16 June 2000

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Understanding Earth's Dynamics

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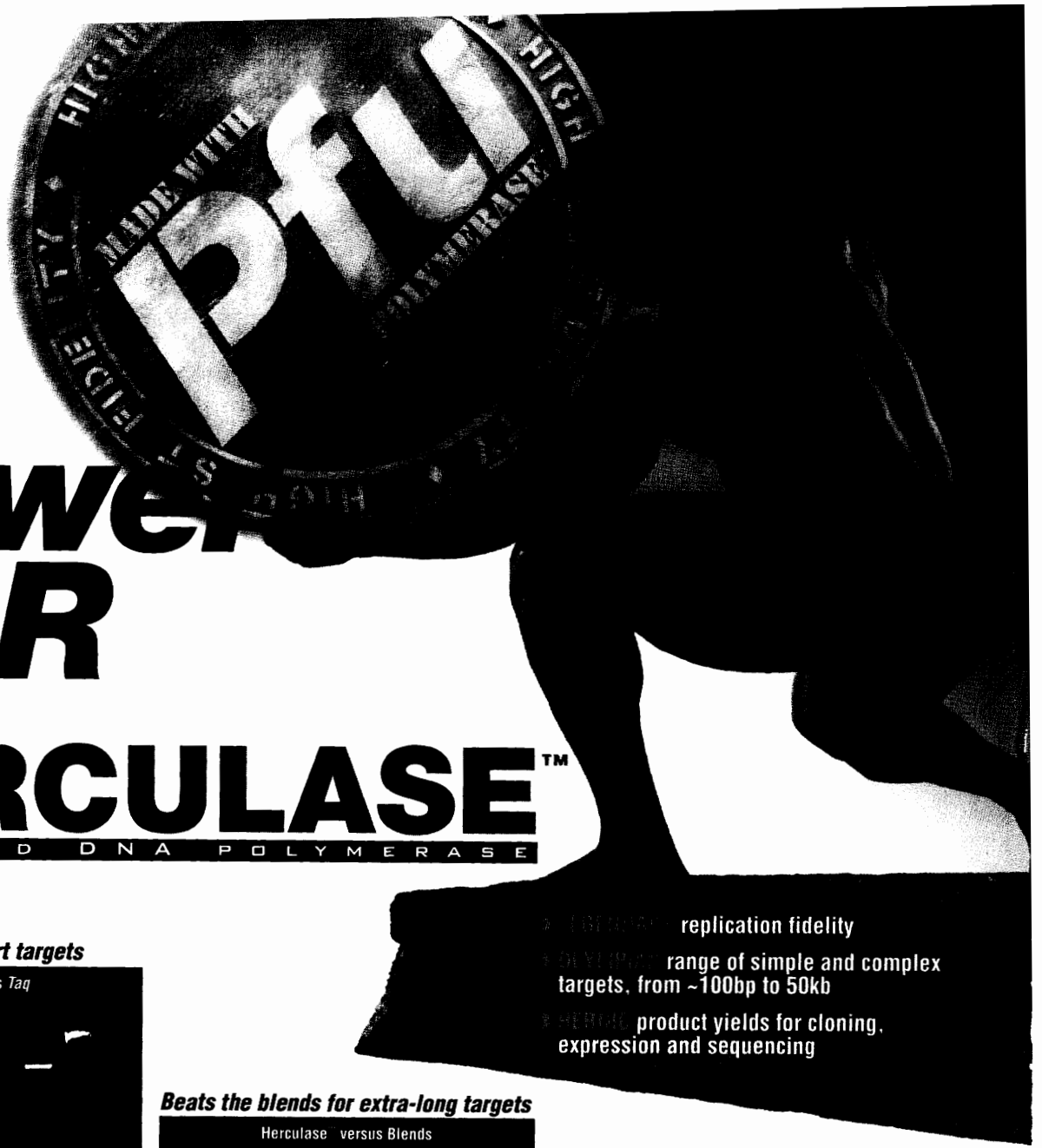

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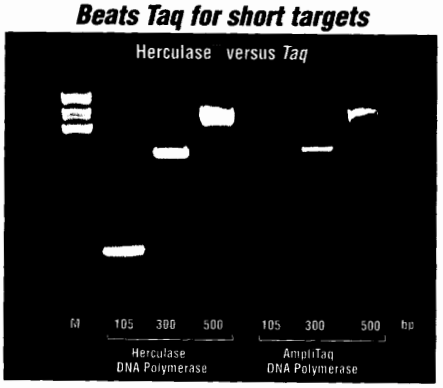

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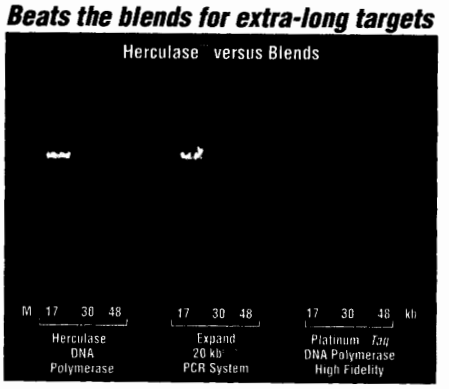

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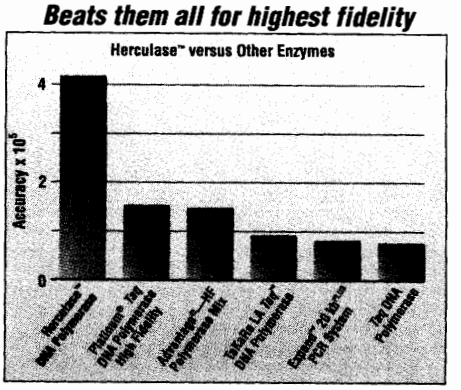

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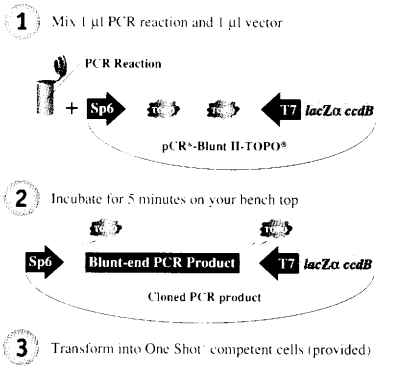

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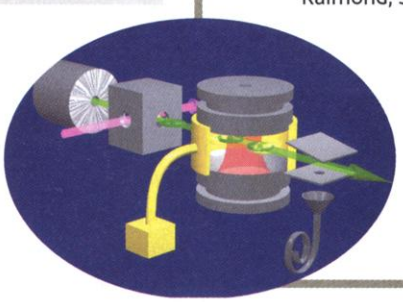
COVER Earth, from its innermost core to its outermost magnetosphere, is continually shaped by the highly interconnected array of forces that act on it. The subtle interplay of the fields and motions that are generated by and that generate these forces creates a planetary magnetic field, stirs the mantle, mixes the oceans and atmosphere, and modulates the solar wind. A special section starting on p. 1983 explores some of the dynamic systems that make Earth a true "terrestrial web." [Illustration: John Michael Yanson]

Exclusive interview with Jiang Zemin



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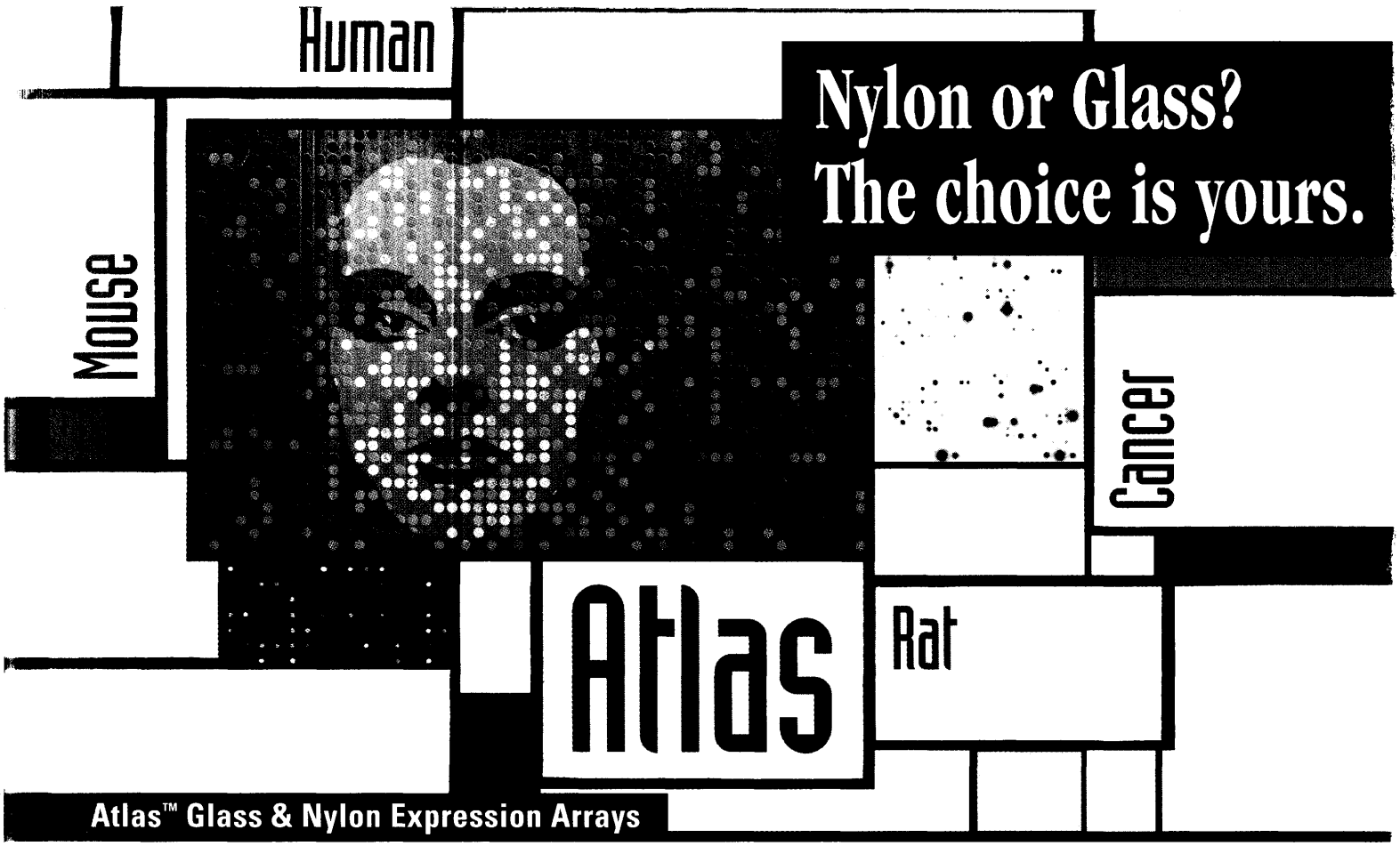

Illustration inspired by the art of Piet Mondrian (1872–1944).

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STRETCHING EXTREME MATTER

Most materials become narrower in cross section when stretched, but some materials, such as reentrant foams, have the unusual property of becoming wider when stretched. In an anisotropic material, expansion in one direction may be accompanied by contraction in another, and the process usually leads to overall densification. Baughman *et al.* (p. 2018; see the Perspective by Lakes) now show that such materials can also be incompressible, that is, show almost no change in volume upon stretching. They predict such unusual behavior for materials with very high density, such as neutron star crusts, or very low density, such as ion plasmas. Experimental data demonstrate the validity of these predictions for ion plasmas.

QUIESCENT ACCRETION

The formation of accretion disks around a massive object requires the dissipation of angular momentum of the gas and therefore some process that gives the gas viscosity. For close binary systems where the disks are weakly ionized and quiescent, the process of accretion does not follow the standard model of self-sustained magnetohydrodynamical turbulence. Menou (p. 2022) shows that an anticorrelation between the recurrence of outbursts and the mass ratio of the two objects leads to spiral waves, or to shock waves tidally induced by the companion, that ensures accretion during quiescent periods.

ESTIMATING OCEANIC PRODUCTIVITY

Approximately half of the photosynthetic production of O_2 takes place in the ocean. In addition to producing O_2, this process also consumes atmospheric CO_2 and is important in evaluating the effects of fossil-fuel burning. Luz and Barkan (p. 2028; see the Perspective by Bender) have developed a new technique for estimating oceanic production that takes advantage of the ability of marine biological activity to erase an isotopic anomaly in ^{17}O that is introduced into O_2 by the mass-independent fractionation that occurs in the stratosphere. This technique allows a time-integrated value of production to be calculated.

ENTANGLED ONE-BY-ONE

The development of quantum computers will depend on the ability to control the entanglement the quantum states of the information elements, the qubits. Many-body entanglement (to date, four qubits) has been an all-or-nothing process, and so addressing and interrogating individual qubits would be difficult because of the close proximity of the qubits to each other. Rauschenbeutel *et al.* (p. 2024) describe a process in which the qubits can be entangled step-by-step and are spatially separated (on the order of a centimeter). The technique provides a powerful route for many-bodied engineered entanglement.

COOLER FUEL CELLS

Most fuel cells run on hydrogen, which would likely be obtained by reforming hydrocarbon fuels at high temperatures. Another approach is to react light hydrocarbons such as methane, ethane, or propane directly with air. In these fuel cells, the electrolyte is a ceramic that becomes ionically conducting only at high temperatures (typically above 550°C). Hibino *et al.* (p. 2031; see the news story by Service) now report that lower operating temperatures (as low as 350°C) can be achieved by using samarium-doped ceria as the electrolyte. In this single-chamber cell design, fuel and air enter the electrolyte together, and current is drawn from the electrodes that bracket both sides of the electrolyte.

REVERSE GENETICS IN *DROSOPHILA*

T. H. Morgan's choice of *Drosophila* a century ago for studying the mechanisms of hereditary has resulted in the lowly fruit fly becoming one of the model organisms of biology. *Drosophila* has played a critical role in revolutions in genetics and molecular biology—the announcement in 1981 that the P transposable element could be used to create transgenic fruit flies also assured *Drosophila* a prominent place in genome research. Despite this utility and convenience, a couple of very important tools—homologous recombination and targeted mutagenesis—have been missing from the fruit fly molecular tool kit that yeast and mouse researchers take for granted. Rong and Golic (p. 2013; see the Perspective by Engels) now report a method of gene targeting by homologous recombination in the fruit fly that may also find use in other organisms.

BAD WEATHER FOR BIRDS

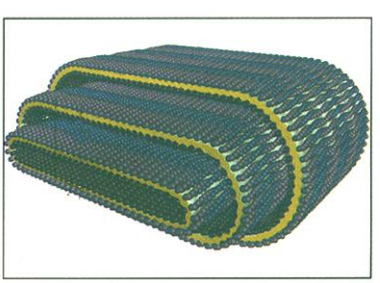
An understanding of the factors that affect the population dynamics of migratory birds, many of which are declining in abundance, requires long-term observation at both breeding and overwintering localities. Sillett *et al.* (p. 2040; see the Perspective by Sæther) have used a 13-year data set to show that populations of a migratory songbird are susceptible over a range of spatial and temporal scales to shifts in global climate patterns. Regional climate patterns like El Niño can affect a species on its breeding grounds as well as its wintering grounds; all demographic parameters (fecundity, survival, and juvenile recruitment) were lower than normal in El Niño years.

SMALL MOLECULE SWITCHES

The ability to switch macromolecular interactions on or off would give control over many cellular events. Guo *et al.* (p. 2042) have used a small molecule to modulate the interaction between human

FORMING THREE-LAYERED MEMBRANES

Complexes of cationic lipids with DNA, which have found application in gene transfer, can exhibit intricate structures that result from complex interactions between these oppositely charged species. Wong *et al.* (p. 2035) have extended this approach by replacing DNA with another polyelectrolyte, filamentous actin (F-actin) of the cytoskeleton, which has a lower surface charge density. What results is a network of micrometer-scale tubules. An analysis of x-ray scattering and freeze-fracture electron microscopy data reveals that F-actin self-assembles into two-dimensional parallel arrays on both sides of the lipid bilayers and wraps to form ribbon-like tubules; these tubules can then be surrounded by similar layers separated by water layers that form through osmotic swelling. These results suggest that many unusual morphologies can be accessed by "frustrated" assembly in which charge interactions cannot be easily accommodated by simple structures.



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THIS WEEK IN *SCIENCE*

CONTINUED FROM PAGE 1929

growth hormone and its receptor. They introduced a mutation into each of the proteins to create a cavity at the interaction interface. They then screened a library of indole analogs and selected a ligand that increased the affinity of the mutant hormone for its receptor more than 1000-fold. Cell proliferation and JAK2 phosphorylation assays showed that the ligand switched on the growth hormone signaling pathway in cells containing the mutant hormone and receptor.

KNOW THYSELF

The immune system attacks foreign cells and viruses when they lack "markers of self." Oldenborg *et al.* (p. 2052; see the news story by Hagmann) describe a marker of self on the red blood cell that is distinct from the well-known major histocompatibility antigens. This protein, CD47, must be present on red blood cells for them to avoid destruction by a class of splenic macrophages, the red pulp macrophages.

GROWING BUT NOT DIVIDING

The molecular mechanisms by which cell growth is coordinated with proliferation are not well understood. Volarević *et al.* (p. 2045) show that the two processes are separated in mice in which the gene encoding ribosomal protein S6 is conditionally deleted during adulthood. In cells from such animals, 40*S* ribosomal subunits (of which the S6 protein is a component) were absent. However, liver cells in such animals showed normal growth when nutrients were restored to fasted animals. In contrast, liver cells from animals lacking S6 did not proliferate after partial hepatectomy as do cells from normal animals, apparently because they did not increase the expression of cyclin E. A checkpoint mechanism may exist that halts cell proliferation if deficiencies in the ribosomal translational machinery are detected.

FOLDING SINGLE RNA MOLECULES

Less is understood about RNA folding versus protein folding, in part because less is known about RNA secondary structure elements and in part because of stringent technical challenges. Zhuang *et al.* (p. 2048) describe results from observations of single RNA molecules, in this case the group I ribozyme from *Tetrahymena*. From histograms of the changes in fluorescence of single molecules, they derive the docking and undocking rate constants for the substrate and ribozyme active site. They also uncover a new pathway for folding that occurs too rapidly to have been observed in previous ensemble measurements.

TECHNICAL COMMENT SUMMARIES

Recombination in Human Mitochondrial DNA

The full text of these comments can be seen at www.sciencemag.org/cgi/content/full/288/5473/1931a

Awadalla *et al.* (Reports, 24 Dec., p. 2524) found a decline in linkage disequilibrium (LD) with distance in human and chimpanzee mitochondrial DNA (mtDNA) that they held is consistent with genetic recombination. Four groups dispute that conclusion on a number of grounds. Kivisild and Villems question the quality of the data used, and suggest that some of the observations "can be more plausibly interpreted phylogenetically." Jorde and Bamshad, along with Kumar *et al.*, argue that the measure of LD used by Awadalla *et al.*, r^2, is highly sensitive to allele frequency variation, and note that reexamining the data using another LD measure, D', yields no evidence for a significant relationship between LD and distance. Kumar *et al.* also assert that a phylogenetic analysis of the data supports "the lack of recombination in human mtDNA, rather than providing evidence for it." And Parsons and Irwin, focusing on the human mtDNA control region (CR), find "no indication of a negative correlation between LD and distance that would signal the action of recombination."

Awadalla *et al.* argue that neither random nor systematic sequencing errors are likely to influence their analysis, and show that even when several data specifically cited as suspect by Kivisild and Villems are removed from the analysis, "the correlation between LD and distance remains negative." They present several lines of evidence that "r^2 should have more power to detect recombination than D'," and note that the phylogenetic analysis presented by Kumar *et al.* may rest on a logical error, because their phylogenetic tree implicitly assumes that recombination does not occur. Finally, the absence of evidence of an LD-distance correlation in the CR may not argue against recombination, according to Awadalla *et al.*, as "many sequences that have undergone recombination do not show a significant decline in LD with distance."

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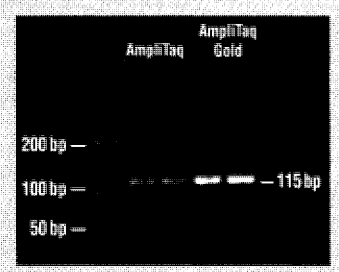

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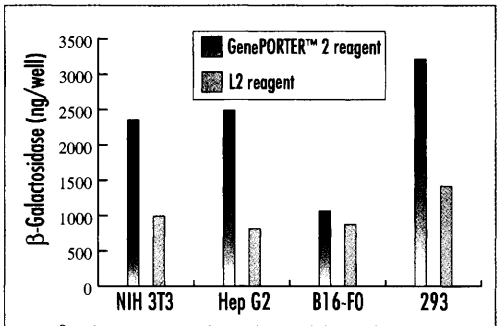

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Transfected Cell Types

293	Murine Es cells
Jurkat	MM54.Sp/Thy
NIH 3T3	AKR-2B
B16-F0	MIN6
PC-12	Hepa-1clc7
BHK-21	Primary hepatocytes
CHO-K1	NSC34
DDT1 MF-2	D6P2T
CV-1	C6
COS-1	INS-1
COS-7	PEF
MO 7E	RK 13
FL5.12	PERN
MCF7	Primary keratinocyte
K-562	SL-29
KG-1	Primary embryonic fibroblast
CL-01	MDBK (NBL-1)
HMSC	A6
HeLa	HEQ 3-3
HeLa S3	CFT-1
SW 1353	Chicken cardiomyocyte
MRC-5	RP-19
FaDu	Y-79
LNCaP.FGC	T-84
PC-3	C_2C_{12}
U-87 MG	BC 3H1
PM-RCC	BALB-10
Hep 3B	Bovine endothedial
Hep G2	T-89G
HEC-1	JAR
LoVo	SKOV-3
U937	Equine derma
293T	L-929
911	EKER
NTD-1	SW-1353
10T 1/2	H-292
Huh7	Rat cortical neurons
293EBNA	
NB324K	
MEF	
308	
WEHI-3B	

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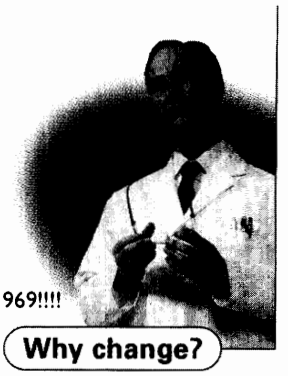

I've used oligo dT since 1969!!!!

Why change?

Because current methods...

- do not bind to mRNA with high secondary structure
- do not differentiate between RNA and DNA
- do not hybridize to mRNA with short poly A tails
- do not allow for DNase treatment of the sample
- co-purify large amounts of ribosomal RNA

a better way to isolate mRNA...

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- More representative mRNA population
- Reduced DNA contamination
- Hybridizes to mRNAs with shorter poly A tails
- Allow for DNase treatment during preparation
- Less ribosomal RNA contamination

mVADER™ uses invasive clamping phosphono PNA (Peptide Nucleic Acid) technology to isolate mRNA from cells or tissue.

mVADER technology allows PNA/poly A mRNA triplexes to form independent of secondary structure between the poly A tail and 5' U rich regions. Furthermore, short poly A tailed messages are more efficiently captured with mVADER, thus ensuring a more representative mRNA population. mVADER technology in conjunction with our proprietary lysis solution allows for isolation of superior quality mRNA.

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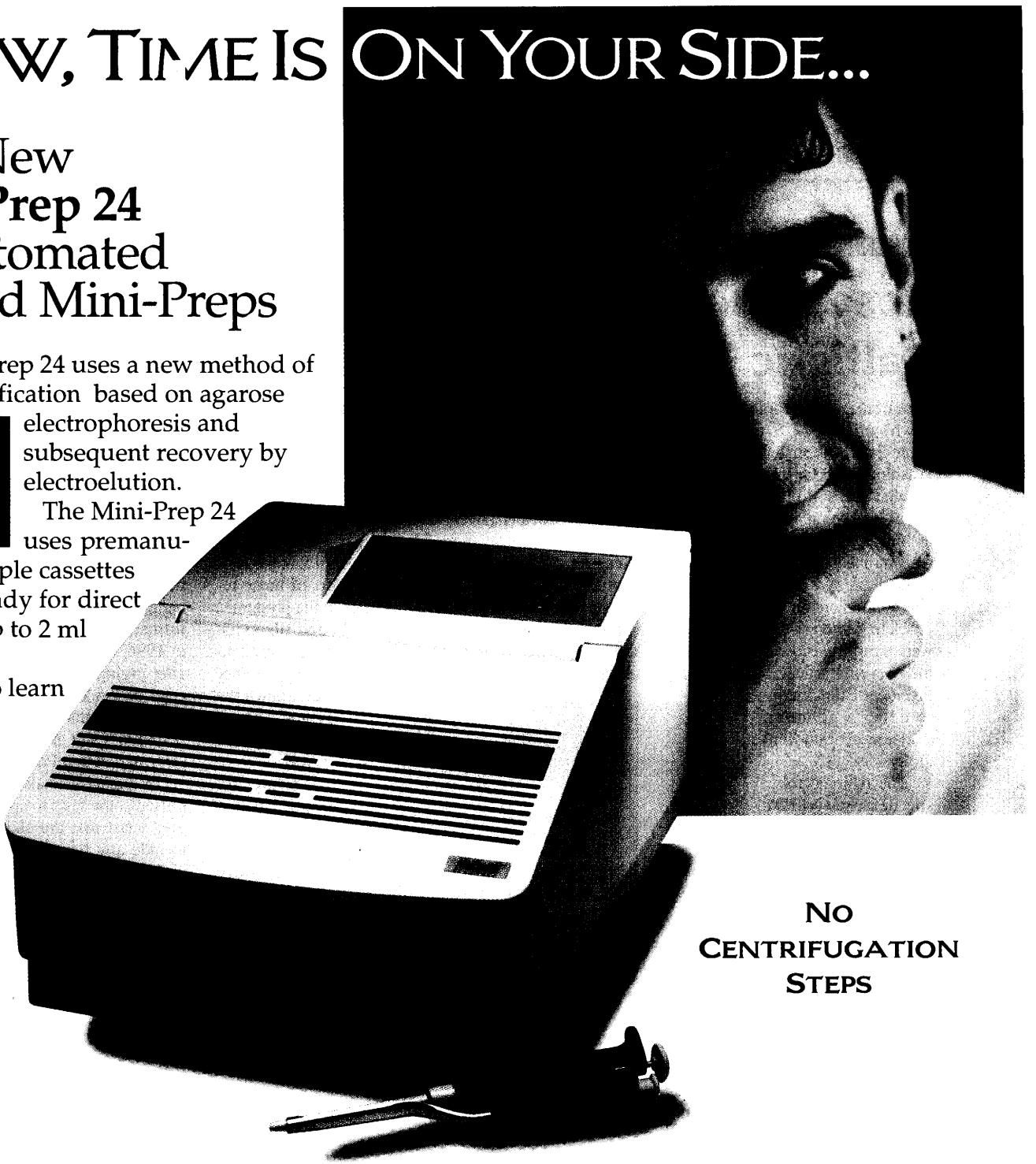

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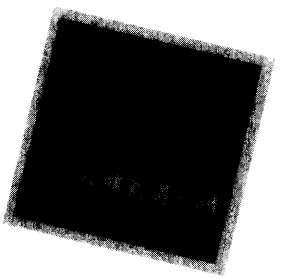

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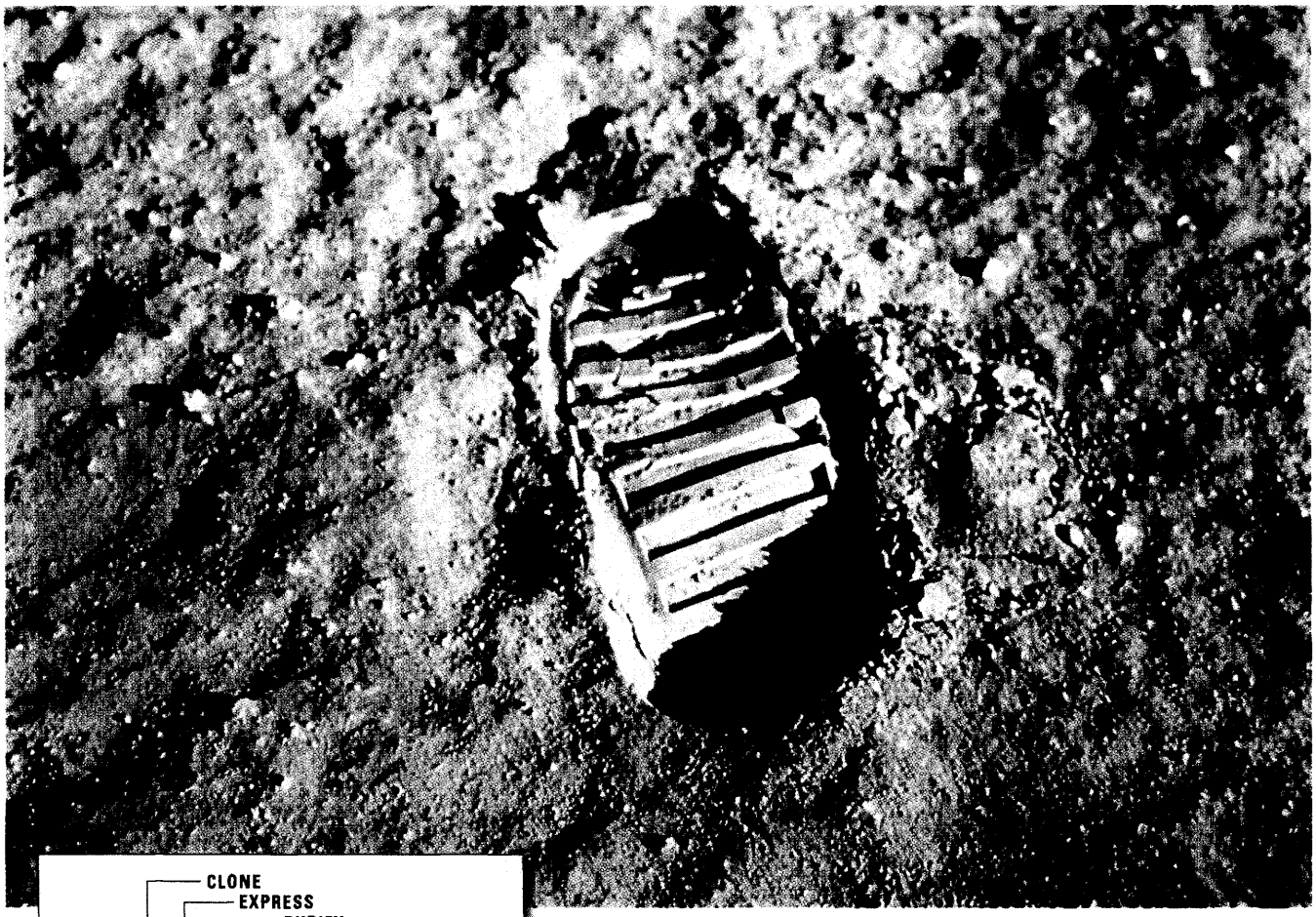

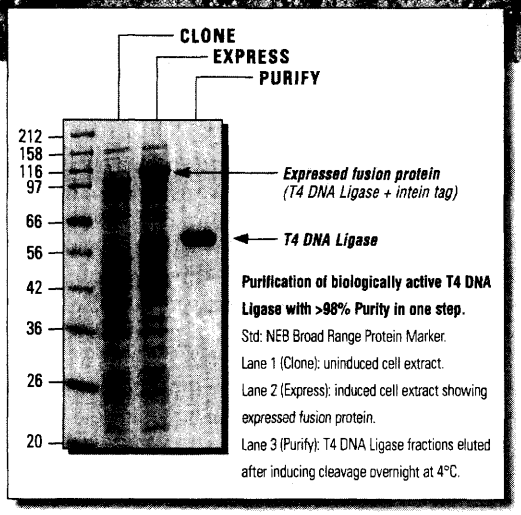

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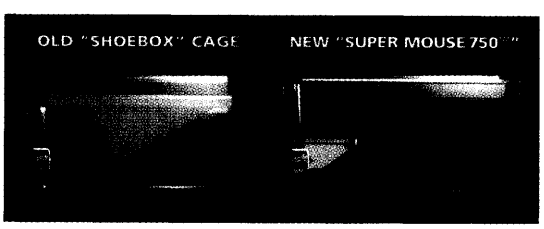

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*Guide for the Care and Use of Laboratory Animals, Institute of Laboratory Animal Resources, Commission on Life Sciences, National Research Council, National Academy Press, 1996.

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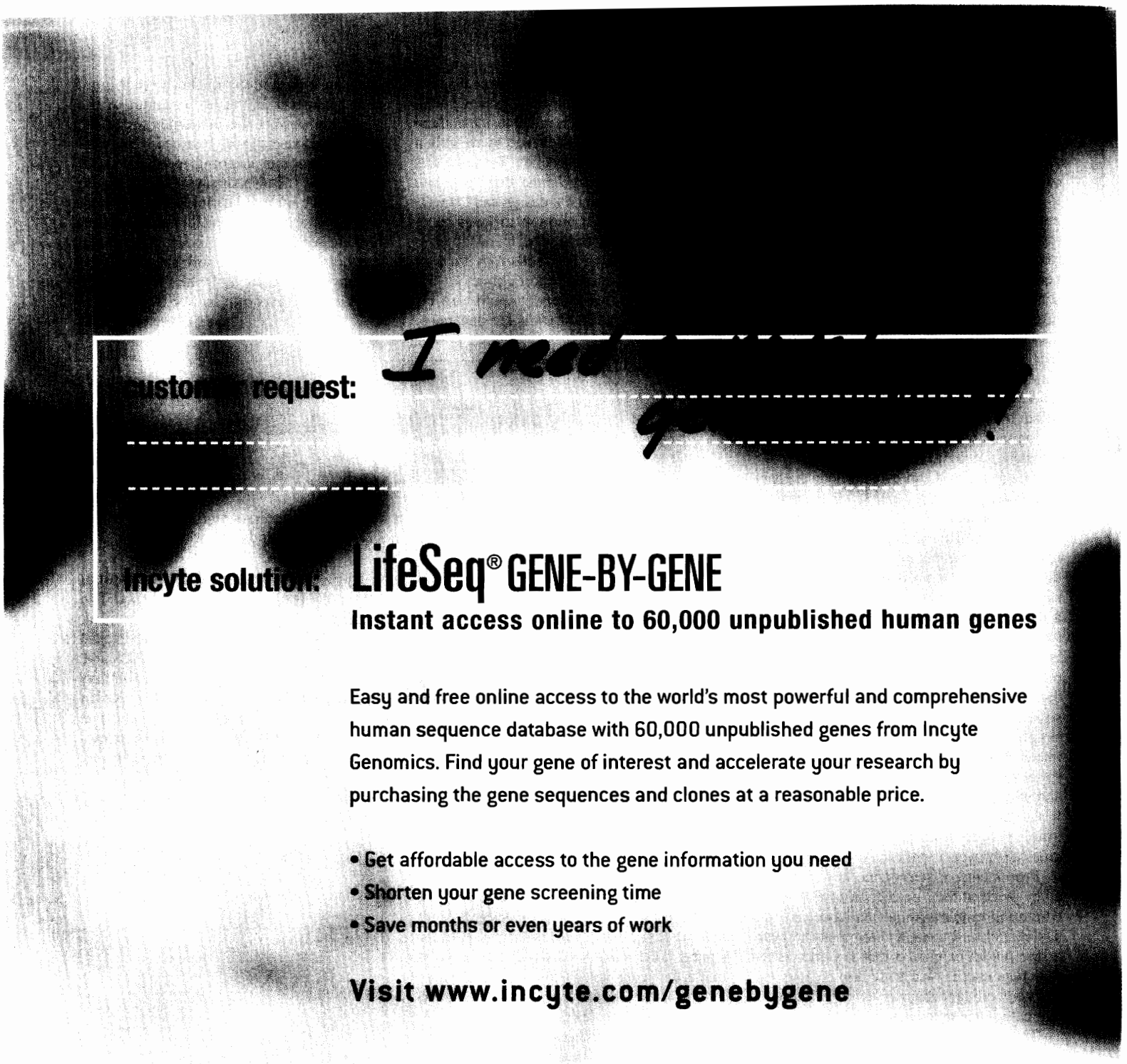

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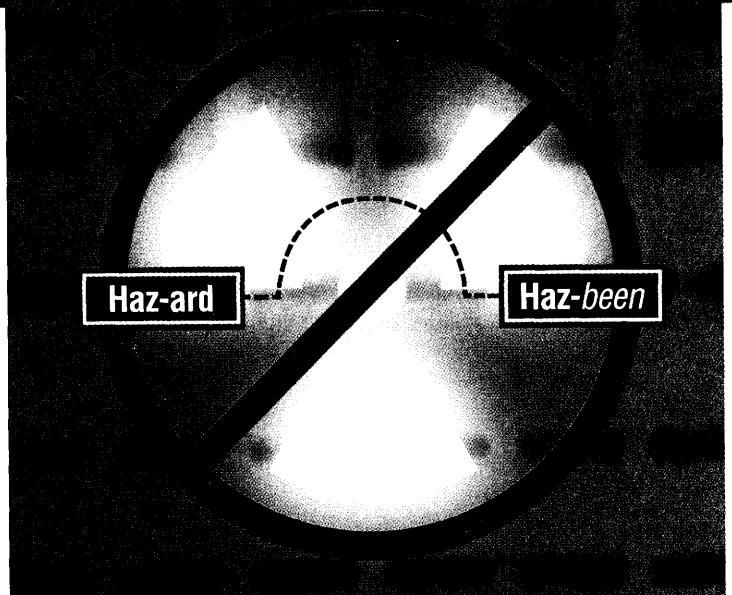
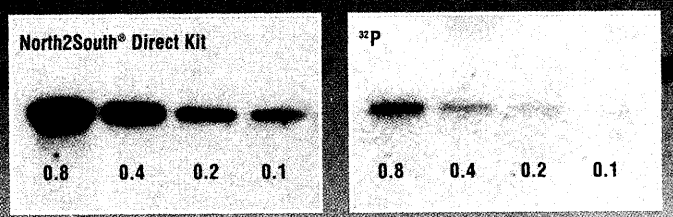


Southern Blot of Yeast Genomic DNA: North2South® Direct Kit vs. Radiolabel



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System	Hybridization	Exposure
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- Example of a multiple tissue Northern blot
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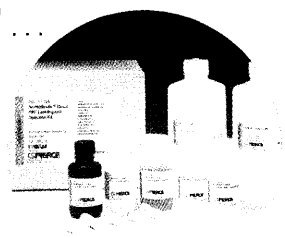

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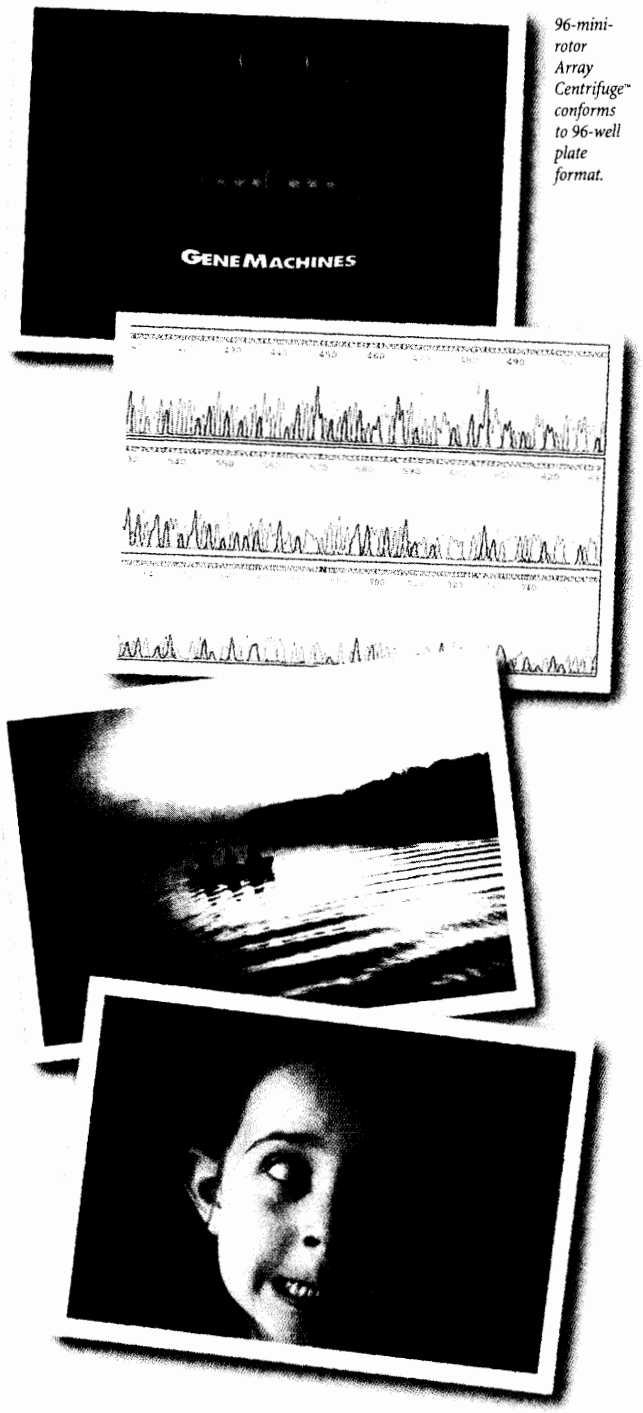

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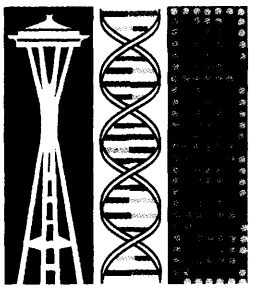

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