models.

ELECTRON INTERFEROMETER

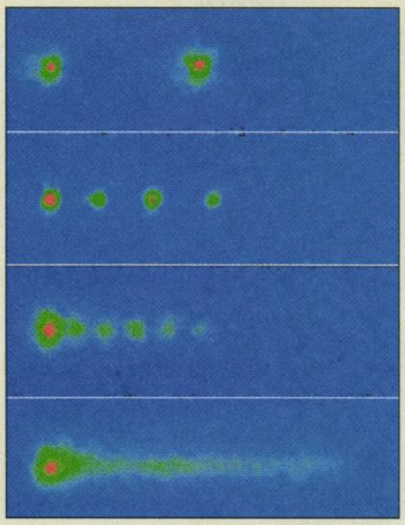
The thickness of the cavity in an optical interferometer is on the same scale as that of the wavelength of the incident light. When an integer number of wavelengths fit into the cavity, constructive interference occurs and a peak in the transmission results. The ability to grow perfect silver thin films up to 100 monolayers in thickness, which is the same length scale as the electron wave function, has allowed Paggel *et al.* (p. 1709; see the Perspective by Himpsel) to create an interferometer for electrons. Photoemission spectra from the metal "cavity" can be analyzed in much the same way as in an optical interferometer and yield a wealth of information about the fundamental electronic properties of the metallic film.

CO_2 COMPLEXITIES

Generally, atmospheric carbon dioxide (CO_2) concentrations were low during glacial times and high during interglacial periods, but whether increases in CO_2, and thus the greenhouse effect, and the retreat of ice sheets have been directly related has been difficult to evaluate. Fischer *et al.* (p. 1712) present a detailed look at how atmospheric CO_2 changed during the last three glacial cycles using new analyses of gases trapped in Antarctic ice. The resulting relation is complex: During deglaciations, increases in CO_2 seem to follow the initiation of warming, and during some glaciations, CO_2 remained high. The interaction is likely controlled by the biosphere and its response to the duration of interglacials.

COHERENT KICKS

Extracting the atoms from a Bose-Einstein condensate in a controlled fashion is the first step in achieving a coherent atomic laser. Previous methods



have had a gravity boost, essentially allowing the atoms to drop from the condensate, but this approach severely limits the beam direction. Hagley *et al.* (p. 1706; see the news story by Voss) now report the use of stimulated Raman emission to kick out a fraction of the condensate with a well-defined momentum and direction.

ALL QUIET ON THE BASIN AND RANGE

The Basin and Range Province of the western United States has nearly doubled its area over the last 15 million years and continues to extend today. Thatcher *et al.* (p. 1714) combined Global Positioning System (GPS) data from surveys in 1992, 1996, and 1998 along an east-west transect across the northern Basin and Range and found almost no current deformation in the middle of the section. All of the deformation was concentrated along the edges of the Basin and Range: adjacent to the Sierra Nevada block in the west and adjacent to the Colorado Plateau in the east. Most of the deformation is oriented in the direction of the motion of the Sierra Nevada block to the northwest. These observations indicate that the internal deformation of the Basin and Range is determined by the traction of the adjacent blocks.

WEIGHING BROWN DWARFS

Many brown dwarfs, dead stars without enough mass to burn hydrogen, have been detected, but the actual mass of one of these objects has not been measured. Martin *et al.* (p. 1718) found an isolated, nearby brown dwarf binary system during the deep near-infrared survey and determined the separation between these brown dwarfs with the near-infrared camera and multiobject spectrometer (NICMOS) on the Hubble Space Telescope. By following the orbital motion of these brown dwarfs for a short time, they will be able to determine the masses of the brown dwarfs.

LEAVING AN IMPRINT ON C_{60}

If materials are put under severe pressure, the arrangement of chemical bonds may change and can be preserved in the material after release of pressure. If the force used to establish the pressure is directional, then a greater compression can result in some directions than in others. Marques *et al.* (p. 1720) show that if polycrystalline C_{60} is put under such directional pressure, a large pressure memory signature is retained in the sample even at atmospheric pressure. The high symmetry of C_{60}, which has 30 isotropically distributed equivalent bonding directions, allows such a pressure memory effect to be retained in grains oriented randomly with respect to the applied pressure. The resulting three-dimensional polymerized C_{60} lattice joins the previously synthesized one- and two-dimensional polymerized C_{60} structures.

PULLING AND TUMBLING POLYMERS

The motion of a polymer chain that enters a region of strong shearing flow is difficult to predict—it may get pulled and stretched, but it can also be tumbled and compacted. This variability makes it difficult to understand the dynamics with methods that average over many molecules, such as light scattering. Smith *et al.* (p. 1724) used video fluorescence microscopy to image individual λ-phage DNA molecules undergoing shear flow and directly observe large fluctuations in extension corresponding to molecules moving in and out of tumbling flow.

CONTINUED ON PAGE 1603

THIS WEEK IN SCIENCE

CONTINUED FROM PAGE 1601

FORCING BONDS APART

Direct measurements of force needed to break a single chemical bond have been made by Grandbois *et al.* (p. 1727) using an atomic force microscope (AFM). Polysaccharide chains adsorbed on silica surfaces were covalently attached to the AFM tip, and the rupture events as the chains were pulled off the surface were analyzed to identify single bond-breaking events. The force measured for rupturing a silicon-carbon bond, 2 nanonewtons, is in good agreement with estimates made from density functional calculations.

MAINTAINING INTEGRITY

During cell division, microtubules are arranged into a mitotic spindle along which chromosomes are transported. The ends of the spindle are formed by the centrosomes, which include a ring of γ-tubulin thought to be important in nucleating spindle microtubules. Avides and Glover (p. 1733) examined the role of a *Drosophila* protein known as Asp and found that it was required to maintain the association between microtubules and the centrosomal γ-tubulin ring.

GETTING A LEG UP

Much is known about limb patterning, but the genetic factors that specify hindlimbs versus forelimbs—whether they are arms in humans or wings in birds—are poorly understood. Logan and Tabin (p. 1736; see the news story by Vogel) now show that when the *Pitx1* gene is misexpressed in the chick embryonic forelimb (wing bud), the result is a wing that is transformed into a leg. Characteristics that indicate distinct leg specification are seen in the skeletal and muscle development and are evidenced in the expression of leg-specific markers.

SIGNALING AND SEGREGATION IN *DROSOPHILA*

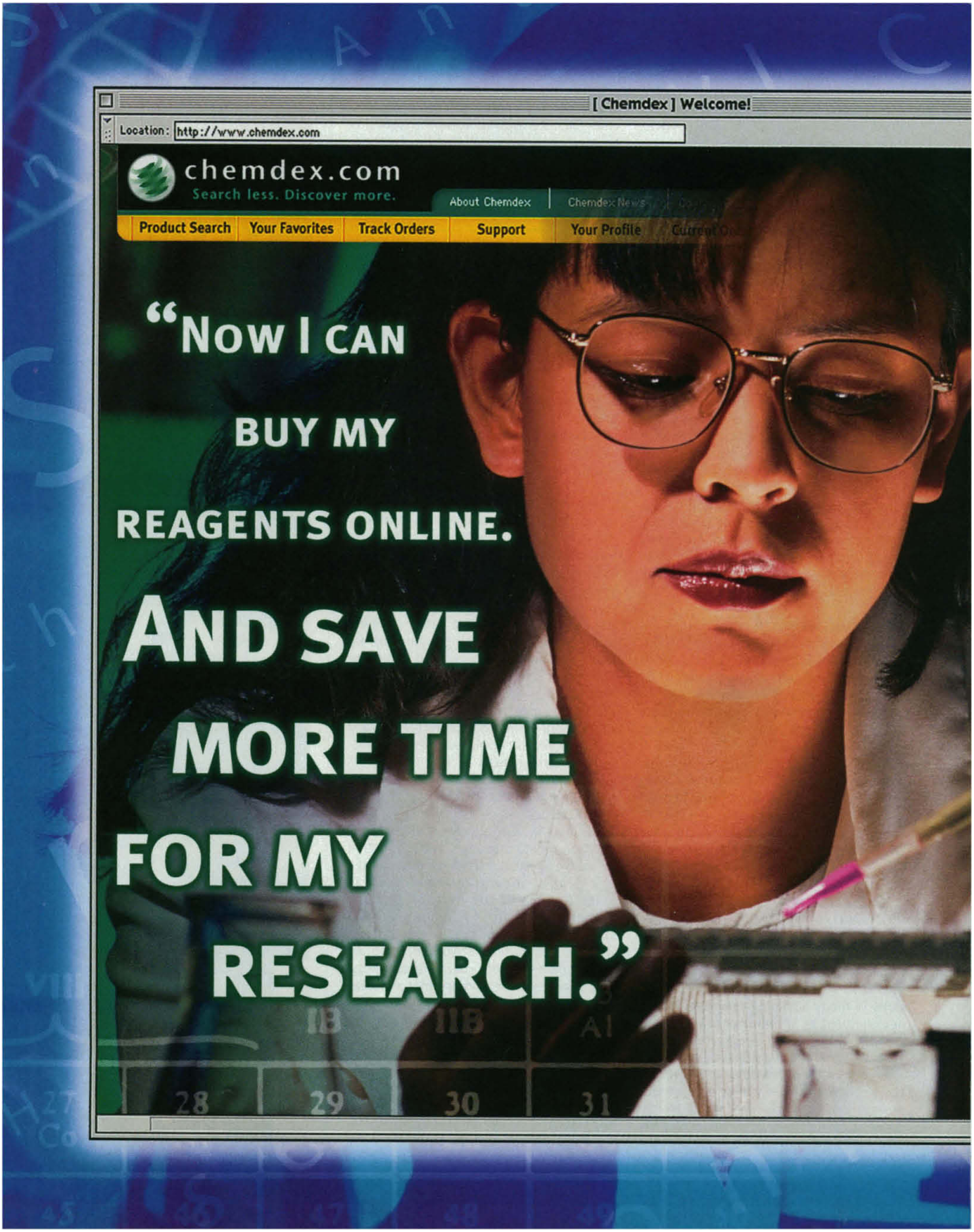
Two reports focus on identifying molecular species that play key roles in *Drosophila* development and genetics. The Wnt/Wingless (Wg) pathway functions in many signaling processes during development by stabilizing the protein β-catenin, which in turn regulates expression of Wnt/Wg responsive genes. In mammals, Axin interacts with β-catenin, the adenomatous polyposis coli protein, and glycogen synthase kinase-3β. Hamada *et al.* (p. 1739) have now isolated the *Drosophila* homolog of Axin, D-Axin, which displays many of the same biochemical interactions with other proteins as seen with mammalian Axin. Furthermore, genetic analyses show that D-Axin negatively regulates Wg signaling by down-regulating Armadillo, the *Drosophila* homolog of β-catenin. *Segregation Distorter* (*SD*) in *Drosophila* is an example of meiotic drive, where one allele or chromosome is preferentially transmitted to offspring through meiosis. Mechanistic insights have been restricted because the identity of the key component of *Sd* was unknown. Merrill *et al.* (p. 1742; see the Perspective by Crow) show that *Sd* encodes a truncated *Drosophila* homolog of RanGAP. Because RanGAP is a guanosine triphosphatase–activating protein that is involved in nuclear import in yeast and mammalian systems, the solution to the mystery of *Sd* may include defective nuclear transport.

DIVERSITY IN DEFENSE

An early theory to explain the enormous diversity of class I and II genes of the major histocompatability complex was that individuals carrying different alleles (heterozygous) at HLA loci could present a greater variety of antigenic peptides, and therefore would mount a better immune response against infecting organisms. By looking at heterozygosity at HLA in three cohorts of HIV-infected individuals, Carrington *et al.* (p. 1748) found that heterozygotes progressed to AIDS and death much more slowly than homozygotes and that two alleles correlated with accelerated AIDS pathogenesis.

NOT JUST FOLLOWING ORDERS

Traditional industrial organizations localize decisions to managers and production to workers. Recent thinking has opened the door to incorporating workers in some aspects of the decision process. Carpenter *et al.* (p. 1752; see the news story by Wickelgren) explore the possibility of a distributed network in the brain for encoding serial order in a stimulus-response task. The primary motor cortex constitutes the first station in the descending pathway leading to the muscles and movement. Nevertheless, some motor cortical neurons appear to encode the presentation of serial stimuli at a time prior to the point at which a response is selected and initiated, which suggests the potential for cognitive processing in this area of the brain.


[Chemdex] Welcome!
Location: http://www.chemdex.com
chemdex.com
Search less. Discover more.
About Chemdex
Product Search
Your Favorites
Track Orders
Support
Your Profile
"Now I can buy my reagents online. And save more time for my research."

Announcing chemdex.com

The Faster, Easier Way to Purchase Biological and Chemical Reagents.

Spend less time searching for reagents and more time pursuing your research. When you purchase your reagents through chemdex.com, you get:

- The world's largest source of biological and chemical reagents for life science research
- Ordering with the click of a mouse—in a secure environment
- The suppliers you know—and trust
- A powerful, precision search engine to quickly find what you need

Purchase your reagents faster. Easier. ONLINE.
At www.chemdex.com.

chemdex.com

Search less.
Discover more.

Chemdex Corporation • 3950 Fabian Way, Palo Alto, CA 94303 • 650-813-0300

Circle No. 25 on Readers' Service Card

Science

www.sciencemag.org

EDITOR-IN-CHIEF
Floyd E. Bloom

EDITOR
Ellis Rubinstein

MANAGING EDITOR
Monica M. Bradford

EDITORIAL

DEPUTY MANAGING EDITORS: Richard B. Gallagher (Biological Sciences), R. Brooks Hanson (Physical Sciences), Katrina L. Kelner (Compass); SUPERVISORY SENIOR EDITORS Linda J. Miller, Phillip D. Szuromi; SENIOR EDITORS Gilbert J. Chin, Pamela J. Hines, Barbara Jasny, Paula A. Kiberstis, L. Bryan Ray; ASSOCIATE EDITORS Lisa D. Chong, Beverly A. Purnell, Linda R. Rowan; EDITORIAL SUPPORT Candace Gallery, Carolyn Kyle, Elise Laffman, Patricia M. Moore, Anita Wynn; ADMINISTRATIVE SUPPORT Sylvia Kihara

***SCIENCE*'S COMPASS**

SENIOR EDITORS/PERSPECTIVES Orla Smith, Julia Uppenbrink; ASSOCIATE BOOK REVIEW EDITOR Sherman J. Suter; CONTRIBUTING EDITORS Kevin Ahern, Richard Peters, Robert Sikorski, David F. Voss; PUBLICATION ASSISTANTS Brent Gendleman, Jeffrey Hearn; INFORMATION SPECIALIST Janet Kegg; LETTERS AND TECHNICAL COMMENTS: EDITOR Christine Gilbert; ASSOCIATE EDITOR Steven S. Lapham; PUBLICATION ASSISTANT Charlene King

NEWS

NEWS EDITOR Colin Norman; FEATURES EDITOR Tim Appenzeller; DEPUTY NEWS EDITORS Elizabeth Culotta (contributing editor), Jean Marx, Jeffrey Mervis, Richard Stone; NEWS WRITERS Martin Enserink, Michael Hagmann (intern), Constance Holden, Jocelyn Kaiser, Richard A. Kerr, David Kestenbaum, Andrew Lawler, David Malakoff, Eliot Marshall, Elizabeth Pennisi, Robert F. Service, Gretchen Vogel BUREAUS: BERKELEY, CA Marcia Barinaga (contributing correspondent); SAN DIEGO, CA Jon Cohen; CHICAGO, IL James Glanz; COPY EDITORS Linda B. Felaco, Daniel T. Helgerman; CONTRIBUTING CORRESPONDENTS Barry A. Cipra, Ann Gibbons, Charles C. Mann, Anne Simon Moffat, Virginia Morell, Evelyn Strauss, Gary Taubes, Ingrid Wickelgren; ADMINISTRATIVE SUPPORT Scherraine Mack, Fannie Groom

EDITING AND PROOFREADING

DIRECTOR Dawn McCoy; SUPERVISOR Cara Tate; SENIOR COPY EDITORS Cay Butler, Harry Jach, Barbara Ordway, Christine M. Pearce; COPY EDITORS Jeffrey E. Cook, Etta Kavanagh, Jason Llewellyn, Joshua Marcy; COPY DESK Joi S. Granger, Monique Martineau, Ellen E. Murphy, Beverly Shields; ASSISTANT Kathy Libal

PRODUCTION

DIRECTOR James Landry; MANAGER Wendy K. Shank; ASSISTANT PRODUCTION MANAGER, INTERNET Lizabeth A. Harman; ASSOCIATES Vicki J. Jorgensen, Tara L. Kelly, Jessica K. Moshell, Rebecca Thomas

ART

DESIGN DIRECTOR Amy Decker Henry; ART DIRECTOR C. Faber Smith; ASSOCIATE ART DIRECTOR Elizabeth Carroll; SCIENTIFIC ILLUSTRATOR Katharine Sutliff; GRAPHICS ASSOCIATES Holly Bishop, Preston Morrighan, Darcel Pugh, Patricia M. Riehn; PHOTO RESEARCHER Leslie Blizard

***SCIENCE* INTERNATIONAL**

EUROPE

EDITORIAL: OFFICE HEAD Richard B. Gallagher; ASSOCIATE EDITORS Stella M. Hurtley, Ian S. Osborne, Peter Stern; EDITORIAL ASSOCIATE Belinda Holden; SCIENCE'S COMPASS: SENIOR EDITOR/PERSPECTIVES Julia Uppenbrink; NEWS: EDITOR Daniel Clery; CONTRIBUTING CORRESPONDENTS Michael Balter (Paris) Robert Koenig (Bern); *SCIENCE*'S NEXT WAVE, UK EDITOR: John MacFarlane; ADMINISTRATIVE SUPPORT Janet Mumford, Liz Ellis

ASIA

JAPAN NEWS BUREAU: Dennis Normile (contributing correspondent); CHINA REPRESENTATIVE Hao Xin; Pallava Bagla (contributing correspondent, India)

***SCIENCE*NOW: www.sciencenow.org**

EDITOR Erik Stokstad

***SCIENCE*'S NEXT WAVE: www.nextwave.org**

MANAGING EDITOR Wendy Yee; SENIOR EDITOR Nicole Ruediger WRITER Melissa Mertl; CANADA EDITOR Charles Boulakia; ASSISTANT Suzanne Moore

PUBLISHER
Richard S. Nicholson

ASSOCIATE PUBLISHER
Beth Rosner

MEMBERSHIP/CIRCULATION DIRECTOR
Michael Spinella

MEMBERSHIP/CIRCULATION

SUBSCRIPTION SERVICES: 202-326-6417; 800-731-4939

DEPUTY DIRECTOR Marlene Zendell; MEMBER SERVICES: MANAGER Michael Lung; SUPERVISOR Mary Curry; REPRESENTATIVES Laurie Baker, Pat Butler, Christine Ford, Mari Pope, Jantell Smith; MARKETING: MANAGER Scott Oser; COORDINATOR Lauri Sirois; EUROPE MANAGER Jane Pennington; ASSOCIATE Ruth Jackson; RESEARCH: MANAGER Renuka Chander; BUSINESS AND FINANCE: MANAGER Dwight Theall; ASSISTANT Susan Maxim; COMPUTER SPECIALIST Charles Munson

FINANCE AND ADVERTISING

BUSINESS AND FINANCE: BUSINESS MANAGER Deborah Rivera-Wienhold; SENIOR ANALYST Randy Yi; FINANCIAL ANALYST Lisa Donovan RIGHTS AND PERMISSIONS: ASSOCIATE Lincoln Richman; ASSISTANT Emilie David MARKETING: DIRECTOR John Meyers; ASSOCIATE Allison Pritchard ELECTRONIC MEDIA: MANAGER David Gillikin; COMPUTER SPECIALIST Wendy Green; PRODUCTION ASSOCIATES Mark Croatti, Ellen McGuire

PRODUCT ADVERTISING

NATIONAL SALES MANAGER NORTHEAST AND E. CANADA Richard Teeling: 973-904-9774, FAX 973-904-9701 • MIDWEST/ SOUTHEAST Elizabeth Mosko: 773-665-1150, FAX 773-665-2129 • WEST COAST/W. CANADA Neil Boylan: 415-673-9265, FAX 415-673-9267 • MID ATLANTIC AND U.S. INSIDE SALES Christopher Breslin: 410-273-1007, FAX 410-273-1591 • INTERNET SALES Laura Tellez 202-326-6599, FAX 202-682-0816 UK/SCANDINAVIA/FRANCE/ ITALY/BELGIUM/NETHERLANDS Andrew Davies: (44) 7-071-226-216, FAX (44) 7-071-226-233 • GERMANY/SWITZERLAND/AUSTRIA Tracey Peers: (44) 1-260-297-530, FAX (44) 1-260-271-022 JAPAN Mashy Yoshikawa: (81) 3-3235-5961, FAX (81) 3-3235-5852 • TRAFFIC MANAGER Carol Maddox; SALES ASSOCIATES Sheila Myers, Sandra Walls; ADMINISTRATIVE SUPPORT Jessica Tierney

RECRUITMENT ADVERTISING

SALES AND PRODUCTION OPERATIONS MANAGER Terri Seiter Azie U.S.: SALES MANAGER Gabrielle Boguslawski: 718-491-1607, FAX 202-289-6742; SALES SUPERVISOR Daryl Anderson; SALES REPRESENTATIVES Troy Benitez, Beth Dwyer, Bren Peters-Minnis, Kristin Westapher; ASSISTANTS Erika Bryant, Kathleen Clark; Christina Geiger PRODUCTION: SENIOR ASSOCIATE Jennifer Rankin; ASSOCIATES Chriss Borkowski, Elizabeth Lenox COPY EDITOR/PROOFREADER Chris Filiatreau U.K./EUROPE: SALES MANAGER Debbie Cummings; SALES EXECUTIVE Sabine Lenud; ASSISTANT Elisabeth Py: (44) 1-223-326-5000, FAX (44) 1-223-326-532 AUSTRALIA/NEW ZEALAND: Keith Sandell: (61) 02-9922-2977, FAX (61) 02-9922-1100 JAPAN: Mashy Yoshikawa: (81) 3-3235-5961, FAX (81) 3-3235-5852

Published by the **American Association for the Advancement of Science (AAAS)**, *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.

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

For 12-liter processing you could buy two centrifuges.

Or just get one with a bigger bottle.

SORVALL®

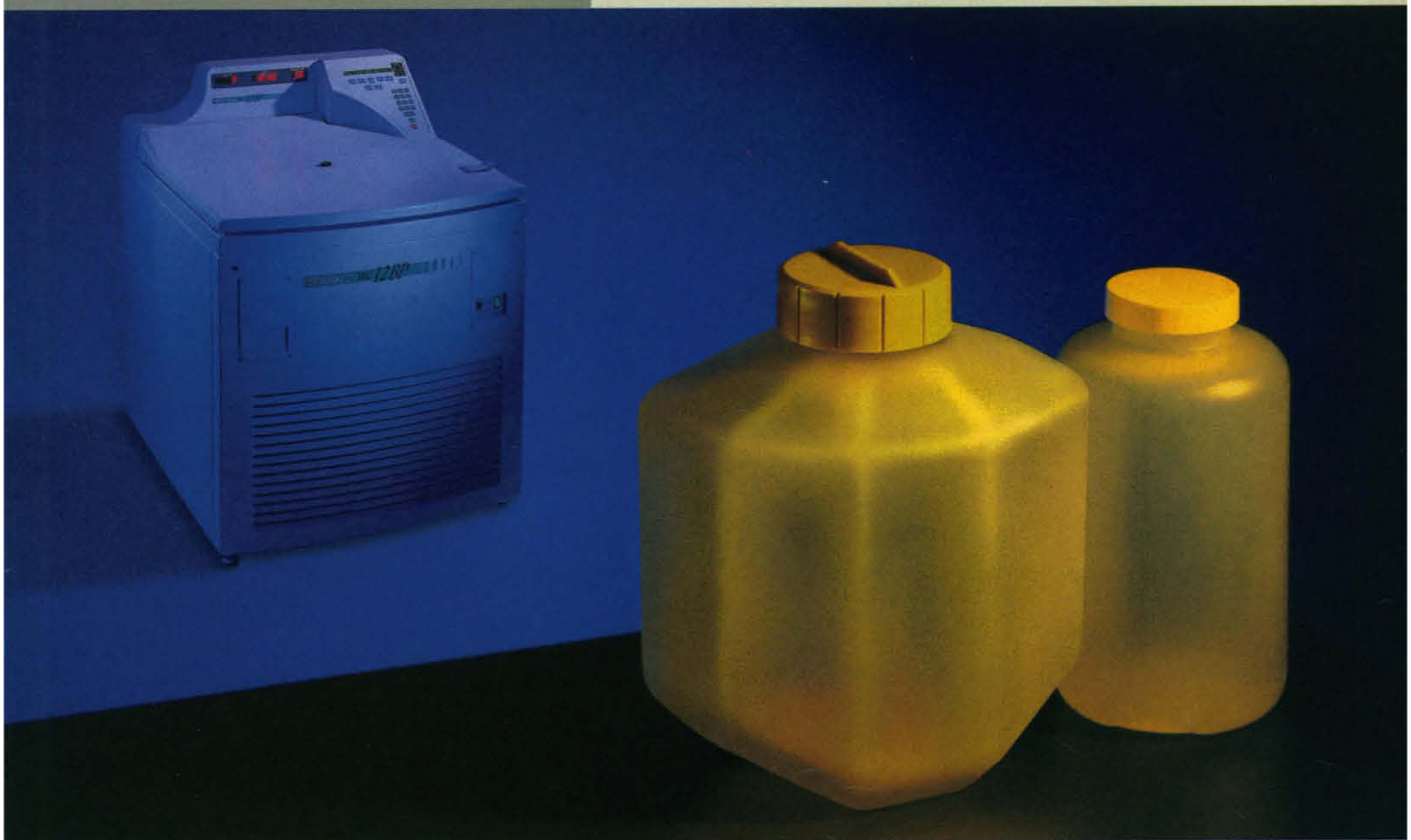
Introducing the SORVALL® *RC12BP*™ Total Processing Solution – the first lowspeed centrifuge to offer a 12-liter capacity. Designed specifically for large-scale batch processing, the ***RC12BP*** system not only gives you twice the capacity of other centrifuges, but also helps maximize production efficiency while increasing the ease of GMP compliance.

The new, ergonomically designed ***RC12BP*** centrifuge lets you process 12-liter batches at up to 7,333 x g, while occupying about the same amount of floor space as a 6-liter instrument – but with a lower deck height and shorter reach. It also enhances separation quality through features like SORVALL's Accumulated Centrifugal Effect **(ACE)** system that maintains reproducible total centrifugal effect from run to run, and instrument to instrument. Plus, there's Minimal Sample Resuspension **(MSR)**, and a hot-gas bypass system for improved temperature control and reduced moisture accumulation.

The **H-12000** rotor holds up to six 2-liter polypropylene bottles featuring tapered bottoms to hold pellets more securely. And for safer transport, the system offers a six-place bottle rack.

For easy, automatic data logging, you can network up to 16 SORVALL ***RC12BP*** and ***RC3BP*** centrifuges, using our **WatchLog Network Plus™ Software** and a standard PC. Also, you can quickly link batches to their run conditions with **BarTrace™** Barcoding Packaging.

Call Kendro Laboratory Products today, and double your pelleting capacity – with one total processing solution.



Kendro Laboratory Products

A worldwide company formed by the merger of Heraeus Instruments and Sorvall.

Circle No. 39 on Readers' Service Card

Offices worldwide. In the US, call 1-800-522-SPIN, Fax 203-270-2210.
In Europe, 49 (6181) 35-300, Fax 49 (6181) 35-59 44.
In Asia Pacific, 203-270-2080, Fax 203-270-2210.
Or contact your local Kendro Laboratory Products Representative.
www.kendro.com

Nytran® SuPerCharge

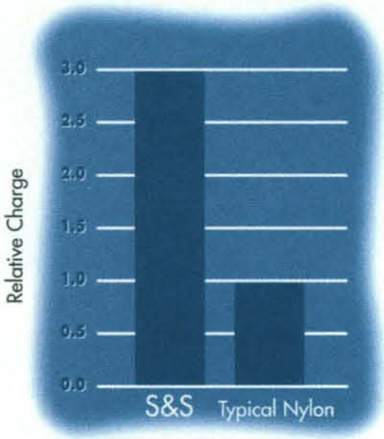
NYLON TRANSFER MEMBRANE

NEW!

Clearly Better Blotting Demands A Clearly Better Membrane

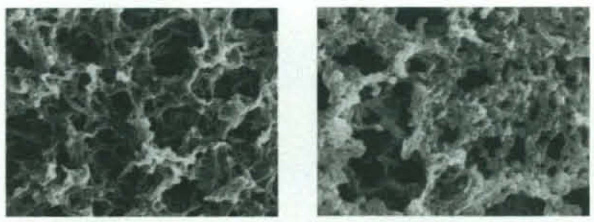
Introducing a Breakthrough in Nylon Membrane Manufacturing Nytran® SuPerCharge

Nytran SuPerCharge vs. Typical Nylon



Binding Ratio of a Negatively Charged Dye to the Membrane Surface

- **Highest Positive Charge**
- **Consistent Membrane Morphology**
- **Low Background**



SEMs showing uniform pore size and distribution in Nytran SuPerCharge membranes (left) and inconsistent pore size and uneven distribution in typical nylon membranes (right).

Limited Time Special Offer!

Description	Qty/Pk	Item#	Price
81.5 mm circles	50	416206	$55/pk
30.1 x 60.1 cm sheets	5	416207	$115/pk

To order contact your S&S distributor or call S&S at

1-800-245-4024

Clearly better Blotting

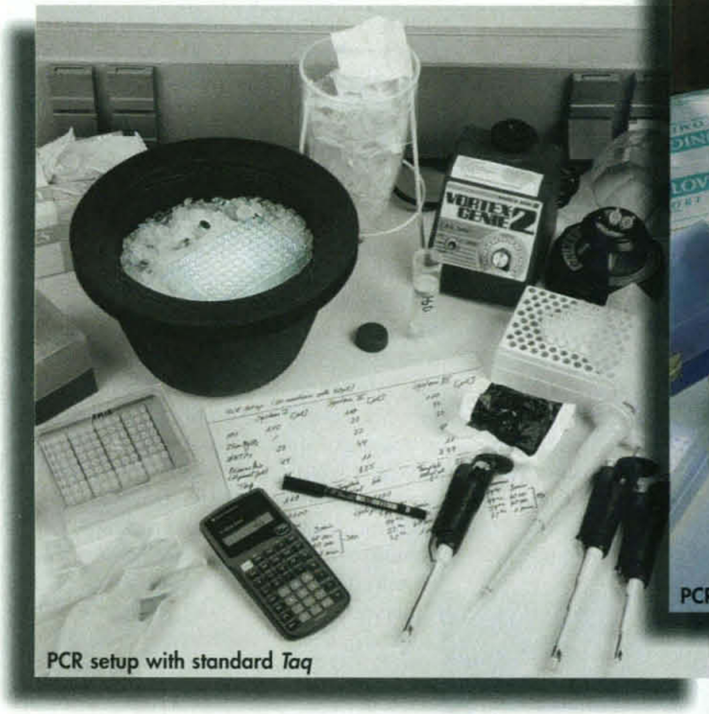
Schleicher & Schuell

Headquarters: Schleicher & Schuell GmbH • P.O. Box 4, D-37582 Dassel • Germany • Tel +49-5561-791-0 • Fax +49-5561-791-536 • filtration@s-und-s.de
USA Headquarters: Schleicher & Schuell Inc. • 10 Optical Avenue • Keene N.H. 03431 USA • Tel (603) 352-3810 • Fax (603) 357-7700 • techserv@s-and-s.com

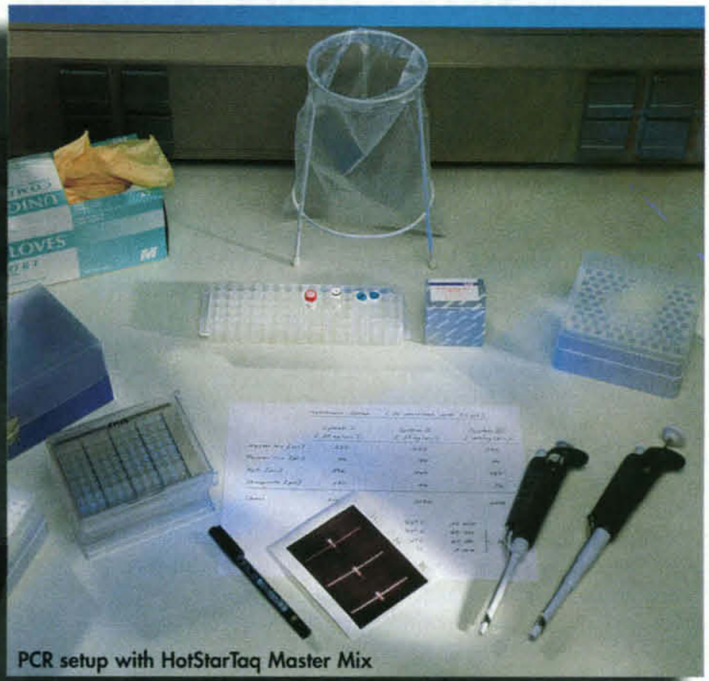
Other Subsidiaries of Schleicher & Schuell GmbH, Dassel/Germany include the Netherlands, Switzerland, France, Belgium, Hungary, Italy and Great Britain.

Circle No. 66 on Readers' Service Card

Simplify all your PCR with the HotStarTaq™ Master Mix Kit



PCR setup with standard *Taq*



PCR setup with HotStarTaq Master Mix

No ice. No mess. No wasted time!

NEW

The **HotStarTaq™ Master Mix Kit** is the only ready-to-use solution to simplify all your PCR applications. This premixed solution containing HotStarTaq DNA Polymerase, optimized QIAGEN® PCR Buffer, and dNTPs provides:

✔ Easy setup

Set up your reactions at the bench at room temperature. The premixed solution eliminates lengthy calculations and reduces pipetting — so you save time and minimize the risk of error or contamination.

✔ Robust amplification in all applications

Use HotStarTaq Master Mix for all your PCR applications. Little or no optimization is needed, even with previously optimized systems.

✔ High PCR specificity

Increase your specificity with hot-start PCR. HotStarTaq DNA Polymerase combined with QIAGEN PCR Buffer ensures high specificity in the first cycle and throughout your PCR.

Ease of use and high specificity make HotStarTaq Master Mix the ideal solution both for projects involving large numbers of samples and for your most demanding applications.

**High specificity in an easy-to-use format —
let the HotStarTaq Master Mix Kit simplify all your PCR!**

The HotStarTaq Master Mix Kit is sold under licensing arrangements with F. Hoffmann-La Roche Ltd, Roche Molecular Systems, Inc. and The Perkin-Elmer Corporation. The PCR process is covered by U.S. Patents 4,683,195 and 4,683,202 and foreign equivalents owned by Hoffmann-La Roche AG.

http://www.qiagen.com

Germany:	USA:	Australia:	Canada:	France:	Japan:	Switzerland:	UK:
QIAGEN GmbH	QIAGEN Inc.	QIAGEN Pty Ltd	QIAGEN Inc.	QIAGEN S. A.	QIAGEN K.K.	QIAGEN AG	QIAGEN Ltd.
Tel. 02103-892-240	Tel. 800-426-8157	Tel. 03-9489-3666	Tel. 800-572-9613	Tel. 01-60-920-930	Tel. 03-5805-7261	Tel. 061-319-30-31	Tel. 01293-422-999
Fax 02103-892-255	Fax 800-718-2056	Fax 03-9489-3888	Fax 905-501-0373	Fax 01-60-920-925	Fax 03-5805-7263	Fax 061-319-30-33	Fax 01293-422-922

DISTRIBUTORS: Austria/Hungary/Slovenia Austria (01) 889 18 19 **Belgium/Luxemburg** 0800-1-9815 **Brazil** (11) 543 1455 or 0800 55 1321 **Central & South America** USA (305) 828-3818 **China** (852)2896-6283 **Czech Republic** (02)4447 1239 **Denmark** 43 86 87 88 **Finland** (09)-804 551 **Greece** (01)-643 61 38 **India** (011)-542 1714 **Israel** 02. 584 1111 **Italy** (055) 500 1871 **Korea** (02) 924-86 97 **Malaysia** (03)-7312099 **Mexico** USA (661) 294-7940 **The Netherlands** (033)-4950094 **New Zealand** (09) 980 6700 or 0800 933 966 **Norway** 22 90 00 00 **Poland** (071) 51 41 06 or 51 54 20 **Portugal** (1)-751 6000 **Singapore** 445 7927 **Slovak Republic** (07) 54 01 336 **South Africa** (021) 615166 **Spain** (93) 902.20.30.90 **Sweden** (08) 621 34 00 **Taiwan** (02) 2880 2913 **Thailand** (02) 412-5672 **In other countries contact:** QIAGEN GmbH, Germany

QIAGEN

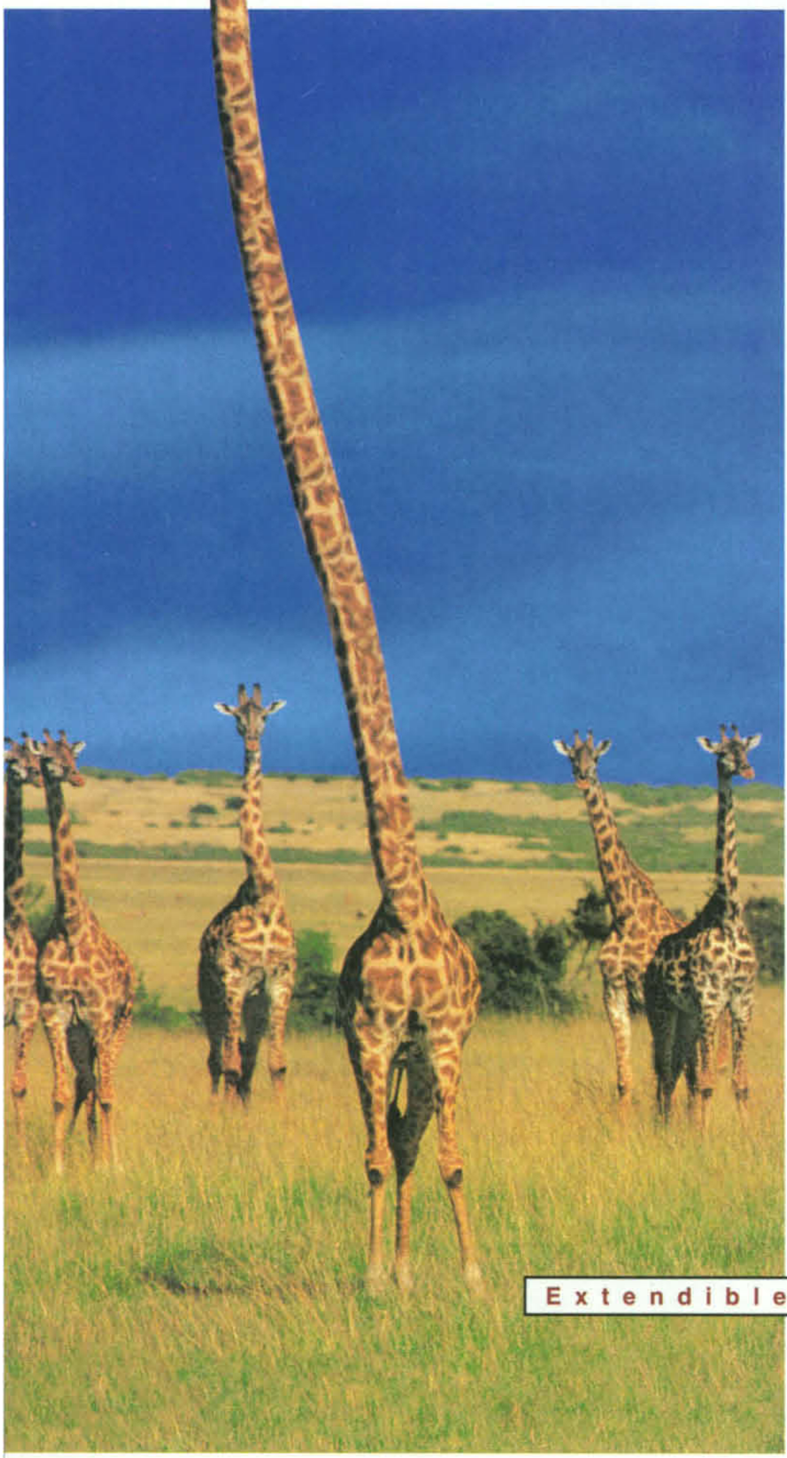
Circle No. 68 on Readers' Service Card

As they work to advance science, labs around the world use our filters and filter-based systems 1,000,000 times a day.

pure science™

outstanding
in Sequence Analysis

New in Version 10
- More sensitive database searching (BLAST 2.0, SSearch)
- Motif identification with MEME
- ABI trace support
- Faster analysis with parallel code
- Year 2000 compliance



Choose the standard: GCG®

Used by over 30,000 scientists at more than 600 institutions worldwide, the GCG Wisconsin Package™ is the sequence analysis package of choice. Scientists choose the proven technology of the Wisconsin Package for its:

Breadth of Analysis

Only the Wisconsin Package offers you the power and flexibility to choose from so many analyses:

- database searching
- sequence comparison
- pattern searching
- primer selection
- sequence assembly
- protein analysis
- evolutionary analysis
- secondary structure prediction

Strength in Database Access

Proprietary in-house data as well as purchased databases can be formatted for accessibility in GCG or FastA formats. Databases included with the software are:

- GenBank
- SWISS-PROT™
- REBASE
- EMBL
- PIR
- SP-TREMBL

The GENESEQ™ patent sequence database is available separately from GCG or Oxford Molecular.

The convenience and accuracy of bimonthly updates to the public databases are available from GCG for an additional fee.

Ease of Use

Choose from three optional interfaces:

SeqLab®. Based on X Windows, SeqLab provides superior sequence and feature editing and annotation.

SeqWeb®. Use your web browser to analyze data on your desktop. Analysis results contain links to sequence resources in the databases and on the web.

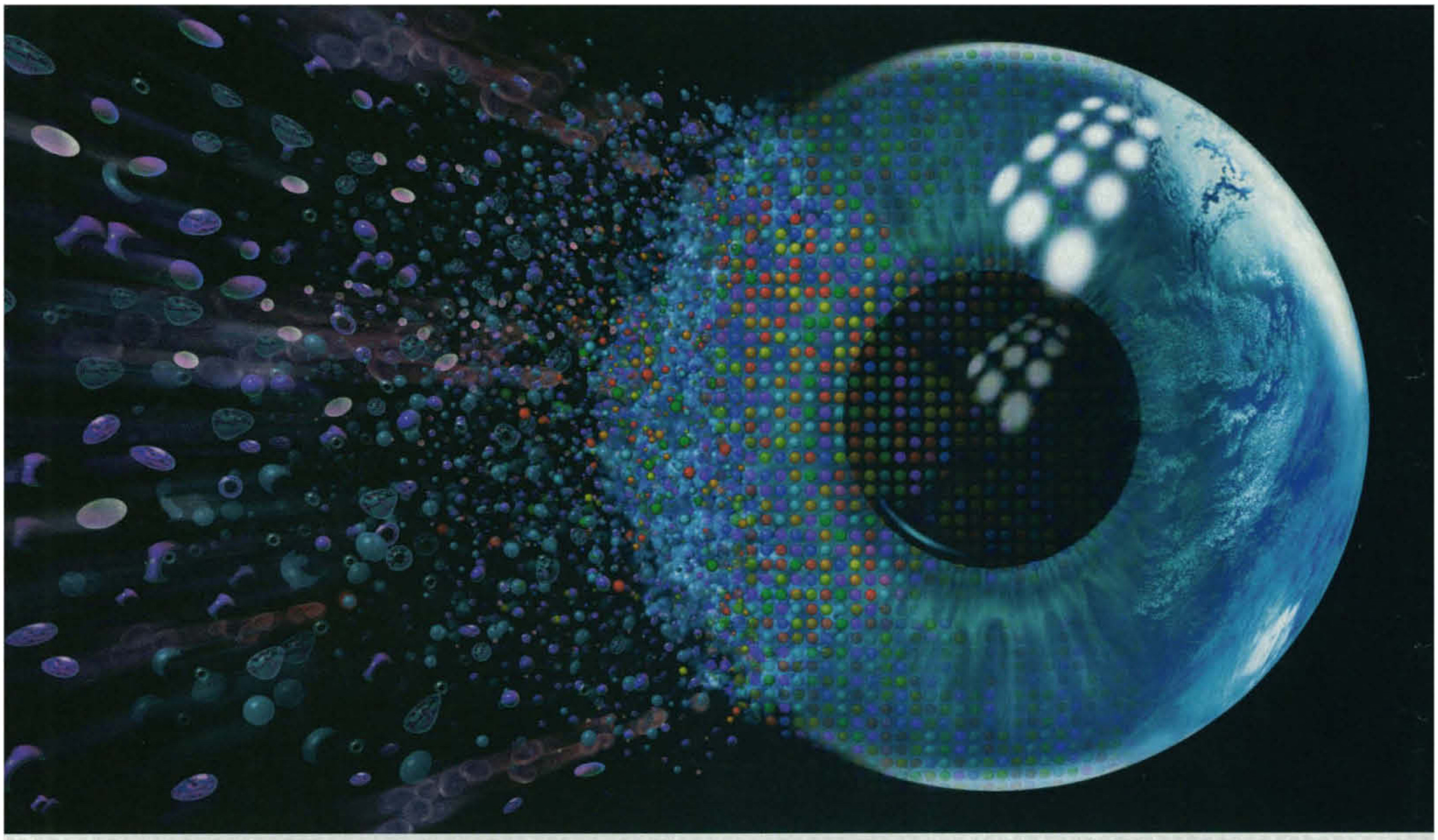
Batch. Scriptable command lines provide the ability to do repetitive and numerous analyses.

Extendible Framework Extensions enable you to join in-house, third-party software, such as CLUSTAL W, WU-BLAST, SPS SWAT™, SPS Cross-Match™, and SPS Phrap™ within SeqLab to provide a common interface and easy access to all users.

For more information about Oxford Molecular products:
tel: 1-800-876-9994
http://www.oxmol.com/prods/bio
e-mail: products@oxmol.com

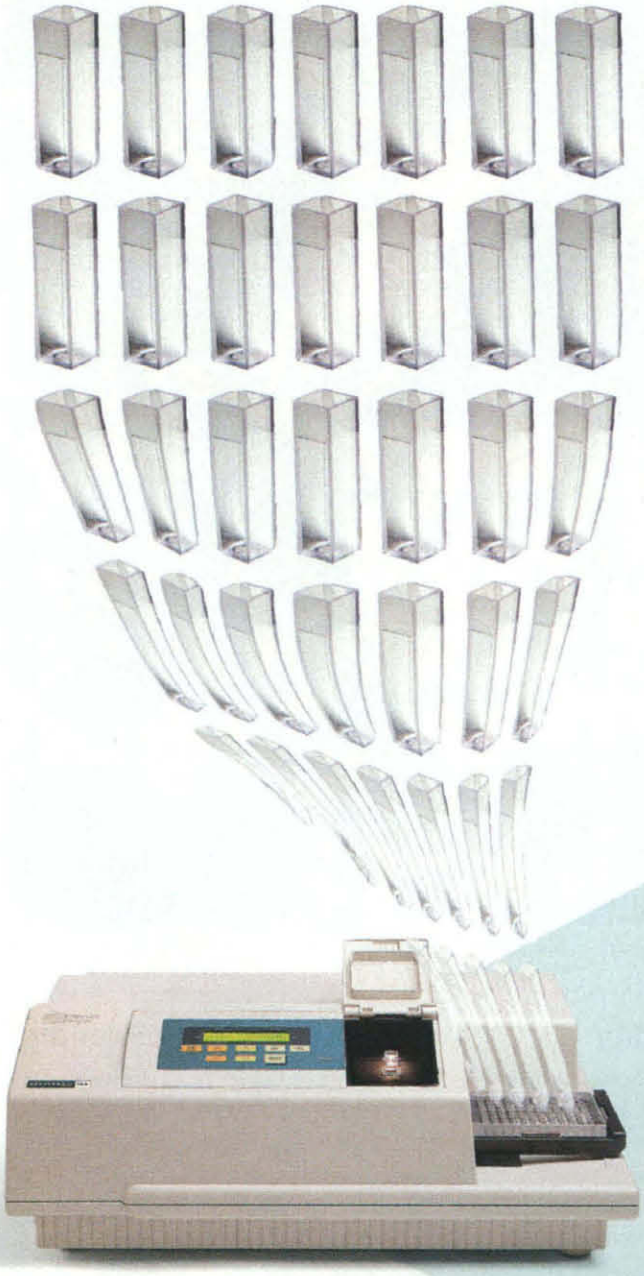
For more information about GCG products:
tel: (608) 231-5200
http://www.gcg.com/framework
e-mail: framework@gcg.com

Circle No. 44 on Readers' Service Card



WHEN WE FIRST MET ALEC™, HE COULDN'T READ...

Break the UV/VIS Throughput Barrier!



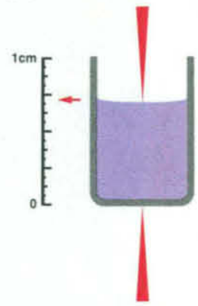
High Throughput Spectrophotometry Defined... ...SPECTRAmax® *PLUS* with PathCheck™ Sensor

At Last... Spectrophotometer Performance in a 96 Sample Format:

- 190-1000 nm wavelength range
- Spectral scanning, kinetics, and endpoint reads in all samples – up to 96 at a time
- 2 nm bandwidth
- 96 samples in 12 seconds
- Flexibility of single cuvette or high throughput analysis in one instrument

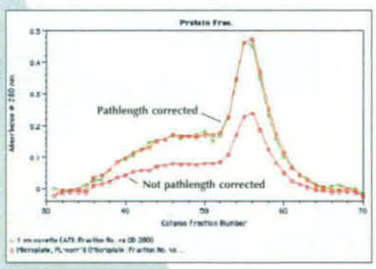
Proprietary PathCheck Sensor Technology

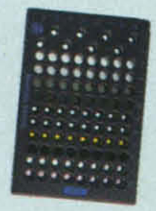
Automatically reports absorbance values as 1 cm pathlength. Compare microplate and cuvette data directly.



Flexible Data Handling

SOFTmax® PRO makes it easy to overlay multiple scans, compare kinetic reactions, use conversion factors, and analyze the data your way. Easy export to Spectroscopy software.





Instrument Validation... Automatically

Extensive SPECTRAtest™ Validation System streamlines GLP compliance.

For detailed information call 800-635-5577 or check our web site at www.moleculardevices.com for a current listing of local representatives.

Molecular Devices

1311 Orleans Drive
Sunnyvale, CA 94089
Tel: 800-635-5577
Tel: 408-747-1700
Fax: 408-747-3602
www.moleculardevices.com

Argentina: 1-4796-0023, **Austria:** +49-89-9620-2340, **Belgium:** 02 474 50 70, **Brazil:** 21-592-3232, **Canada:** 800-635-5577, **China:** +886-2-2322-3857, **France:** 02 99 25 03 13, **Germany:** 089-9620-2340, **Hong Kong:** +886-2-2322-3857, **Italy:** 02 891391, **India:** 044-434 0174, **Israel:** 03-902-1330, **Japan:** 797-32-2677, **Korea:** 02-553-2038, **Netherlands:** 0318-486652, **Scandinavia:** +46-31-68-0490, **Singapore:** 65-775-7284, **Spain:** (91) 551 54 03, **Switzerland:** 061 269 1111, **Taiwan:** 2-2322-3857, **United Kingdom:** 01293-619 579

Circle No. 60 on Readers' Service Card