10 May 2002

Science

Vol. 296 No. 5570
Pages 969–1188 $9

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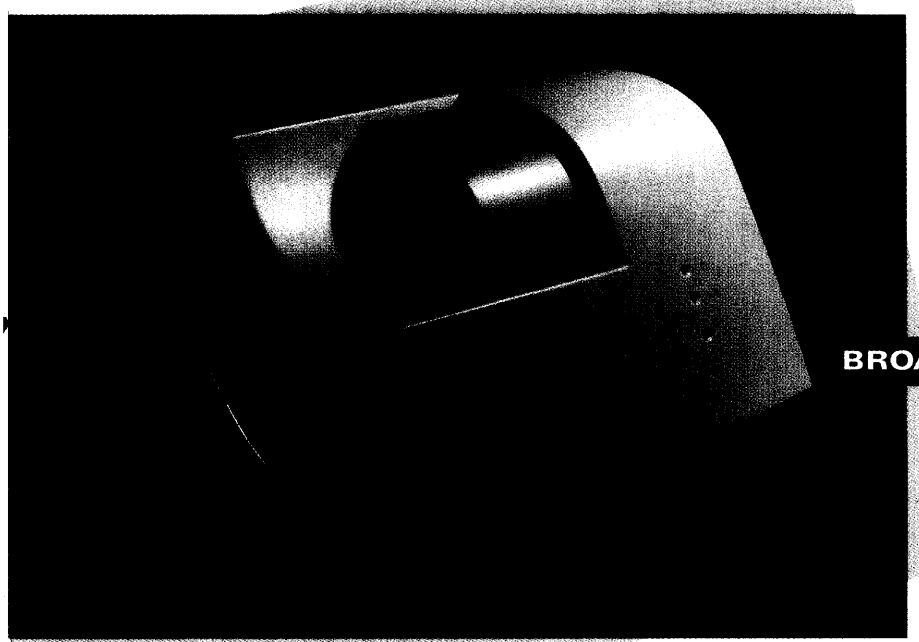

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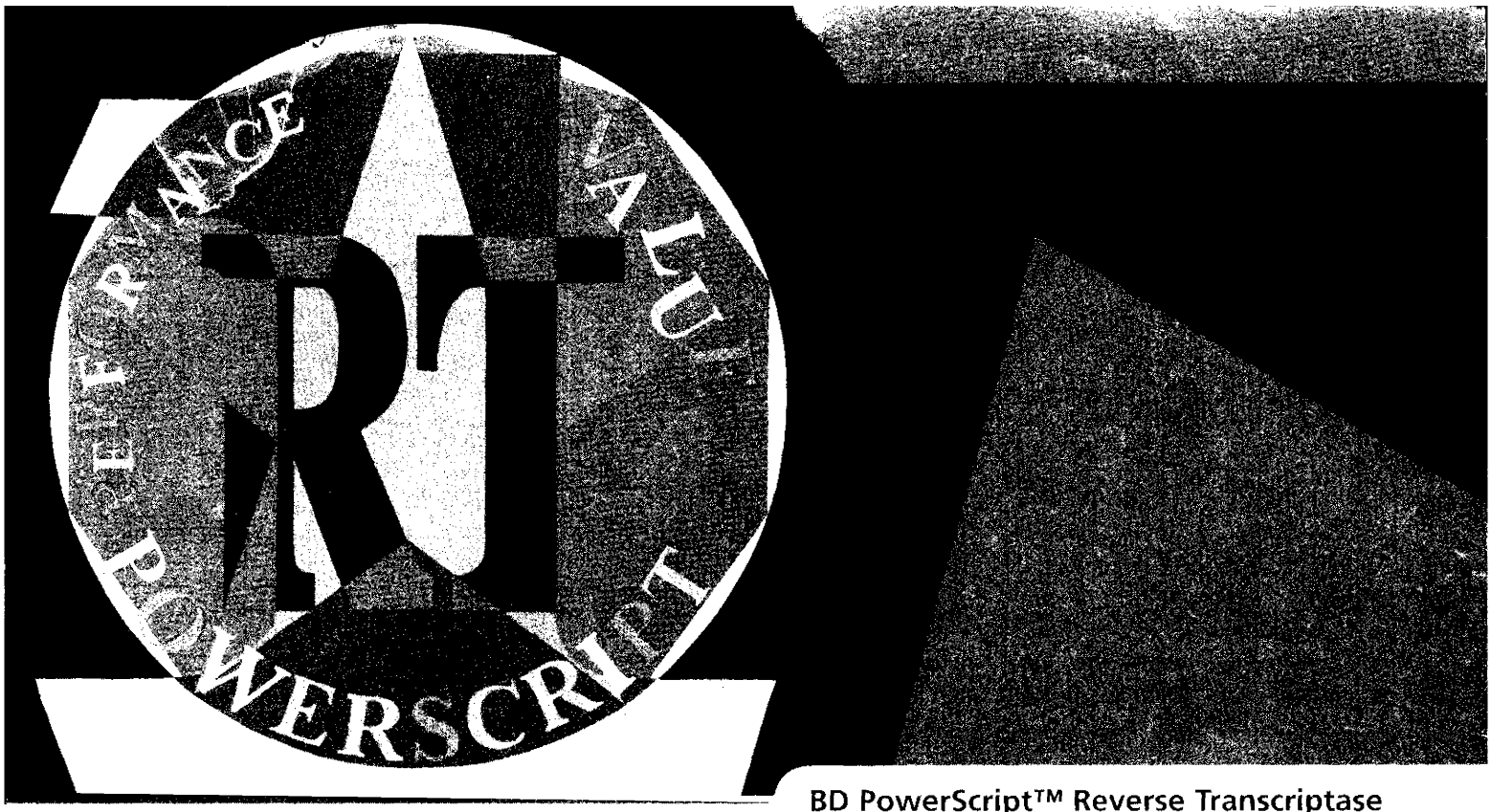

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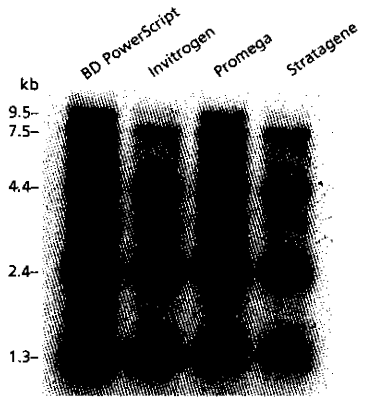

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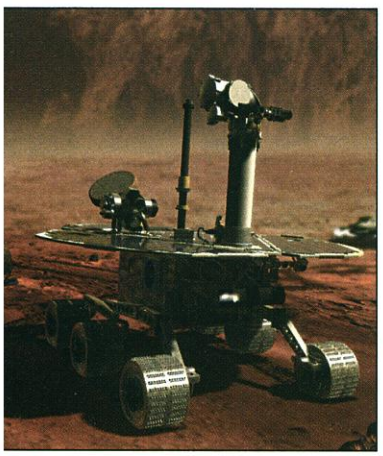

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Four-site saga on Mars

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NEWS OF THE WEEK

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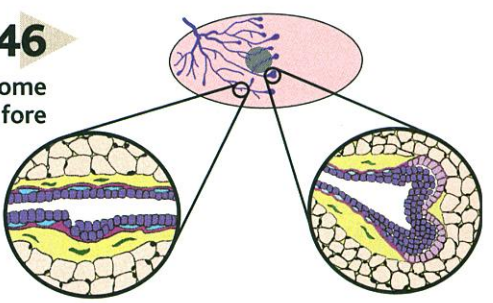
Stromal cells come to the fore



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Music and the mind

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ENVIRONMENTAL MICROBIOLOGY

NEWS

VIEWPOINTS AND REVIEWS

***See also* Science's *STKE* on p. 975, Report on p. 1127, and News of the Week story on p. 1000.**

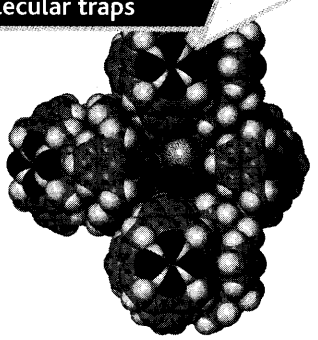
COVER 1055

Bubbles from the acidic thermal mudpot "the Gumper," Yellowstone National Park, USA. Studies of microbes from hydrothermal systems such as this one and many other environments, not all extreme, are providing information on how microbes are distributed, evolve, and thrive, as well as their role in the evolution of Earth's atmosphere and oceans, as highlighted in a special section on environmental microbiology. [Photo: A.-L. Reysenbach]

1124

***Wolbachia* and cytoplasmic incompatibility**

New on *Science* Express Interstitial molecular traps



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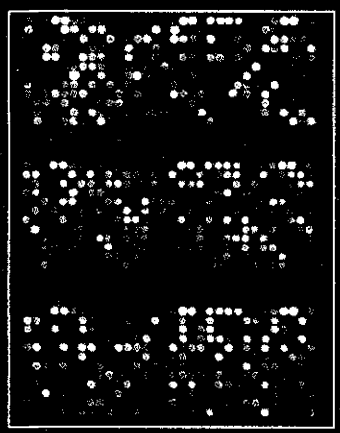

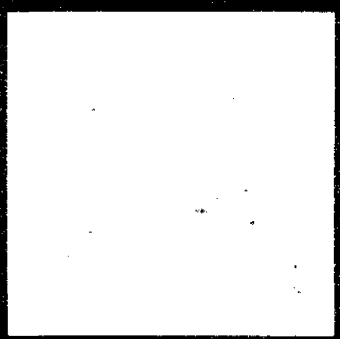

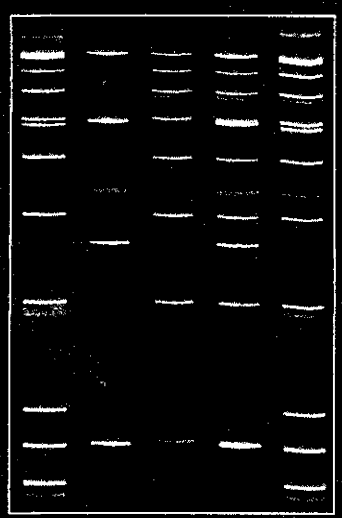

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Storage of Methane and Freon by Interstitial van der Waals Confinement J. L. Atwood, L. J. Barbour, A. Jerga

Crystals of a cryptand compound trap methane and freons in the interstitial spaces between the molecules.

Comparative Genome Sequencing for Discovery of Novel Polymorphisms in *Bacillus anthracis* T. D. Read *et al.*

1002

PERSPECTIVE: **Microbial Forensics—When Pathogens Are "Cross-Examined"** C. A. Cummings and D. A. Relman

1002 Whole-genome sequencing and statistical modeling are used to look at variations among isolates of *B. anthracis*, including one from the 2001 bioterror attacks.

Structure of an HIF-1α–pVHL Complex: Hydroxyproline Recognition in Signaling J.-H. Min *et al.*

Interactions with hydroxyproline provide the specificity that is required for signaling.

TECHNICAL COMMENTS

Islands, Equilibria, and Speciation

Studying the molecular phylogeny of land birds to estimate their relative colonization times in the Lesser Antilles, Ricklefs and Bermingham (Reports, 16 Nov. 2001, p. 1522) found that the species accumulation pattern over time did not follow the exponential distribution predicted for constant colonization and extinction rates and concluded that the data instead suggested "an abrupt, roughly 10-fold increase in colonization rate or a 90% mass extinction event 0.55 to 0.75 million years ago." Cherry *et al.* comment that Ricklefs and Bermingham did not adequately consider other models that might explain the data—in particular, a model incorporating migrations and speciation events, which, Cherry *et al.* argue, "deserves further consideration." Ricklefs and Bermingham call the Cherry *et al.* proposal "an important alternative to our analysis." They also note that determining which of the two models provides a better explanation "can be tested by how well it predicts the geographic structure of genetic variation," and suggest that this test tends not to favor the Cherry *et al.* model.

The full text of these comments can be seen at www.sciencemag.org/cgi/content/full/296/5570/975a

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career resources for scientists

EUROPE: Is the Italian Brain Drain Becoming a Flood? C. Pelizon

Young Italian scientists see brighter career prospects abroad, but attempts are being made to lure them back home.

UK: Proof Positive—Scots Are Enterprising H. Marshall

Through its Enterprise Fellowships and Proof of Concept Fund, Scottish Enterprise is providing tools for Scottish academics to commercialize their research.

CANADA: Science Communication—The Next Frontier C. Wilhelmson

Countering persistent charges of pervasive serial obtuseness, today's scientists are increasingly drawn toward the growing business of science communication.

US: Tooling Up—Making Lasting Connections D. Bomzer

Networking is an indispensable career skill, but what is required for effective networking?

SINGAPORE: A Primer on Commercialization A. H. C. Yu

Our expert discusses technology transfer and strategies for generating cash from your latest invention.

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science of aging knowledge environment

Death Comes for the Fungus R. J. Davenport

Yeast protein mimics mammalian cell suicide trigger.

Classic Papers Section

From *Science*, 1982: "Dietary Restriction in Mice Beginning at One Year of Age: Effect on Life-Span and Spontaneous Cancer Incidence," by R. Weindruch and R. L. Walford.

science's stke

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signal transduction knowledge environment

Review: An Attractive Surface—Gram-Negative Bacterial Biofilms M. A. Schembri, M. Givskov, P. Klemm

1055 Bacterial surface sensing and quorum signaling.

Perspective: Amplification of Signaling Events in Bacteria F. W. Dahlquist

1055 How bacteria sense and respond to chemoattractants.

Perspective: Information Processing in Bacterial Chemotaxis J. B. Stock, M. N. Levit, P. M. Wolanin

1055 A bacterial probrain integrates signals to produce an optimal response.

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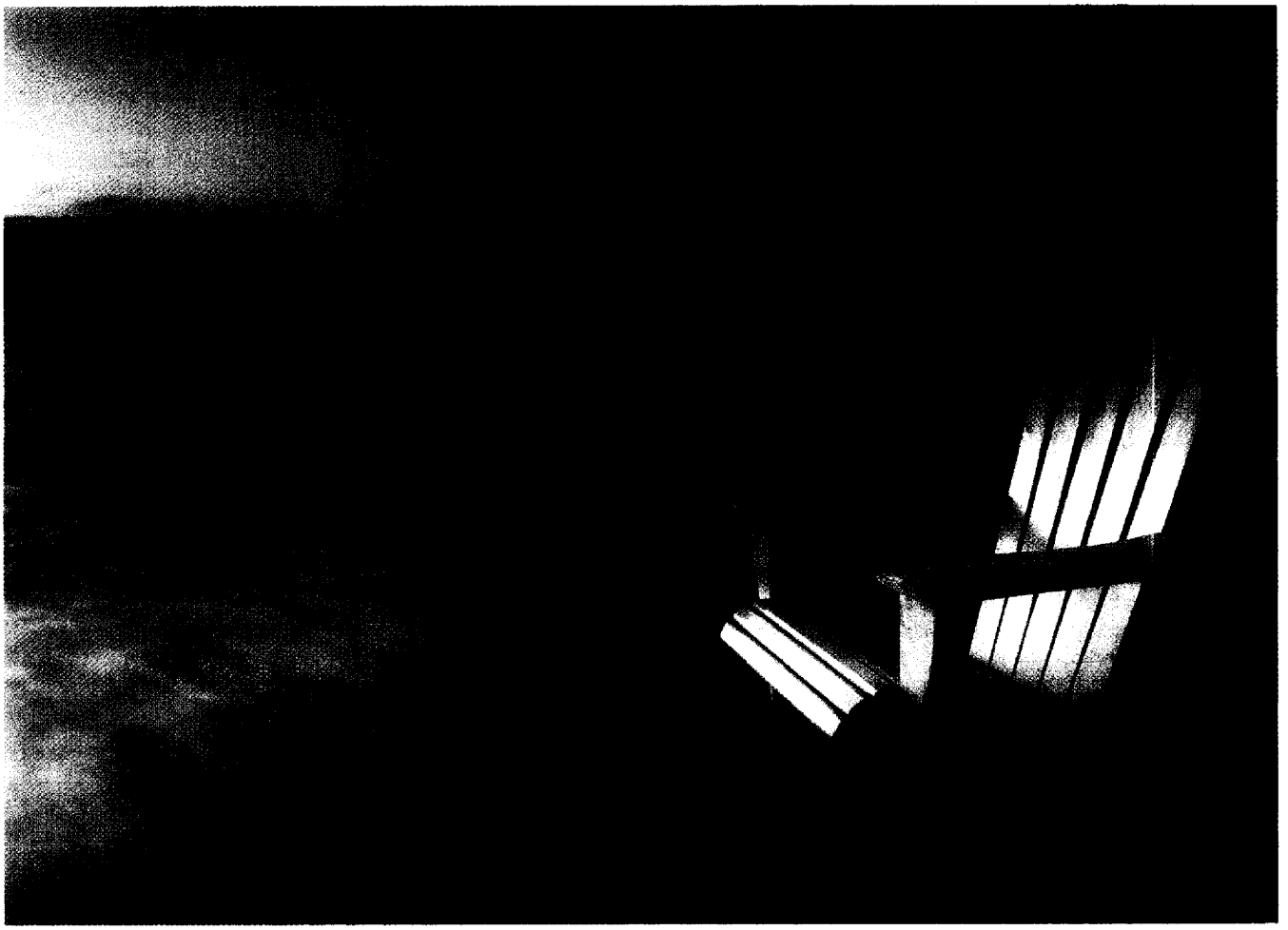
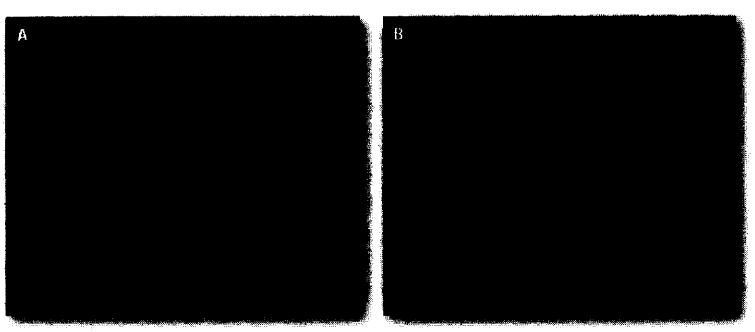
NEW ENGLAND BIOLABS

Savor the silence.





RNAi in *C. elegans*
Fluorescence microscopy of a *C. elegans* adult female with a transgenic GFP reporter gene (green) highly expressed in the pharynx (A). Double-stranded RNA corresponding to the GFP coding region was produced using the HiScribe RNAi Transcription Kit and injected into the syncytial gonad of transgenic adult worms. RNAi is demonstrated by the reduction of GFP expression in the progeny (B).

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THIS WEEK IN Science

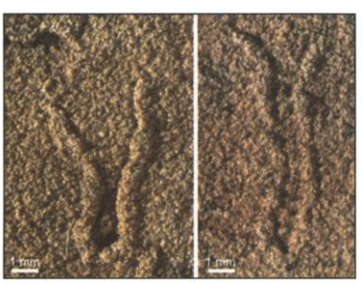
edited by Phil Szuromi

Three Ways with Light

Light can be used in a variety of ways to fabricate materials or provide power to devices, as illustrated in three reports. Manipulation of particles with light has been generally limited to trapping and rotation. MacDonald *et al.* (p. 1101) have developed a range of techniques based on optical interference for forming and manipulating three-dimensional structures of microscopic particles. The interference pattern generated by Laguerre-Gaussian optical beams results in a spiral type structure of optical traps that can be used to trap, rotate, and translate the microscopic particles over macroscopic distances and in three dimensions. A challenge for nanotechnology is powering small devices, and one may be to feed in the energy in the form of light. Hugel *et al.* (p. 1103) show that the light-driven cis-trans isomerization in individual chains of an azobenzene polymer can generate force and thus perform mechanical work. A common approach to three-dimensional fabrication is to use pairs of lasers beams to define a point in space where photoprocesses can be used to initiate reactions in polymer precursors, such as through the generation of acids. Nonlinear two-photon excitation (in which two infrared photons combine to produce ultraviolet excitation) can reduce unwanted background polymerization. Zhou *et al.* (p. 1106) now report the design of a much more efficient two-photon acid generator, as well as initial results for positive-tone microfabrication.

First Impressions Count

Metazoans are generally thought to have arisen in the latest Precambrian (less than about 600 million years ago) and then diversified greatly during the Cambrian explosion. However, there have been some hints, including clues from molecular genetics studies, pointing to a much earlier evolution. Rasmussen *et al.* (p. 1112) have dated and reexamined rocks from the Stirling Range Formation, Australia, that were provisionally assigned an edicaran age (latest Precambrian), based in part on the presence of discoidal impressions that were analogous to some accepted edicaran fauna. However, uranium-thorium-lead dating places the age of the rocks to be older than 1.215 billion years. Although these discoidal impressions may have a nonbiological origin, they also see what appears to be fossilized trackways of a motile organism, either a metazoan or lineage that went extinct.



CREDIT: RASMUSSEN *ET AL.*

1087 Comet Flyby

The nuclei of comets may contain frozen primordial remnants from the formation of our solar system. However, only the nucleus of 1P/Halley, a comet derived from the Oort cloud, has been imaged. Soderblom *et al.* (p. 1087) provide images and spectra of the nucleus of 19P/Borrelly, a comet derived from the Kuiper Belt, that were collected during a close flyby (as close as 2171 kilometers) by the Deep Space 1 ion-propulsion spacecraft in September 2001. The nucleus of Borrelly is extremely dark, with an albedo similar to C-type asteroids, and its surface is mottled and rough. Spectra indicate that the nucleus is very dry, with no evidence for water or hydrated minerals. Several collimated jets of dust and gas show that the comet is still actively sublimating, and the main jet accounts for the sunward asymmetry of Borrelly's coma. ⇶

And in Brevia ...

Bearing sons was associated with a reduction in human maternal life-span after menopause, whereas bearing daughters was associated with an increase, according to an analysis of preindustrial demographic records by Helle *et al.* (p. 1085).

The Wheres of Electrons

Although transport measurements on quantum dots have revealed single-electron charging effects and Coulomb repulsion, they do not provide information on where the electrons are within the dot. Scanning probes provide spatial resolution but generally provide very limited electronic information. Using a metallized tip in an atomic force microscope, Woodside and McEuen (p. 1098) now extend scanning probe microscopy to imaging single electrons within the quantum dot.

A Big South American Hit?

Tektites are glass fragments attributed to melt ejecta from an impact event, and several areas in Indonesia, Australia, and the Czech Republic are concentrated in glass fragments and thought to be strewn fields from an impact. Bland *et al.* (p. 1109; see the Perspective by Melosh) have found a tektite-strewn field on the Pampean plain of Argentina, and their observations suggest that a 0.5-kilometer-diameter bolide may have hit the plain about 0.5 million years ago.

Culture for the Masses

A major challenge for microbiologists is that 99% of bacteria cannot be isolated from the wild and cultured in the laboratory. Kaeberlein *et al.* (p. 1127; see also the news story by Green and the special issue coverage starting on p. 1055) have developed a simple diffusion-chamber method for growing and passaging pure cultures of marine bacteria in contact with, but separated from, their natural sediments. They obtain sufficient quantities of pure organisms to satisfy the needs of most molecular biologists and ecologists. Their initial studies suggest that the primary barrier to cultivating naturally occurring bacteria is the characteristic interdependence for nutrients, or various diffusible signals, among species.

The Third Way

A recurring problem in evolutionary biology and in human societies is how cooperative groups develop and survive. Cooperation among individuals can lead to greater goods, yet defectors within cooperative groups can reap greater benefits. Punishment only works in small groups where the culprits can be identified. Hauert *et al.* (p. 1129)

⇶ Published online in *Science* Express

CONTINUED ON PAGE 979

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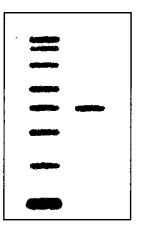

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leaven this mix of protagonists by adding a third type of agent, the loner. They show that the option to withdraw, or sit out, leads to dynamic coexistence of cooperators, defectors, and loners, with individuals rotating their behavior, as in the child's game of rock-paper-scissors.

How Bacteria Get Their Vitamin B_{12}

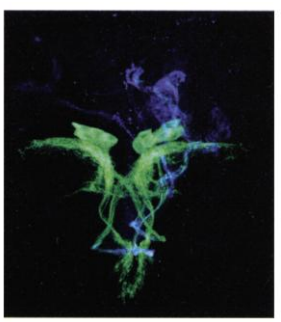
The largest class of membrane proteins that pump substances, either into or out of cells, are known as the ABC transporters for their common adenosine triphosphate (ATP)–binding cassette domains that couple the energy from ATP hydrolysis to active transport. The ABC transporter family includes members such as the cystic fibrosis transmembrane conductance regulator and multidrug resistance proteins. Locher *et al.* (p. 1091; see the Perspective by Davidson) provide a close-up at 3.2 angstroms of the transporter BtuCD, which enables bacteria to accumulate vitamin B_{12}. The arrangement of interfaces between the halves of the transmembrane chamber, formed by 20 helices, and between these halves and the cytoplasmic ABC domains leads to a proposal for how the transport pathway opens and closes.

Insights into Aneuploidy

Errors in meiosis that lead to too many or too few copies of a chromosome (aneuploidy) are often lethal to the embryo. During the production of germline cells (meiosis), homologous chromosomes undergo extensive pairing and recombination via a synaptonemal complex (SC). Prior studies have shown that the SC filament protein SCP3 is necessary for male fertility. Yuan *et al.* (p. 1115) now analyze the functional role of SCP3 in the female germ cells of mice and find that SPC3-deficient female mice produce healthy offspring but have a greatly reduced litter size caused by chromosomal abnormalities. In addition, the incidence of chromosomal abnormalities increases with maternal age. This mouse model may serve to shed light on chromosomal nondisjunction and age-dependent aneuploidy in humans.

Diabetic Fruit Flies?

The genome of the fruit fly *Drosophila* encodes several peptides with sequence homology to human insulin. Through cell ablation experiments, Rulifson *et al.* (p. 1118) show that the primary source of the systemic insulin required for larval growth is a small number of neurons in the dorsomedial brain. These neurons share several intriguing functional properties with pancreatic islet b cells in mammals, including the regulation of carbohydrate metabolism. This work raises the possibility that genetically tractable invertebrates like *Drosophila* may be useful models for studying insulin-dependent diabetes.



CREDIT: RULIFSON *ET AL.*

A Matter of Timing

Wolbachia are bacteria that can infect various species of insect, and in so doing they alter the reproductive dynamics of the insects. Cytoplasmic incompatibility is one symptom of such infections such that when the sperm from infected males fertilizes eggs from uninfected females, embryonic lethality ensues. Matings between two infected individuals are fully fertile. Tram and Sullivan (p. 1124; see also the news story by Zimmer) examined the likely cause of cytoplasmic incompatibility and discovered an induced asynchrony between maternal and paternal pronuclei early after fertilization that prevents effective completion of the first cell division after fertilization.

Cellular Stage Directions

As the cell progresses through the cell cycle, mechanisms must be present to allow the cell to exit one stage and progress to the next one. Ogawa *et al.* (p. 1132: see the Perspective by La Thangue) investigate the mechanism by which genes are turned off in the G_0 stage by the repressor protein E2F-6. They found that E2F-6 exists in a large complex with other proteins, including several DNA binding factors, a histone methyltransferase, the transcription repressor HP1, and polycomb proteins. This multiprotein complex is targeted to E2F-6–responsive promoters in quiescent, but not G_1, cells. As malignant tumor cells have lost the ability to enter the G_0 stage, the elucidation of the mechanisms governing cell cycle–dependent gene expression may reveal important information about cell regulation.

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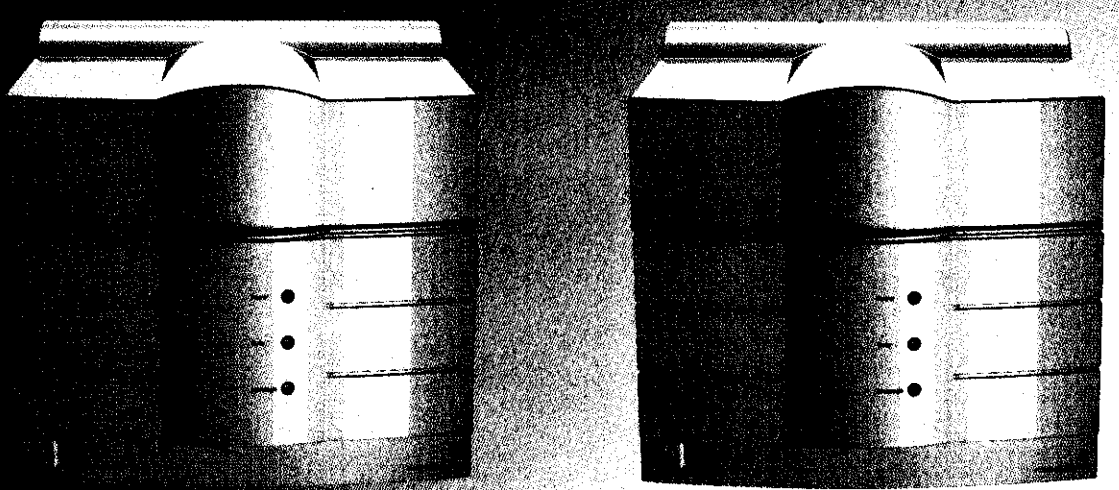

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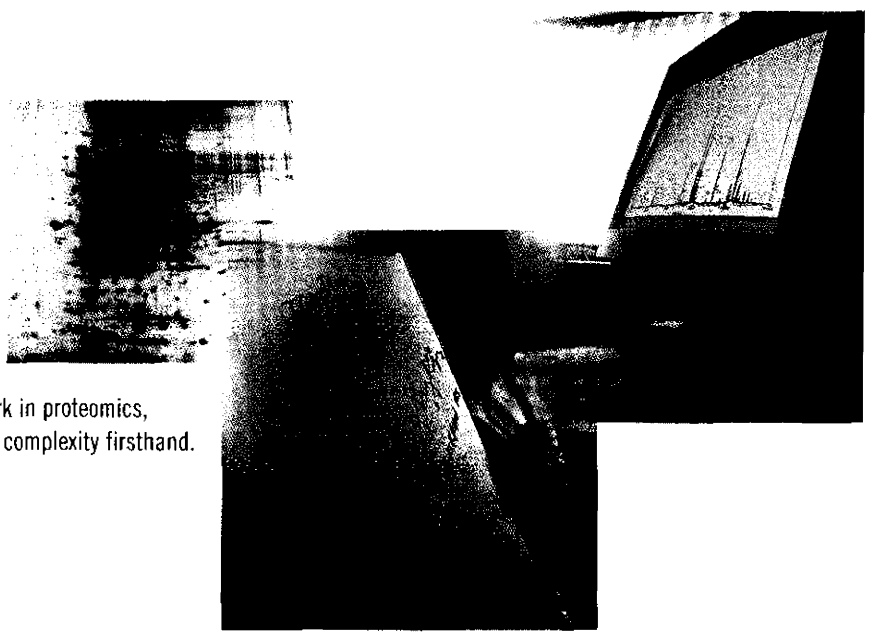

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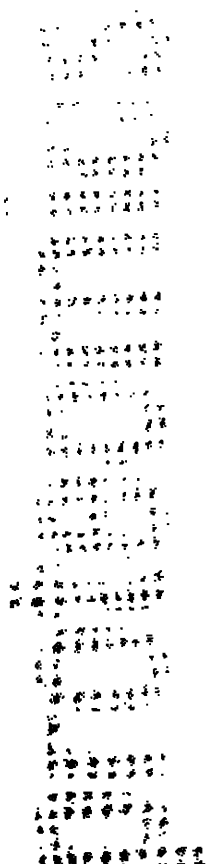

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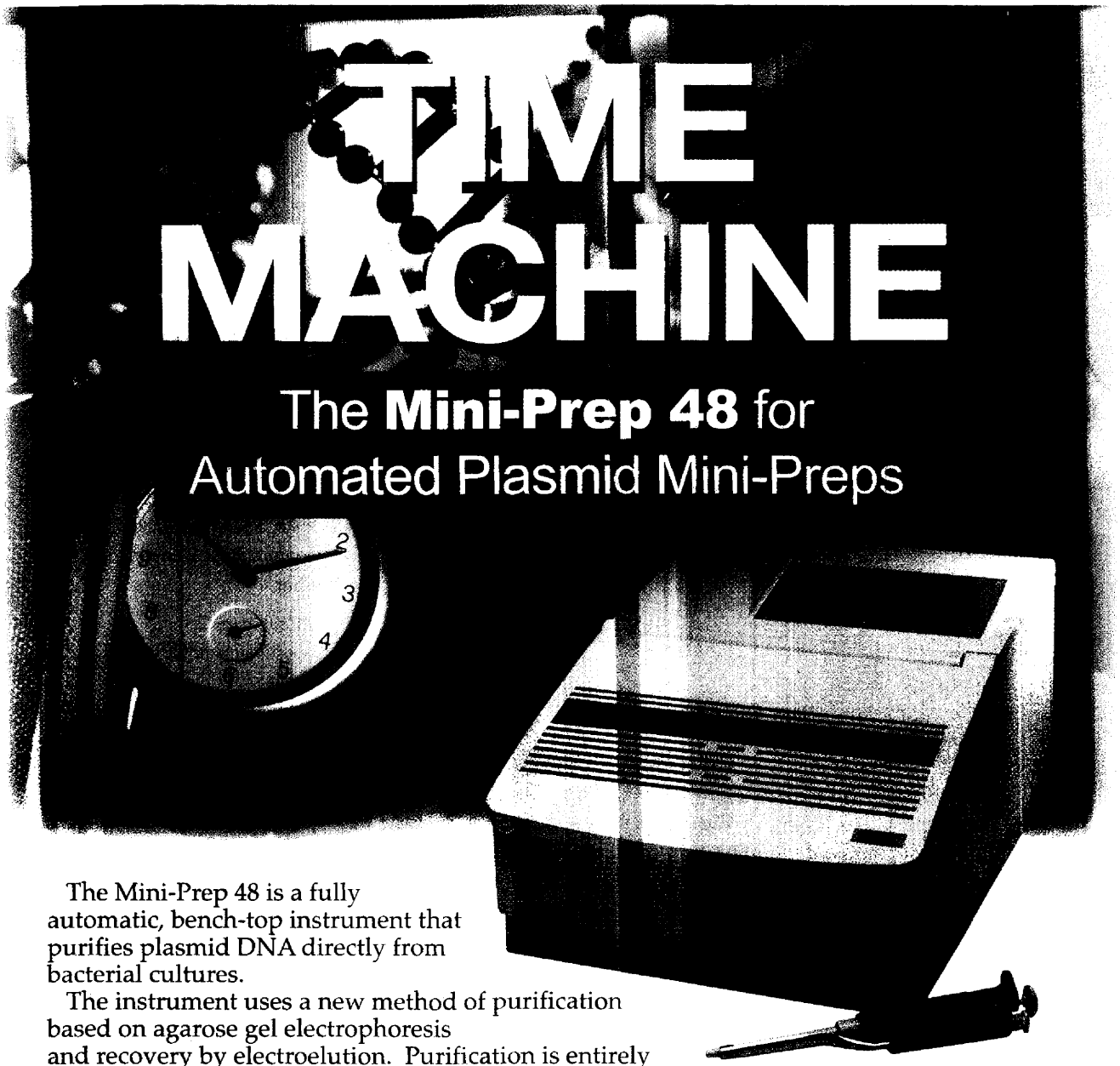

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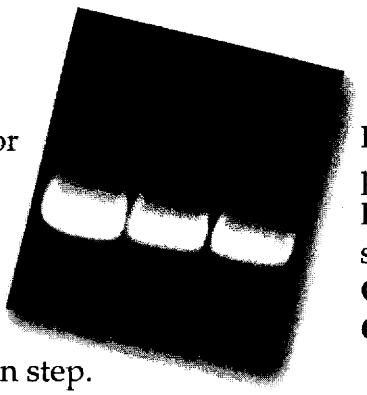

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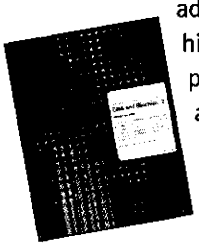

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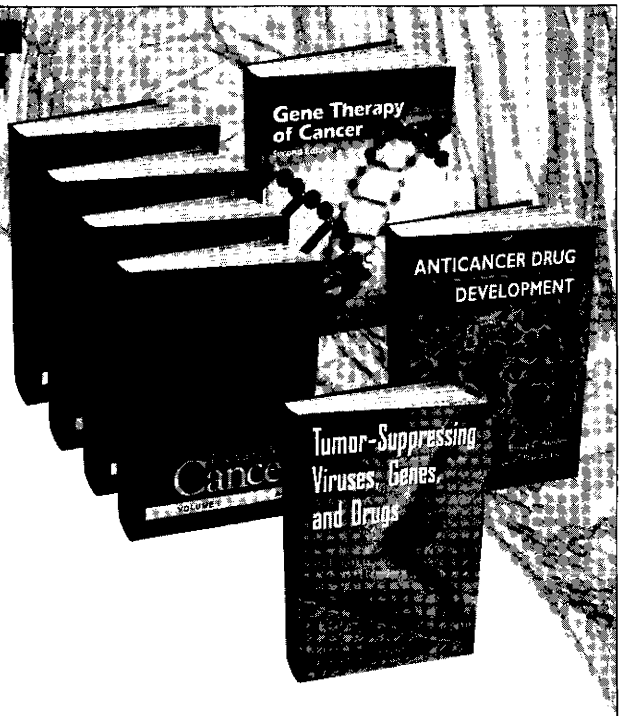

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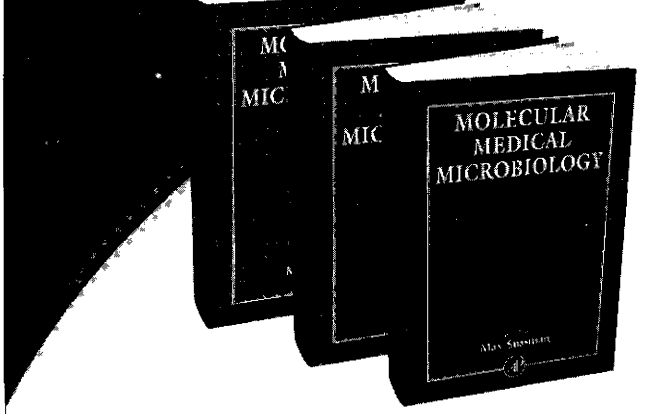

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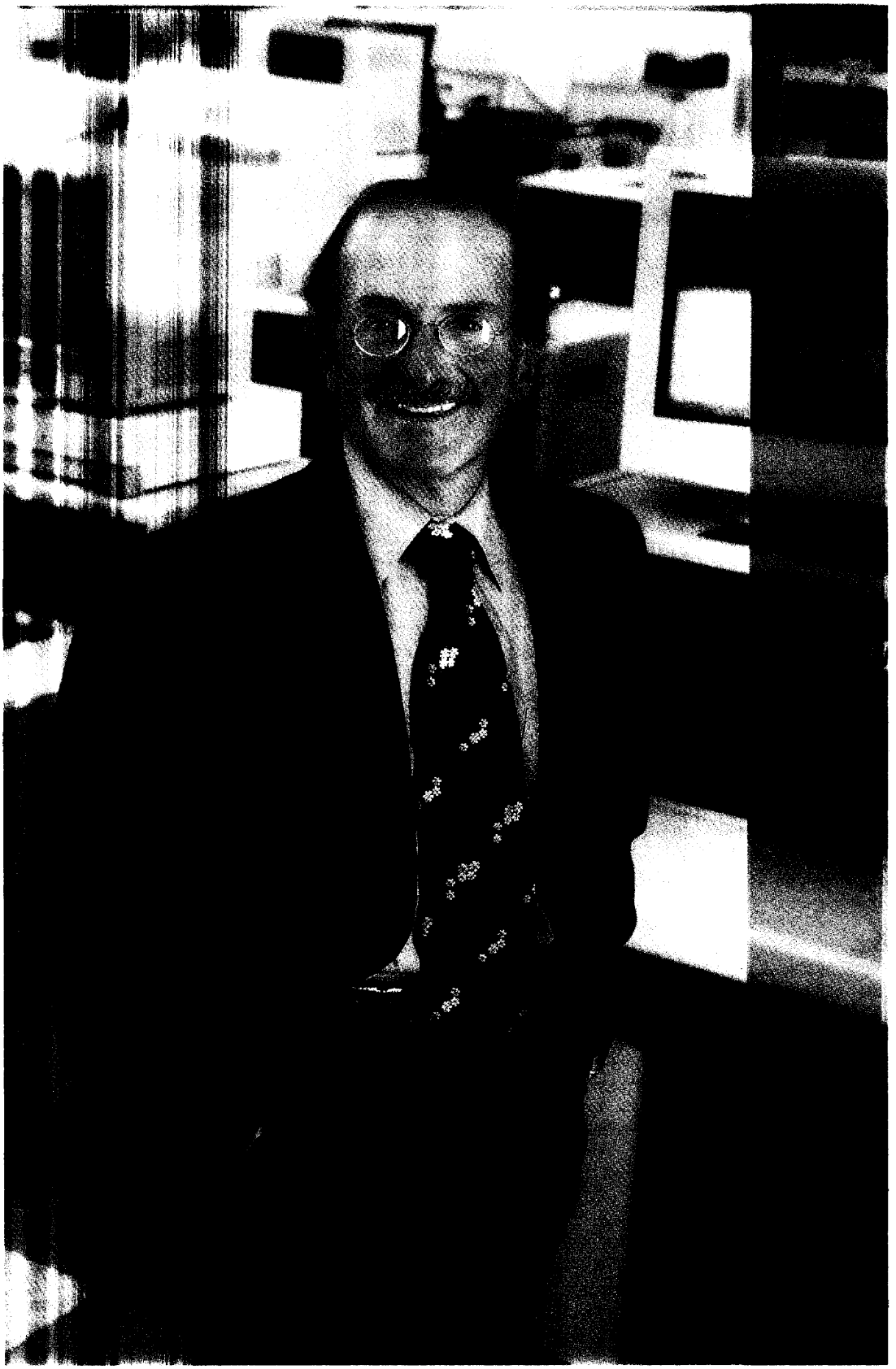

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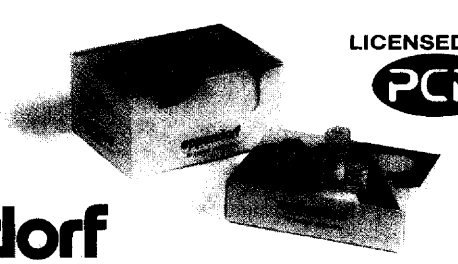

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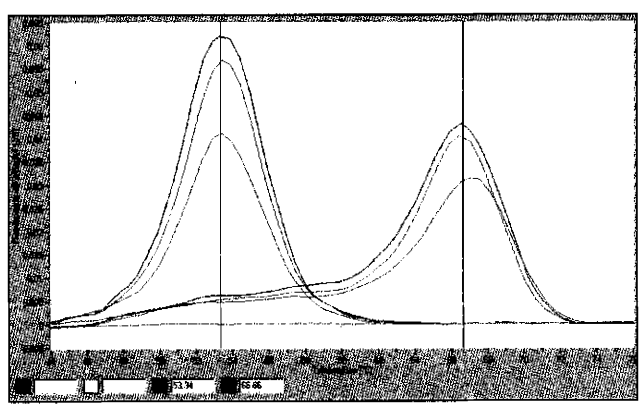

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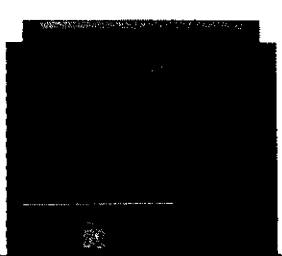

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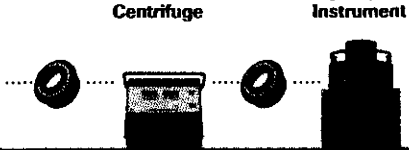

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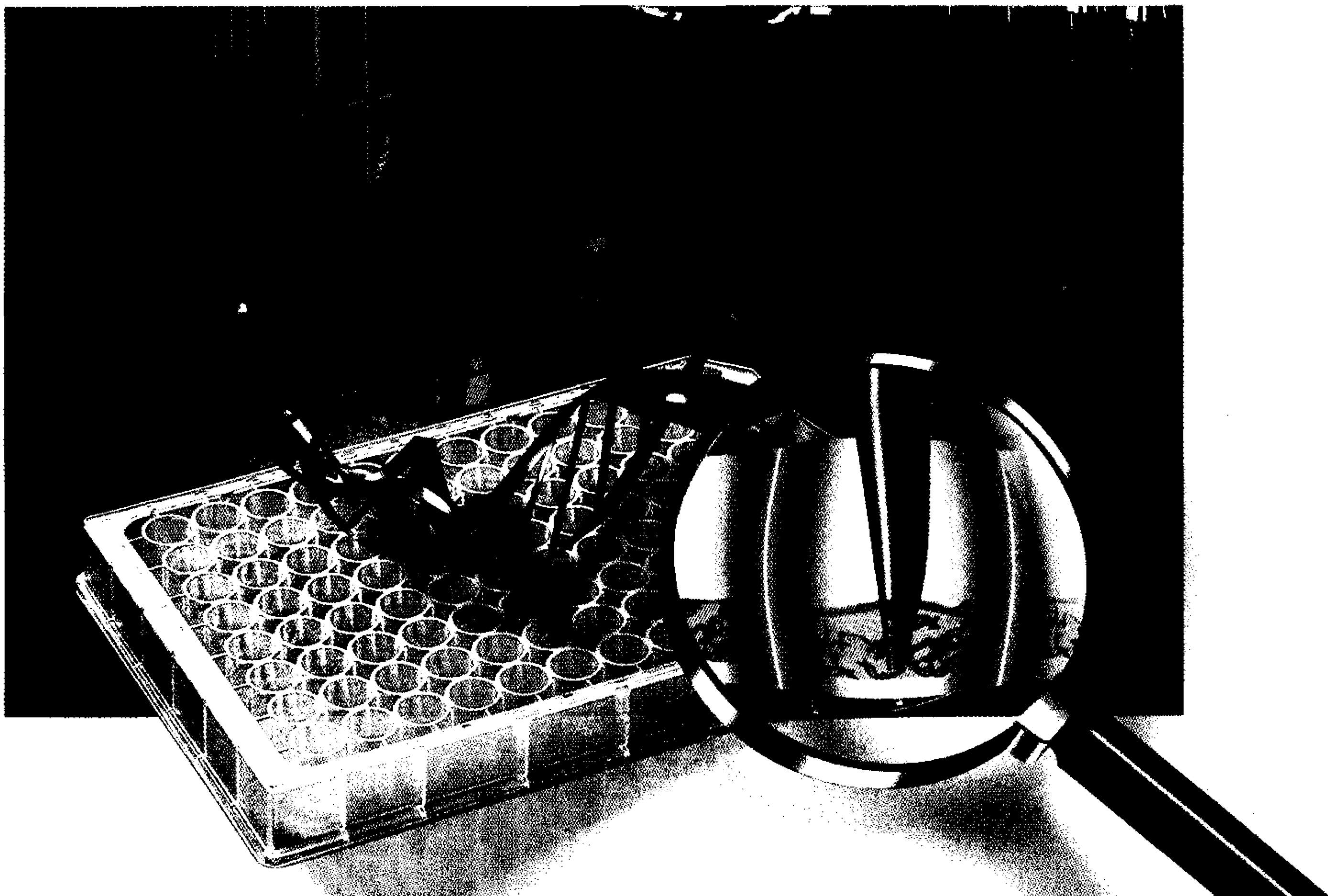

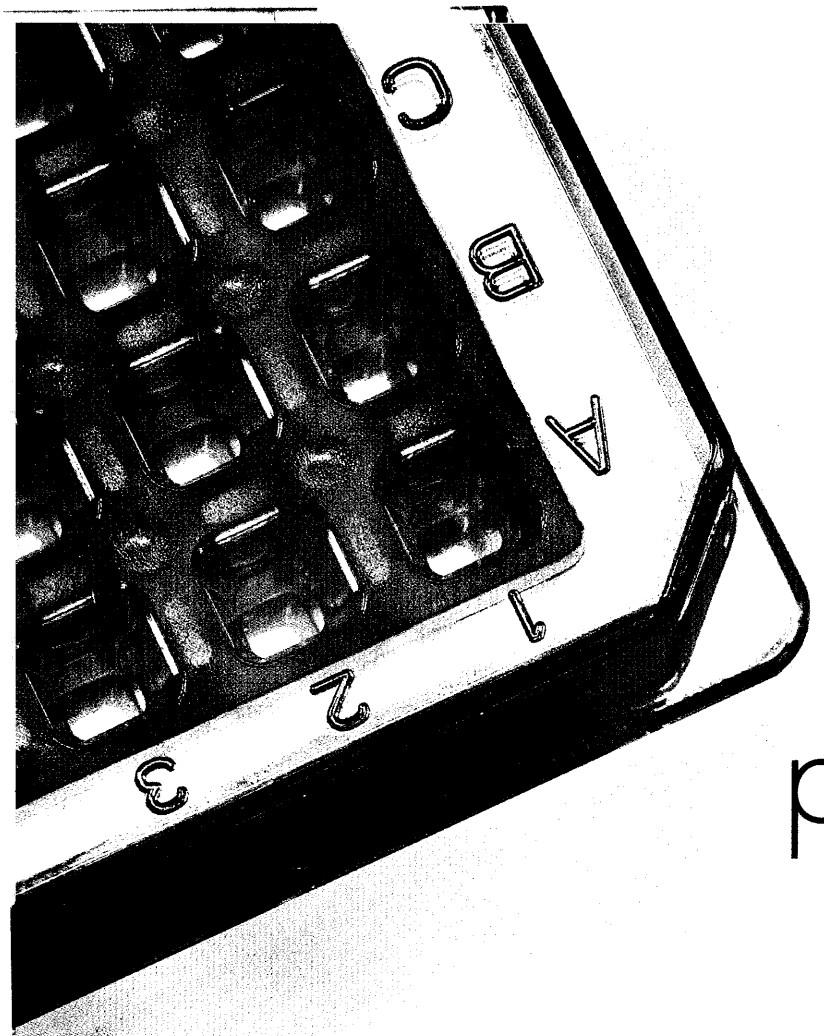

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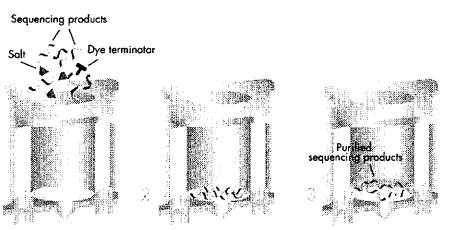

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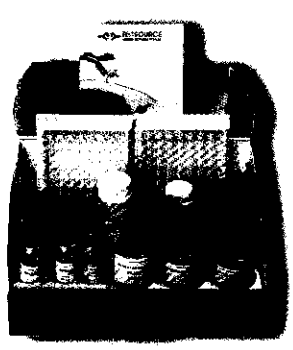

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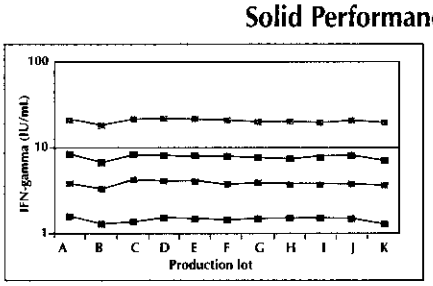

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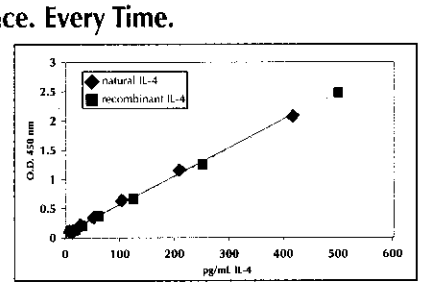

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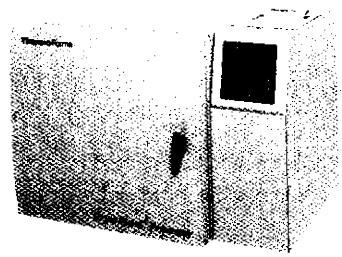

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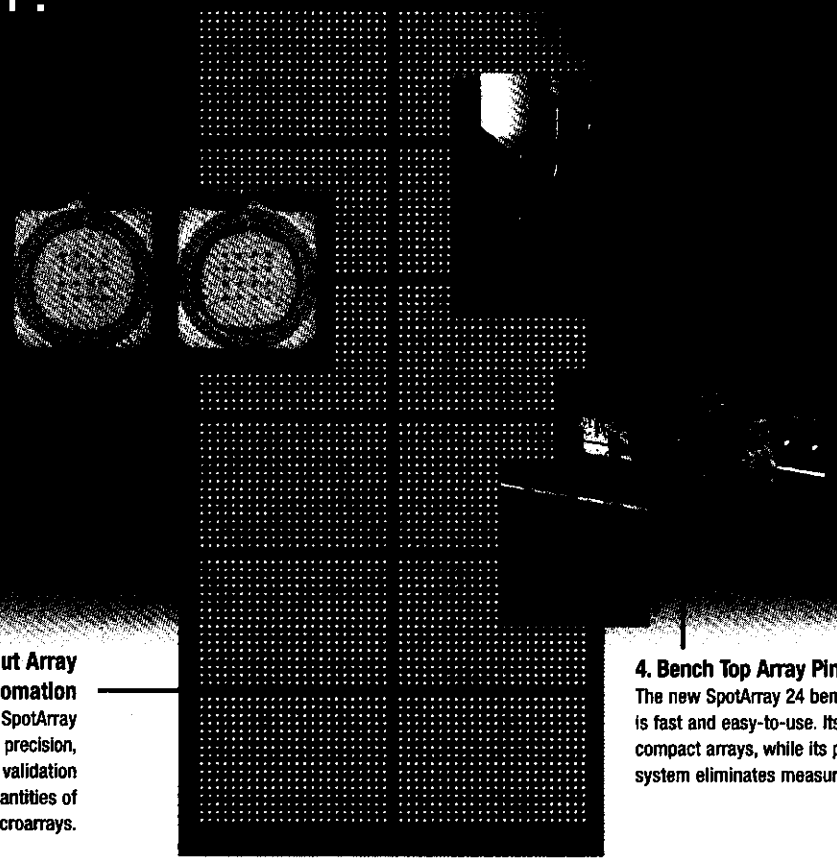

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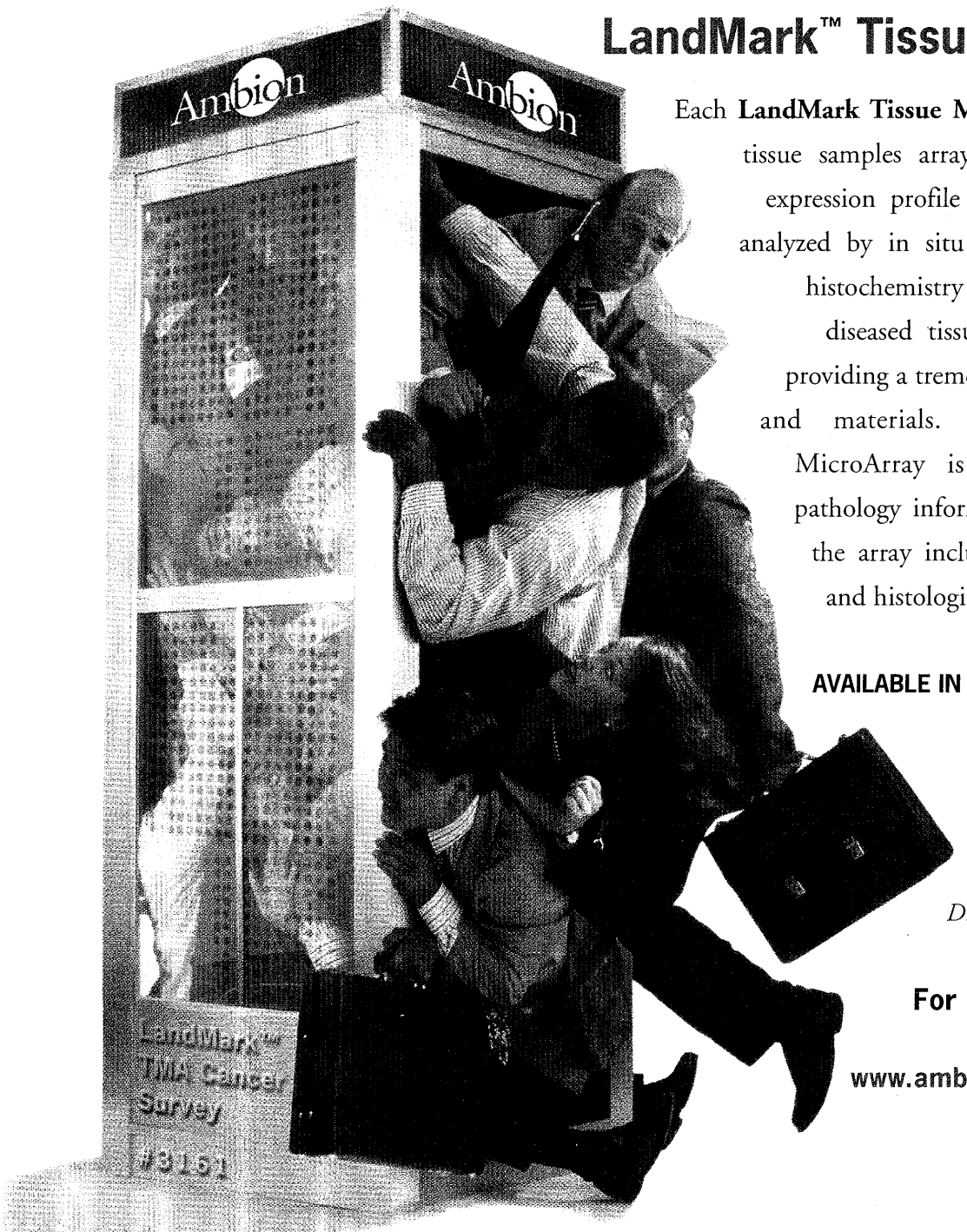

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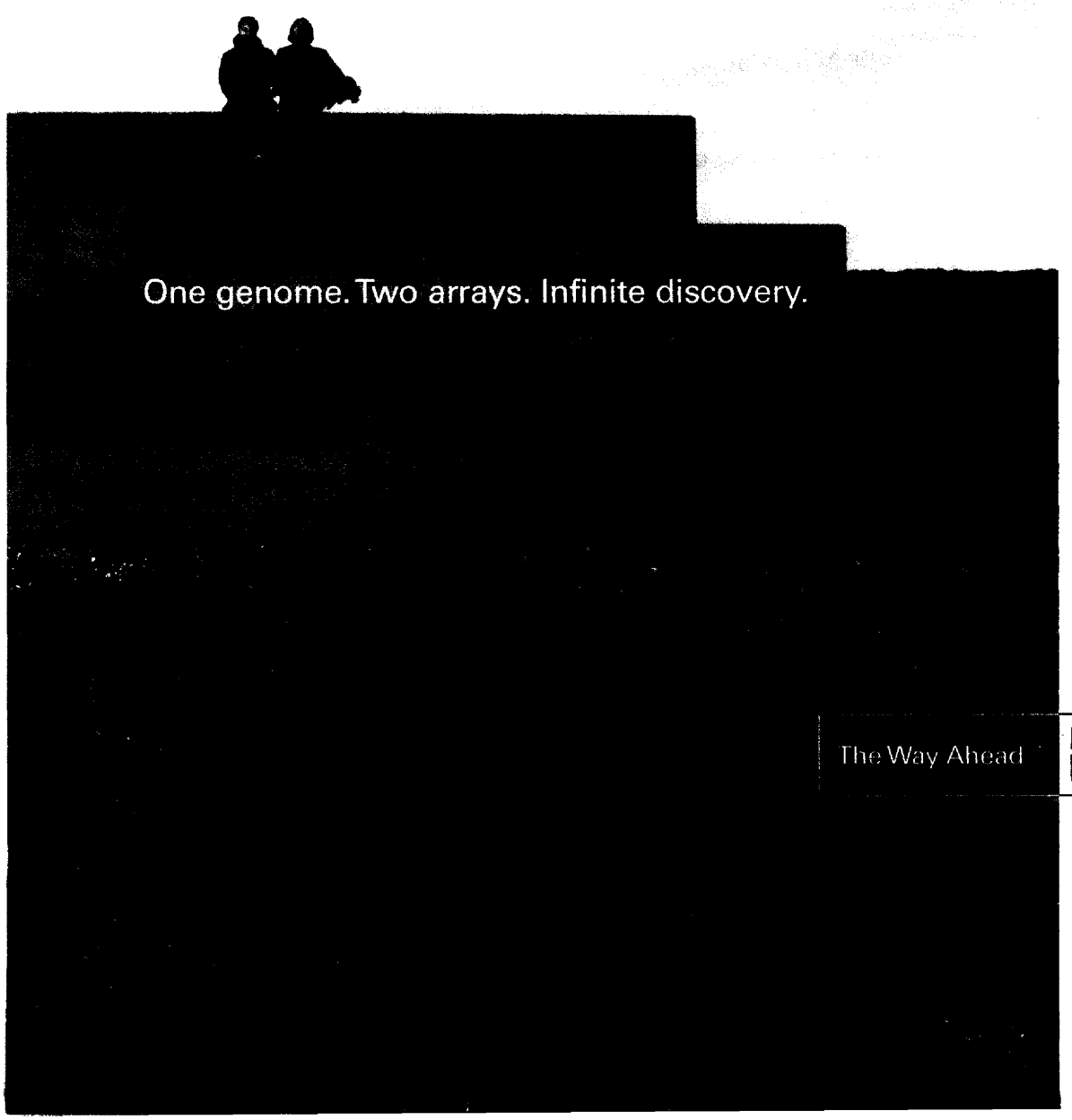

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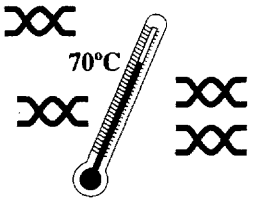

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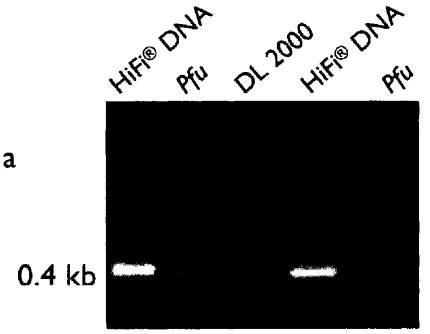


Fig. 1
Pfu fails to amplify a GC-rich template. (far right)

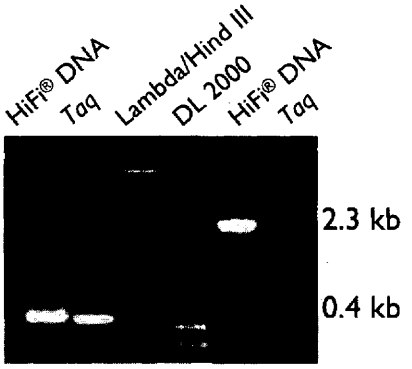


Fig. 2
Taq fails to amplify a 2.3 kb GC-rich template. (far right)

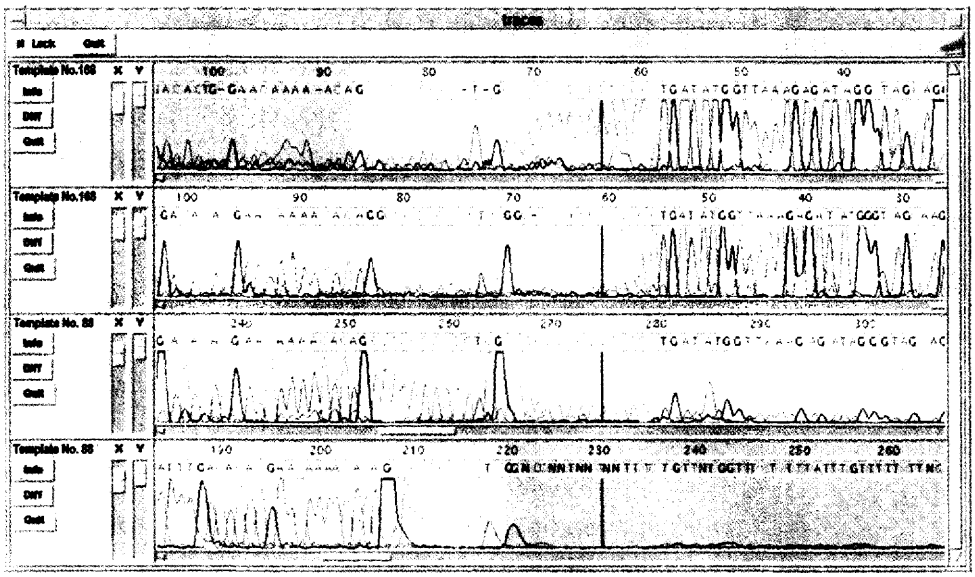
Fig. 3

ThermoSequenase II fails in the extension/termination after the GC-rich segment. (on the left)

HiFi® DNA polymerase in LoTemp™ cycle sequencing continues extension/termination. (on the left)

HiFi® DNA polymerase in LoTemp™ cycle sequencing overcomes this GC-rich segment. (on the right)

AmpliTaq, FS fails to overcome this GC-rich segment in cycle sequencing. (on the right)



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Pharmaceuticals. Vaccines. Biotechnology. All add up to **Wyeth®**

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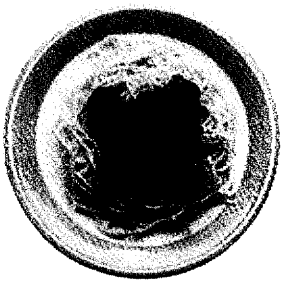

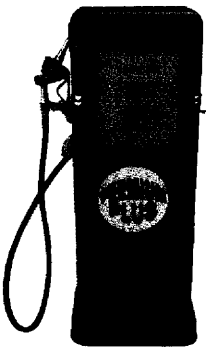

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Power your cell culture system with the right nourishment.

Now you can minimize adaptation time, improve control, increase yield and simplify scale-up with the most trusted name in cell culture.

No matter what your cell type.

Hybridomas. CHO cells. HEK (293) cells. Insect cells. Neurons. Blood and bone marrow cells. Keratinocytes. ES cells. Hepatocytes. Endothelial cells. Mammalian cells for virus production.

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What's more, we make it in a format to suit your system: dry powder, 1X liquid, concentrates, and new Advanced Granulation Technology™.

Use GIBCO™ specialty and serum-free nutrient media.

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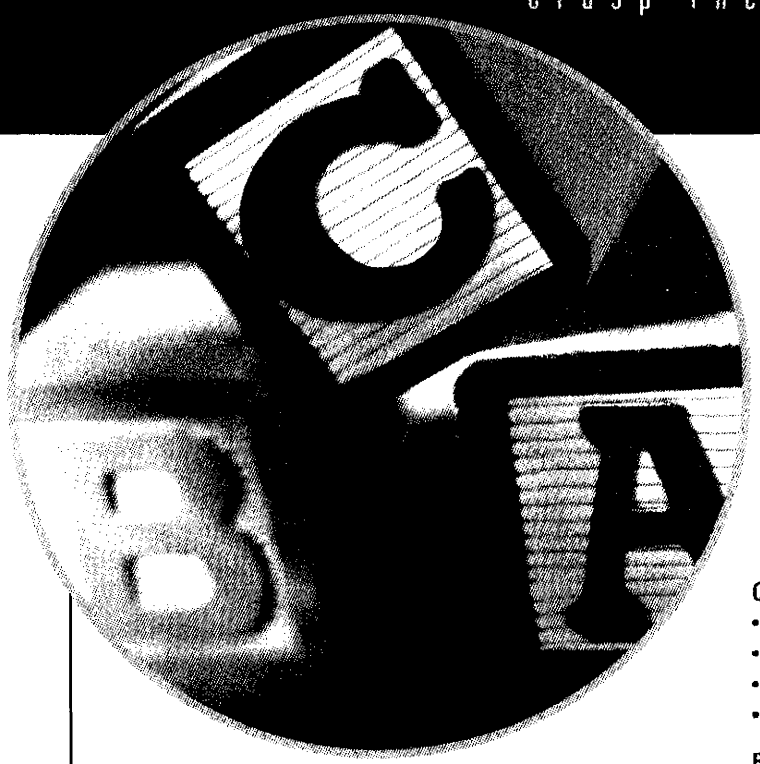
Protein Assay



BCA . . . start with the best basics.

The best protein research begins with a great protein assay.

Get back to protein chemistry basics with Pierce BCA (bicinchoninic acid) Protein Assays. The BCA Protein Assay, which was patented by Pierce,[1] remains a cornerstone for accurately measuring protein concentration in biological samples.

Quantitate protein concentration from 20-2,000 µg/ml for these applications:

- Studying protein:protein interactions
- Measuring column fractions after affinity chromatography
- Estimating percent recovery of membrane proteins from cell extracts
- High-throughput screening of fusion proteins

BCA Protein Assay Features/Benefits:

- Accuracy – less protein:protein variation than dye-binding methods
- Robustness – compatible with most ionic and nonionic detergents
- Speed – faster and easier than the Lowry Method
- Flexibility – adaptable to microplates for 10 µl sample sizes

U.S. Patent # 4,839,295

1. Smith, P.K., *et al.* (1985). Measurement of protein using bicinchoninic acid. *Anal. Biochem.* **150**, 76-85.

Great results begin here.

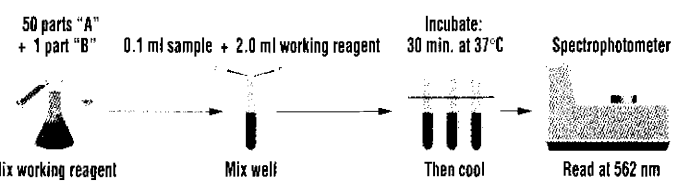
Product # 23225
BCA Protein Assay Kit – 1,000 ml

Back by customer demand!

Product # 23227
BCA Protein Assay Kit – 500 ml

Product # 23229
BCA Compat-Able™ Protein Assay Kit – 500 ml

All kits include standards.
Individual reagents are also sold separately.



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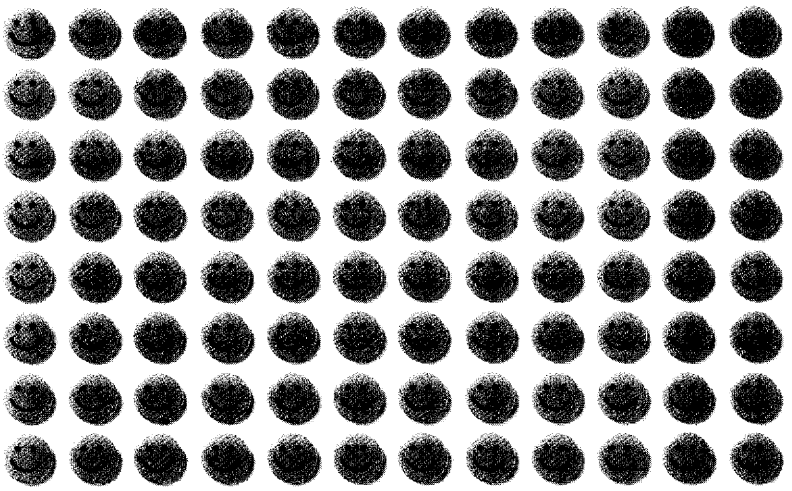
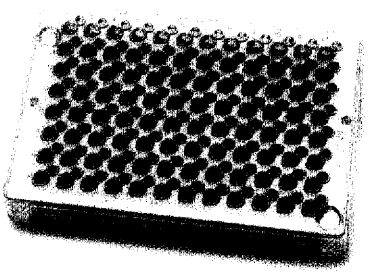


New, validated 96-well Caco-2 system. Confidence built into every well.

Pure reliability. Millipore's new MultiScreen™ Caco-2 System has everything you need for fast-track ADME. 4X the throughput — plus superior cell growth, enhanced assay sensitivity, and proven results that correlate to 24-well devices. The SBS-compliant, 96-well design conserves valuable sample, and lets you grow your cells and test permeability right in the same plate. For added confidence, every lot is QC-released using a Caco-2 cell line. Give yourself something to smile about. Call or visit **www.millipore.com/caco** to evaluate a sample.



System includes 96-well insert tray, feed receiver plate, sterile lid and analysis tray.

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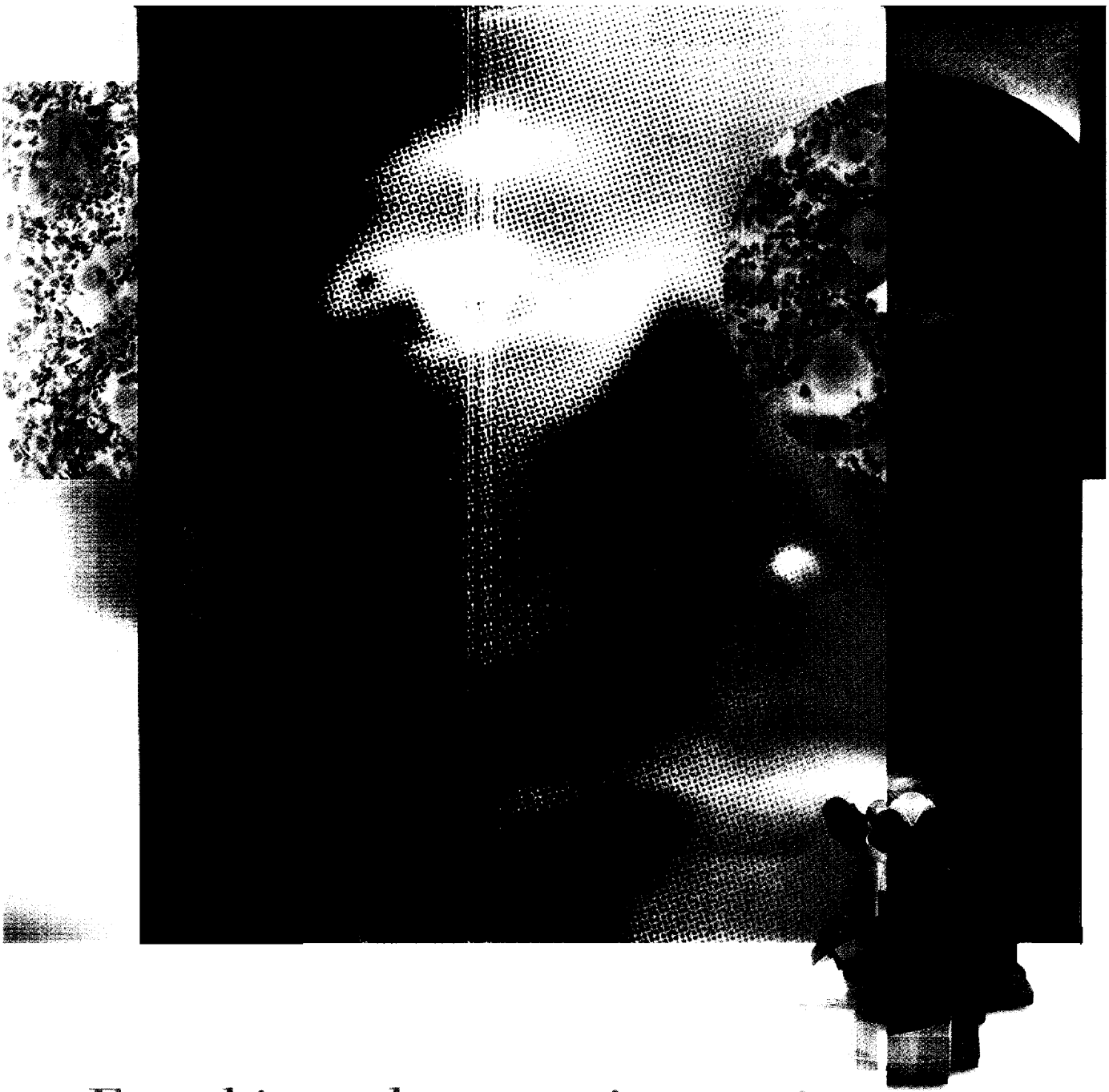
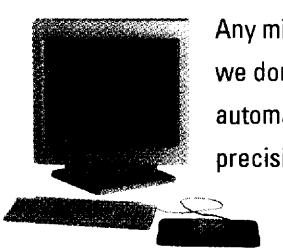


Few things show you innovations as accurately as a microscope system.



Any microscope image can only be precise as the optical systems that produced it. That's why we don't only concentrate on improving the technology of our microscope systems – even by automation – but also pay meticulous attention to their manufacture. The result: the high imaging precision essential today in biology, medicine or industry.

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