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Evolution of Sex

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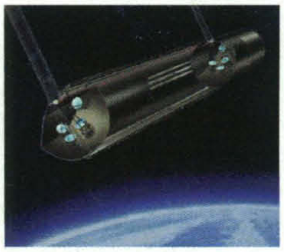
COVER Two eggs of the red abalone with hundreds of sperm cells attached to the envelope surrounding each egg (inner circle, about 175 micrometers in diameter). Sperm are also trapped in the transparent outermost jelly layer. This special issue discusses the latest theories on sex: how it got started, how it works, and who gets it. See the Vacquier Review and the special section beginning on p.1979. [Photo: V. D. Vacquier]



1940 How to spy on other Earths

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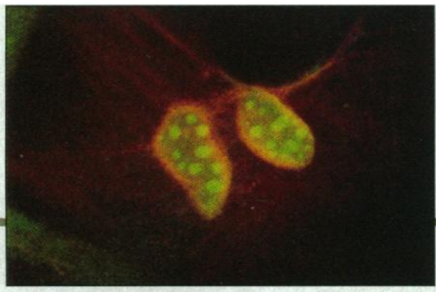
1971

Travels of the asteroids



2013

Labeling cells with glowing nanodots

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2034

Free-living counterpart of ant-cultivated fungi

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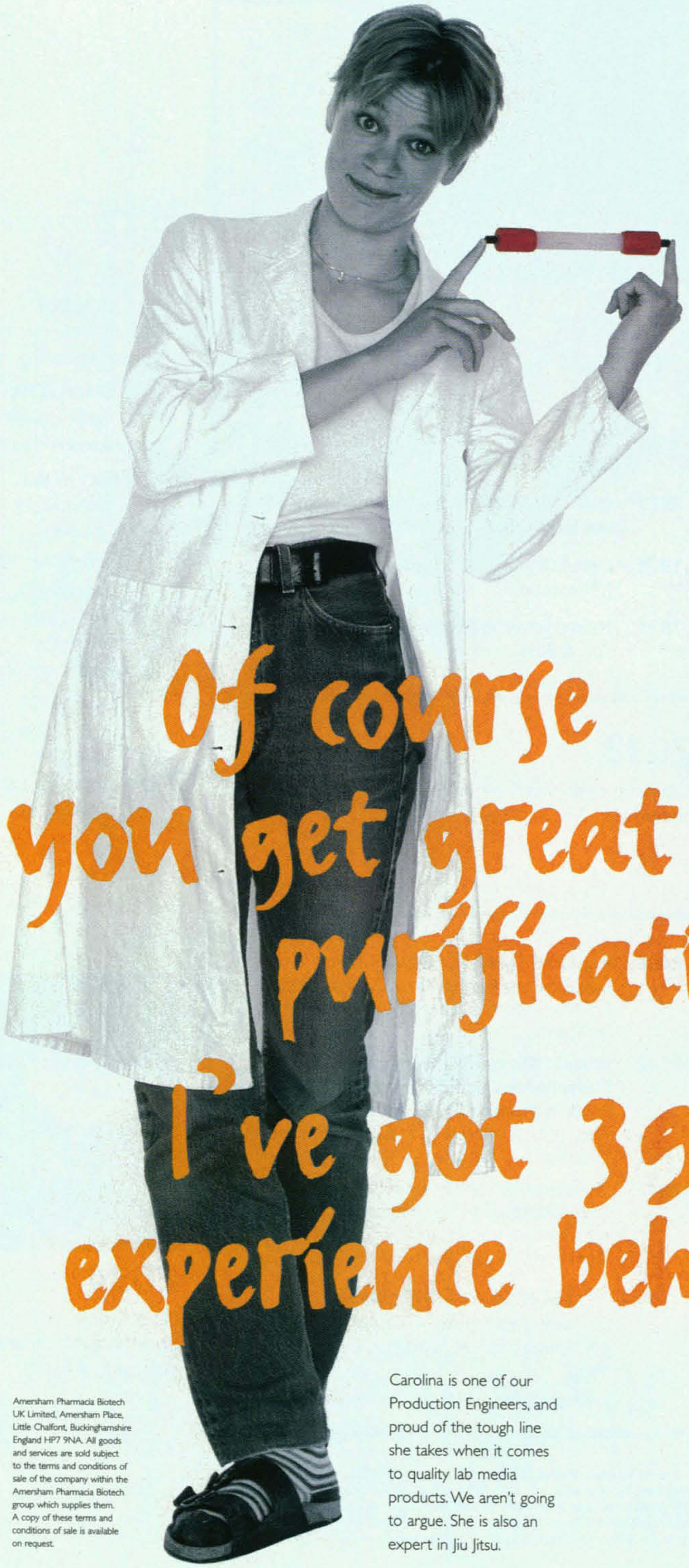

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MELT ME TWICE

Volcanic arcs form above regions where oceanic crust is subducted into the mantle. Heating of the crust as it sinks into the mantle releases fluids, and these fluids in turn flux melting in overlying parts of the mantle to produce the magmas that rise to form volcanoes. This process depletes the mantle in elements that are fractionated into the melt. One of these is rhenium; the isotope rhenium-187 decays to osmium-187. Thus, melting events, which strip away rhenium, can be recorded in osmium isotopic anomalies. Parkinson *et al.* (p. 2011) have examined the osmium isotopic composition of pieces of the mantle preserved in part of the Izu-Bonin-Mariana arc system, an arc that first formed about 40 to 50 million years ago in the western Pacific Ocean. Surprisingly, the data show that these pieces of mantle seem to record a much earlier melting event, dating to about 1 billion years ago. In contrast, most oceanic crust is younger than about 150 million years ago because it is continually destroyed by subduction. These data may imply that the upper mantle is quite heterogeneous or that subduction zones may harbor very old pieces of the mantle.

NANODOTS FOR BIOLOGICAL DETECTION

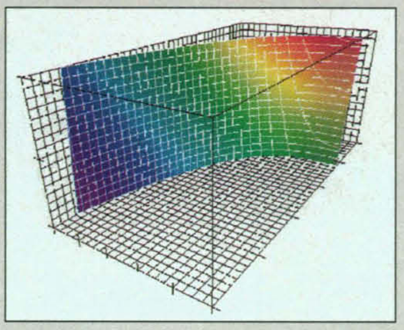
Quantum confinement effects in semiconductor nanoparticles lead to narrow emission spectra that can be tuned over a wide range of wavelengths. Their brightness, low toxicity, and the ability to use a single excitation wavelength make them attractive alternatives to organic dyes for biological labeling, but their low water solubility has limited this application. Two different approaches are now reported for modifying core-shell nanocrystals consisting of CdSe cores and CdS or ZnS shells (see the news story by Service). Bruchez *et al.* (p. 2013) coated the surface of the particles with silica and then derivatized that surface with biomolecules. Chan *et al.* (p. 2016) directly linked proteins to the ZnS surface using mercaptoacetic acid and showed that nanodots bearing transferrin underwent receptor-mediated endocytosis into HeLa cells.

A TAIL OF TWO STARS

Single brown dwarfs have recently been found in several star-forming regions, such as the Pleiades, and models of collisions of disks of young stars, which cause gravitational clumping within each disks, can explain the origin of some of these substellar objects. Lin *et al.* (p. 2025) have modeled another potential birth mechanism that requires the collision of two young stars with massive disks, which leads to the formation of a tail of material being ejected away from both stars. The authors found that substellar objects could also accumulate in such a tail and leave a lone brown dwarf that is no longer associated with either of its young parent stars and that is not massive enough to burn hydrogen like a star.

EUROPA: FOUR ENCOUNTERS, THREE LAYERS

Radio Doppler data recorded by the Galileo probe during four close encounters with Jupiter's smallest Galilean satellite, Europa, provide the most accurate gravity data for determining the structure of the interior of



this moon. Anderson *et al.* (p. 2019) show that their preferred fit to the gravity parameters yields a three-layer interior with an 80- to 170-kilometer-thick mixed outer shell of water ice and liquid, a middle shell of rock or a rock-metal mixture, and an iron or mixed iron–iron sulfide core that could have a maximum radius of about 780 kilometers (about 50% of the radius of Europa). A Europan core requires high temperatures in the interior of Europa to separate the iron from the rock mantle early in the moon's evolution. Models of the Galilean satellites will have to be refined to allow for such differentiation.

HOW DID THE ASTEROID CROSS THE EARTH?

Earth-crossing asteroids (ECAs) are a population of bodies whose orbits at some point cross that of Earth. It has been assumed that these bodies come from the main asteroid belt, which lies between Mars and Jupiter, either through collisions or because of orbital perturbations caused primarily by Jupiter. However, simulation studies have generally shown that strong orbital resonances with other planets actually cause the asteroids to cross the orbits of the terrestrial planets on a very short time scale and head toward the sun. Migliorini *et al.* (p. 2022; see the Perspective by Greenberg) have found a slightly different mechanism in their simulations that effectively allows multikilometer-diameter asteroids to evolve into Mars-crossing asteroids and ECAs. The key to their mechanism is the weak resonant orbits in the main belt that allow asteroids in these resonances to evolve to Mars-crossing orbits; eventually these bodies evolve into ECAs. Thus, weak resonances allow large asteroids to achieve a longer lifetime in the inner solar system and may also help to explain the origin of some of the meteorites that have hit Earth.

MITOCHONDRIAL ROUTE FOR CELL DEATH

Many proteins and subcellular organelles conspire to kill a cell in a process known as apoptosis. The proapoptotic protein Bax moves to the mitochondria and can be isolated from mitochondrial membranes along with a complex of proteins that form the mitochondrial permeability pore. Marzo *et al.* (p. 2027) found that Bax specifically binds to the adenine nucleotide translocator of the pore complex. This interaction was necessary and sufficient for permeabilization of reconstituted membranes. Thus, Bax seems to induce apoptosis by binding to and altering the function of the mitochondrial permeability pore.

TOO OVERSTIMULATED TO LEARN ANYTHING

The relation between long-term potentiation (LTP) of neurons, which can be induced by high-frequency stimulation, and the long-term changes in synaptic plasticity induced by learning has been difficult to establish experimentally. If LTP is part of the learning process, then saturation of neurons in the hippocampus by high-frequency stimulation would block the ability of an animal to learn, but establishing saturation has been experimentally challenging. Moser *et al.* (p. 2038; see the Perspective by Bliss) ablated part of the hippocampus of rats and used a multielectrode stimulating array to saturate neurons in the input region to the dentate gyrus. After prolonged stimulation, rats were trained in a water maze test. Some of the rats could

CONTINUED ON PAGE 1923

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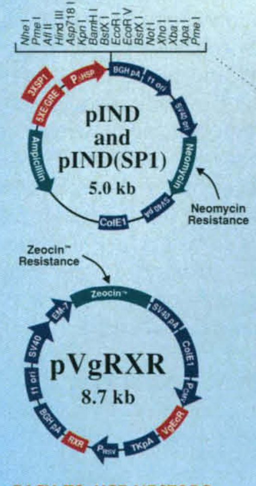

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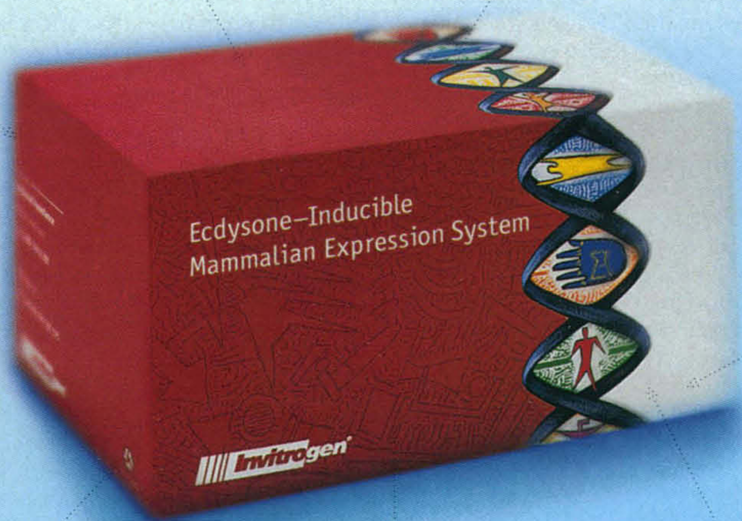

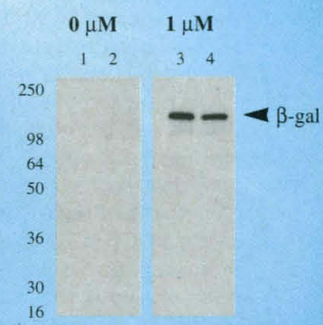

INDUCE WITH PONASTERONE A OR MURISTERONE A

CHO cells stably transfected with pIND(SP1)/Hygro/*lacZ*.
Lanes 1 and 2: Uninduced
Lane 3: Induced with Muristerone A
Lane 4: Induced with Ponasterone A

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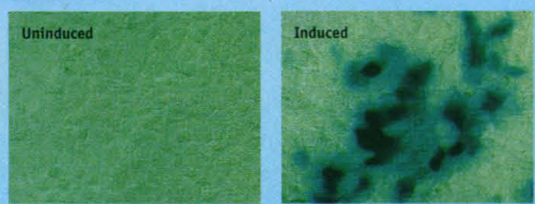

Uninduced and induced transiently transfected 293 cells stained with X-gal.

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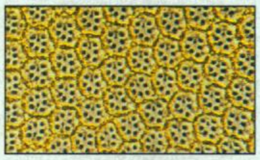
learn the maze and others could not, but the inability to learn the maze was related to the degree to which LTP remained saturated (the amount of LTP that could be induced in the poor learning group after the maze test was ≤10%). These results indicate that saturation of LTP in the hippocampus can impair spatial learning.

Separating Equally

As animals develop, the embryonic cells are often divided into groups, or compartments, that then follow divergent pathways in their further differentiation. Papayannopoulos *et al.* (p. 2031) show that although the outcome can be as different as an eye and a wing, the molecular mechanisms that define one group of cells as being separate from another can be shared. In this study of *Drosophila*, the central dividing line through the eye is defined by the Notch-signaling system, largely similar to the signaling system that defines the top of the wing as different from the bottom.



Fungi Gourmets

Ants, like humans and termites, are farmers, cultivating gardens of fungi. Mueller *et al.* (p. 2034; see the Perspective by Diamond) reveal, through molecular genetic approaches, the full complexity of ant cultivation. Multiple fungi cultivars were identified, which shows that domestication has occurred on a number of occasions; indeed, evidence suggests that the acquisition of novel cultivars is an ongoing process. There is also a certain eclecticism among the ants: A single species may farm a diversity of fungi, and yet single cultivars can be shared by distinct lineages of ants.

Regulation of PKCs by PDK1

The protein kinase PDK1 participates in signaling pathways initiated by various receptors that couple to phosphoinositide 3-kinase (PI 3-kinase). Activation of PI 3-kinase leads to the generation of phosphatidylinositol 3,4,5-trisphosphate and consequent activation of PDK1. PDK1 in turn activates the protein kinases PKB and $p70^{s6kinase}$. Le Good *et al.* (p. 2042) demonstrate that PDK1 also appears to function in regulation of isoforms of protein kinase C (PKC). PKC participates in regulation of many cellular processes, and some isoforms are also regulated by binding of diacylglycerol. Phosphorylation by PDK1 reveals another lipid-dependent regulatory mechanism that functions in control of PKC family members.

Learning from a Lilliputian Landscape

The complex ecosystems of moss-covered rocks have been used to examine one of the most general relations in ecology—the positive correlation between the distribution of a species and its local abundance. Gonzalez *et al.* (p. 2045) created fragmented landscapes by scraping bare the rock between small patches of moss. Within these isolated patches, a decline in the richness of microarthropod species was observed, but when narrow corridors were left connecting the patches, much of the species richness was retained. This experiment supports the "rescue effect" that dispersal among habitat patches serves to enhance local population size, for example, by buffering temporary lows in numbers and thus permitting occupancy of a wider number of sites.

TECHNICAL COMMENT SUMMARIES

Genome Arithmetic

The full text of these comments can be seen at www.sciencemag.org/cgi/content/full/281/5385/1923a

J. M. Freeman *et al.* presented (Technical Comments, 20 Mar. 1998) data showing that integral functions of the base composition and coding sequence (CDS) directionality could reveal the origin of replication and other key features in nine complete bacterial genomes (www.sciencemag.org/cgi/content/full/279/5358/1827a).

A. Grigoriev describes variations in the genome that "may negatively affect identification" of key sites, and he briefly discusses "evolutionary forces [that] seem to affect AT and GC skew differently," such as sequence inversion.

In response, Freeman *et al.* apply six different types of analysis to the nine genomes studied earlier and find that "the best function to use ... is not a priori clear." They conclude that "quantitative analysis ... of these plots should aid in the understanding of the differing dynamics of genomes in different organisms ... [but] it may well be advisable to combine several methods to attack any specific problem."

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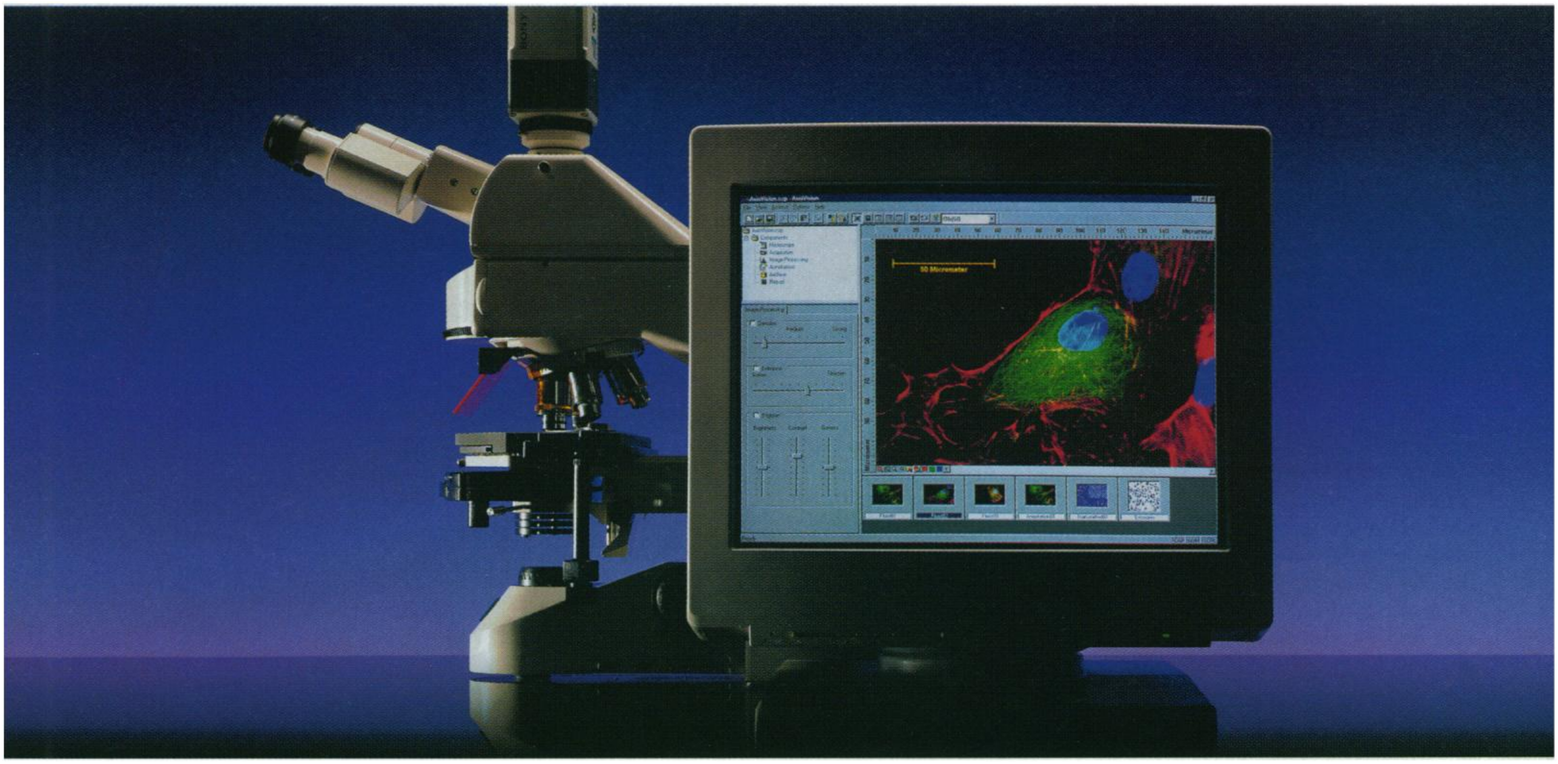

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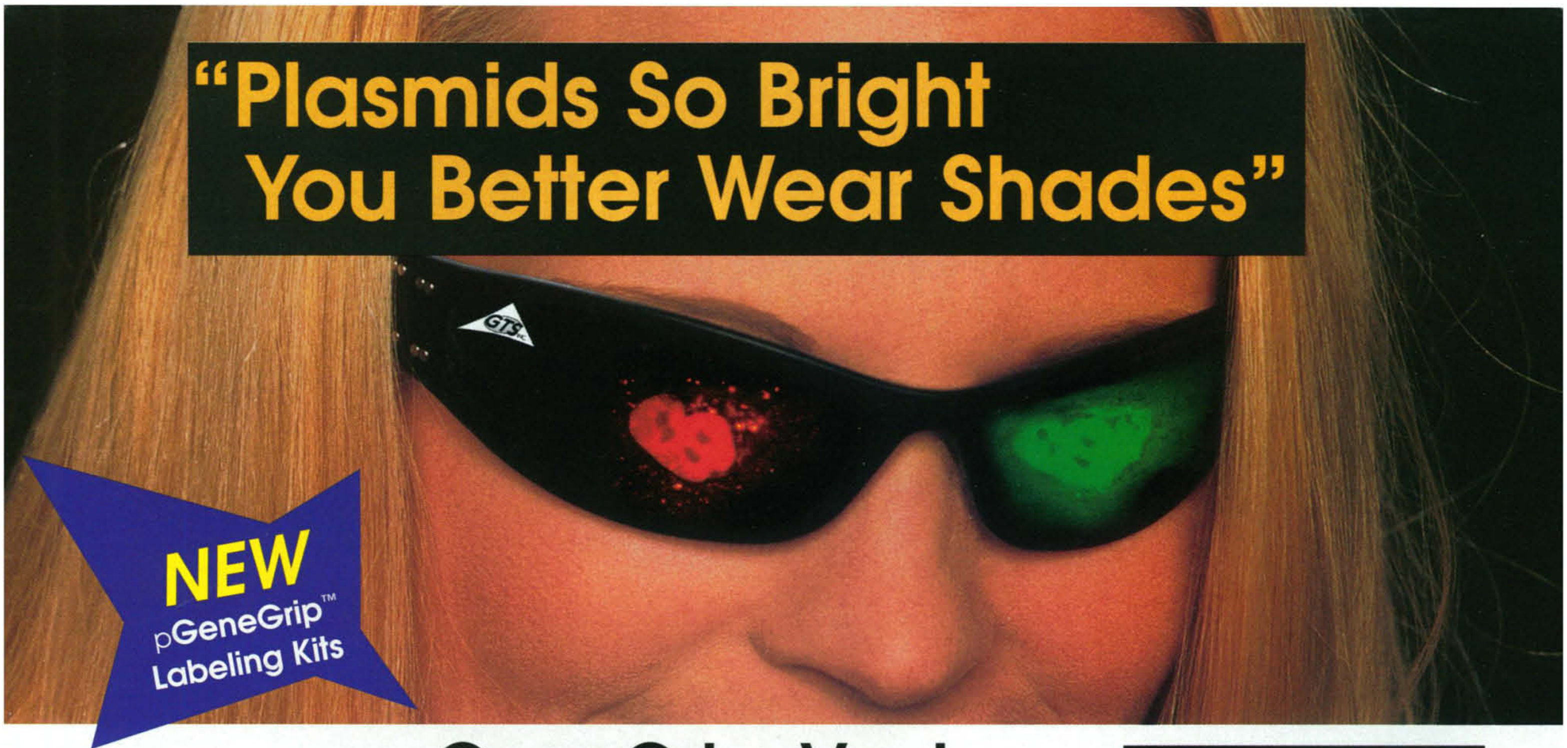

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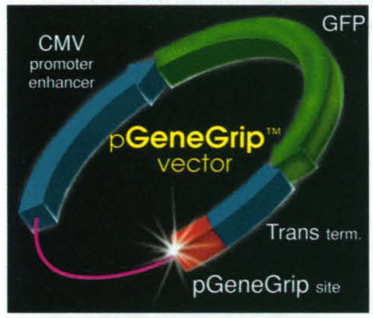

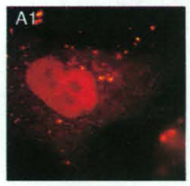

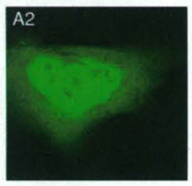

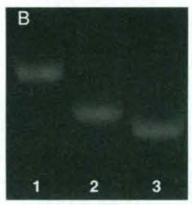

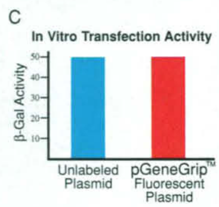

Figures:

A. Fibroblasts transfected with pGeneGrip™ Rhodamine/GFP vector:
1. Rhodamine labeled DNA
2. GFP expression

B. Electrophoresis of pGeneGrip™ Rhodamine labeled fluorescent vector
Lanes: 1. β-gal, 2. GFP, 3. Blank

C. Plasmid expression with and without fluorescent label.

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	100 ug	G101025		100 ug	G103035
Rhodamine/Luciferase	25 ug	G101030	Biotin/Green Fluorescent Protein	25 ug	G103040
	100 ug	G101035		100 ug	G103045
Rhodamine/GFP	25 ug	G101040	Biotin/Secreted Alkaline Phosphatase	25 ug	G103050
	100 ug	G101045		100 ug	G103055
Rhodamine/Secreted Alkaline Phosp.	25 ug	G101050	Rhodamine/Blank Vector	25 ug	G101000
	100 ug	G101055		100 ug	G101005
Fluorescein/b-Galactosidase	25 ug	G102010	Fluorescein/Blank Vector	25 ug	G102000
	100 ug	G102015		100 ug	G102005
Fluorescein/CAT	25 ug	G102020	Biotin/Blank Vector	25 ug	G103000
	100 ug	G102025		100 ug	G103005
Fluorescein/ Luciferase	25 ug	G102030	Rhodamine Vector Labeling Kit (for labeling 100 ug plasmid DNA)	NEW	G10100K
	100 ug	G102035			
Fluorescein/ Secreted Alkaline Phosp.	25 ug	G102050	Fluorescein Vector Labeling Kit (for labeling 100 ug plasmid DNA)	NEW	G10200K
	100 ug	G102055			
Biotin/b-Galactosidase	25 ug	G103010	Biotin Plasmid Labeling Kit (for labeling 100 ug plasmid DNA)	NEW	G10300K
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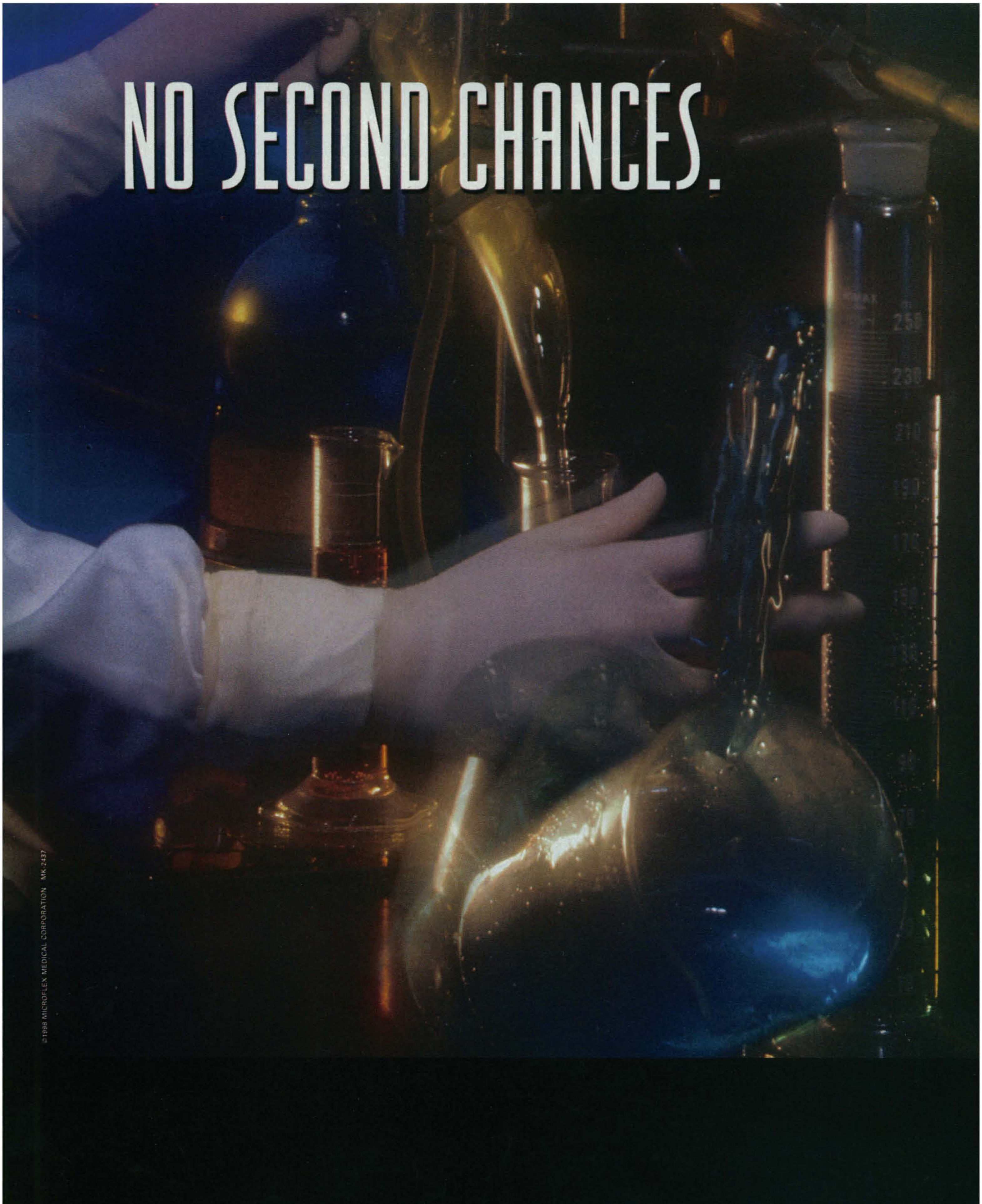
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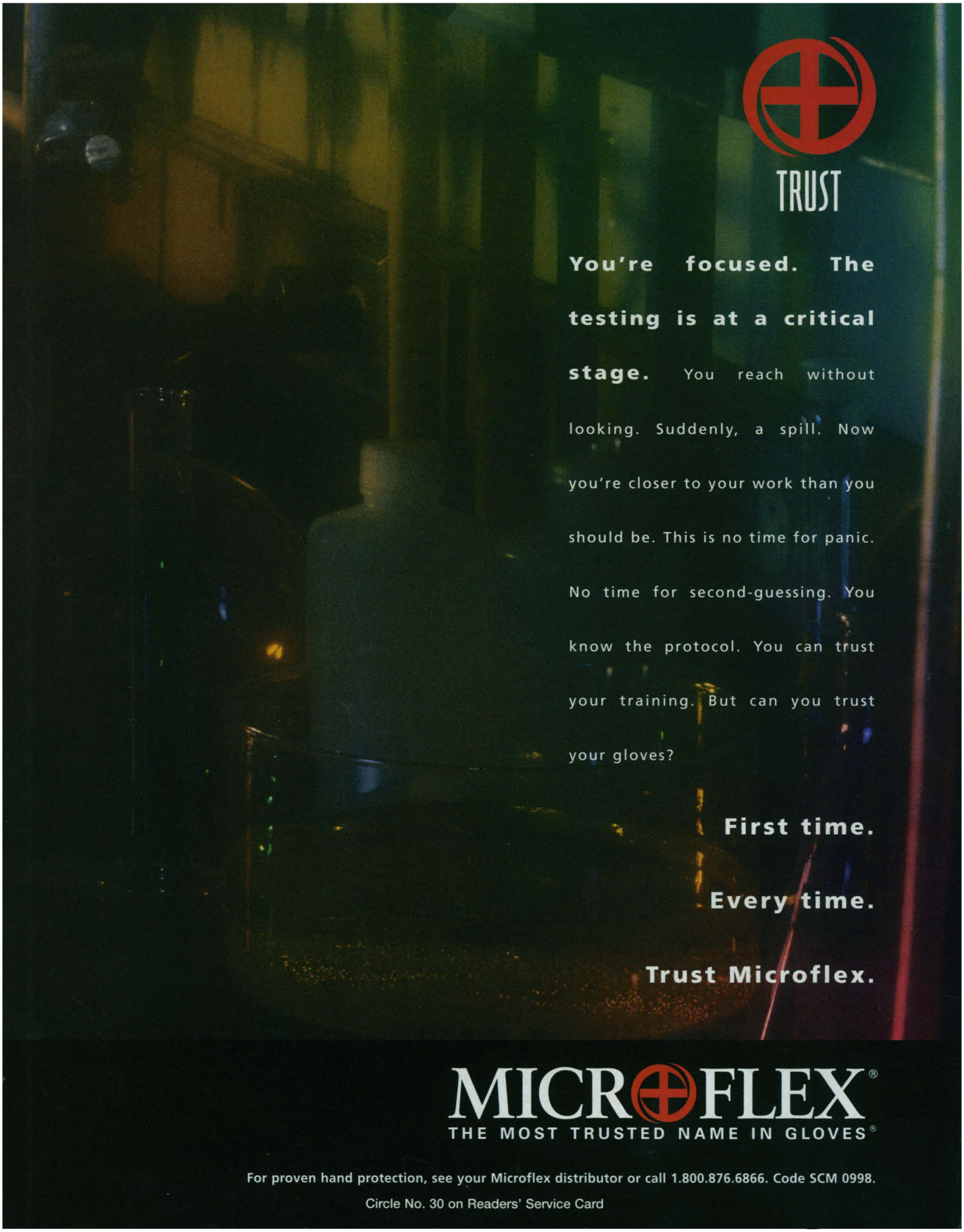
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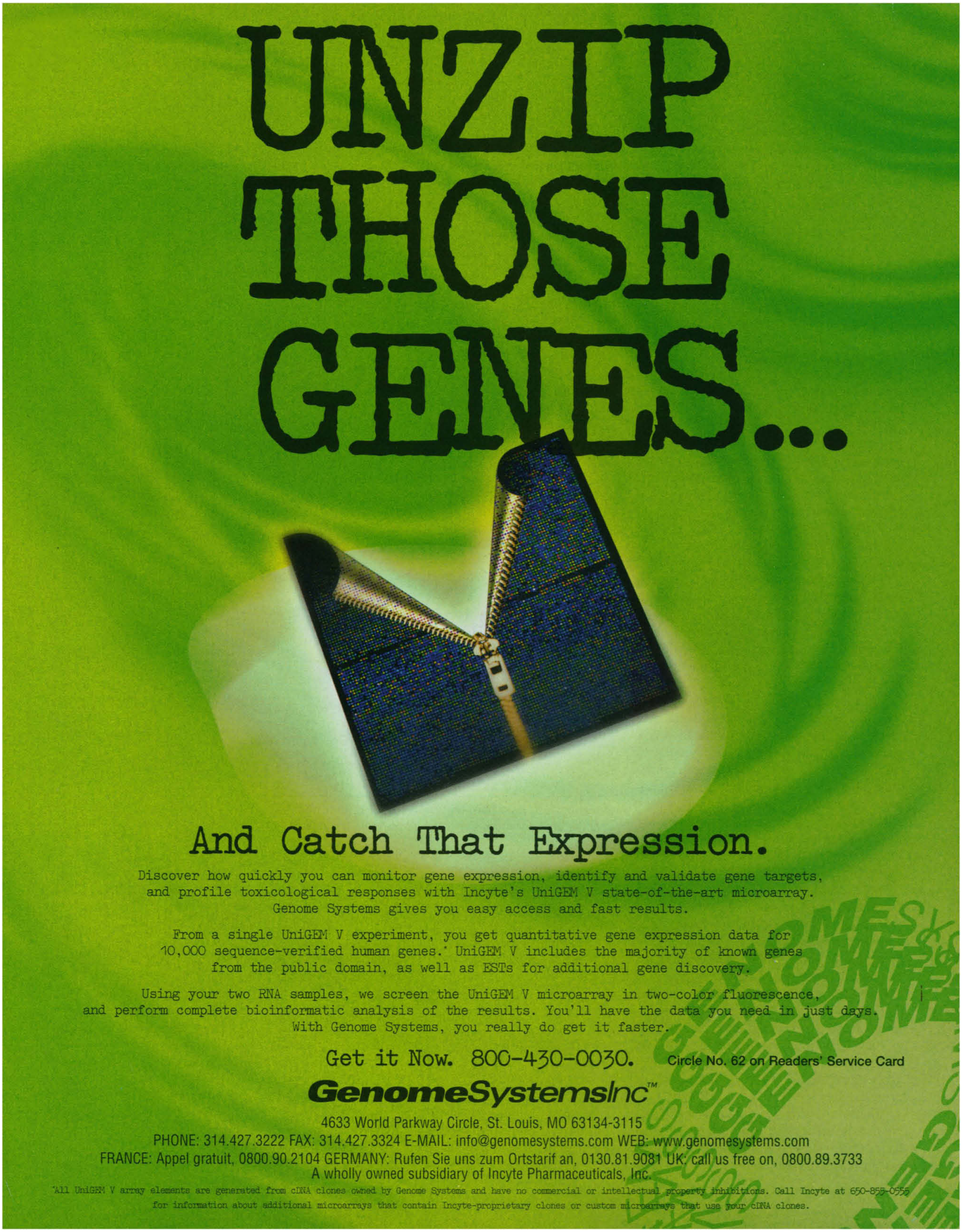
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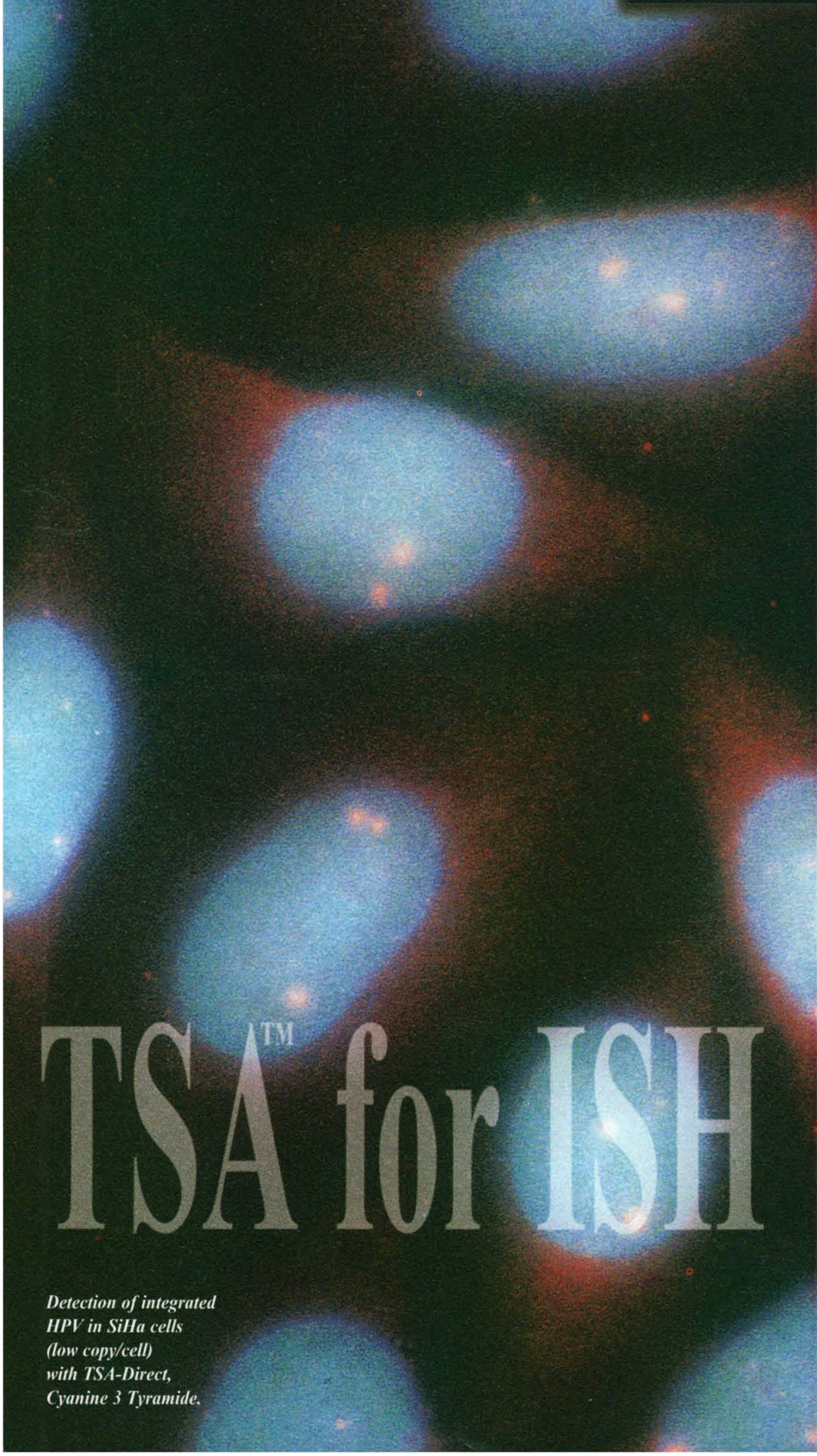

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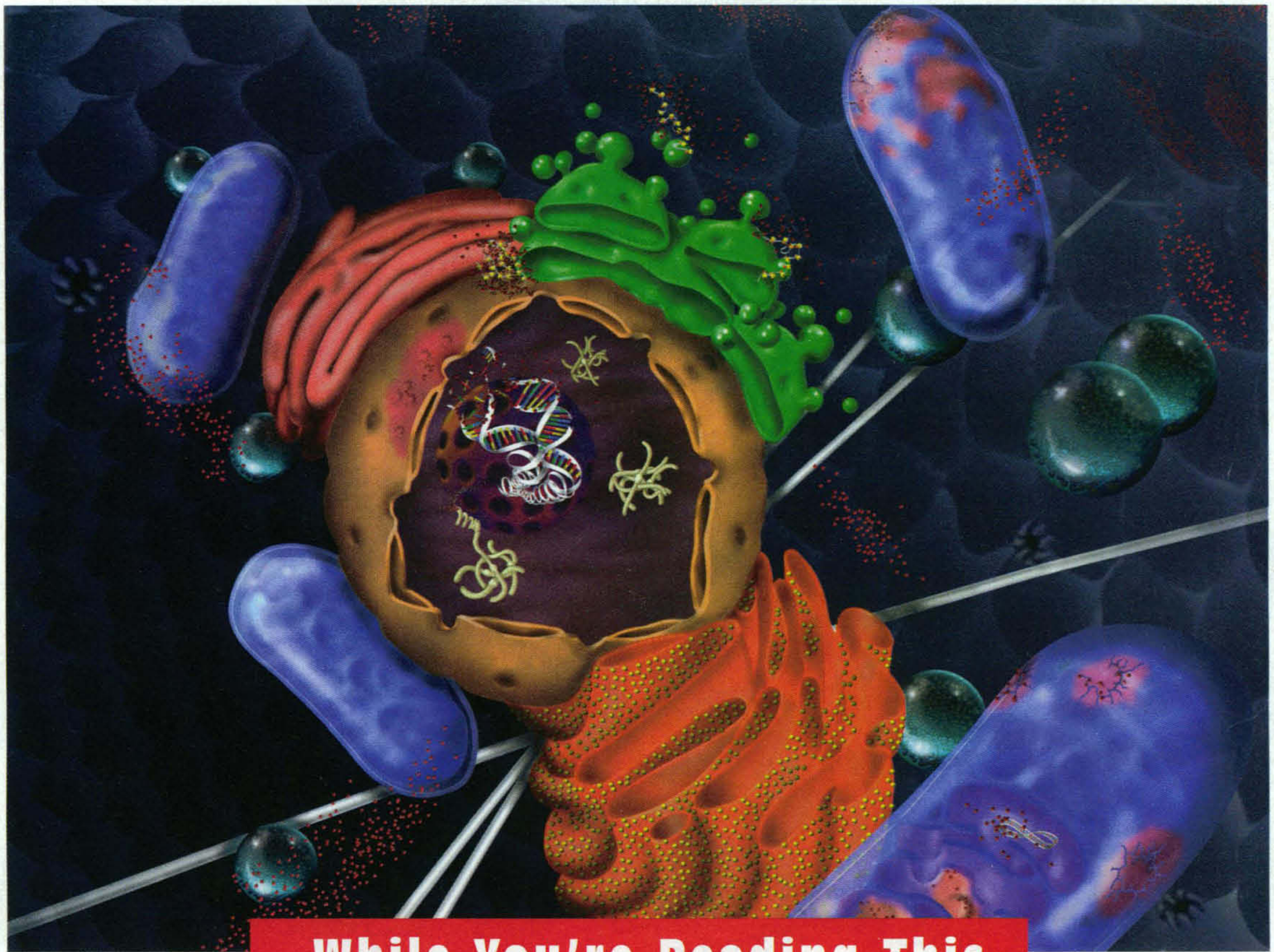

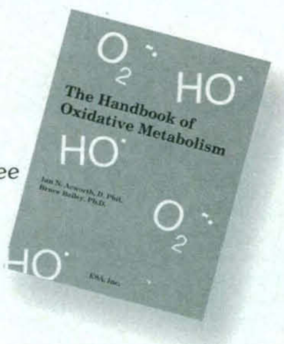

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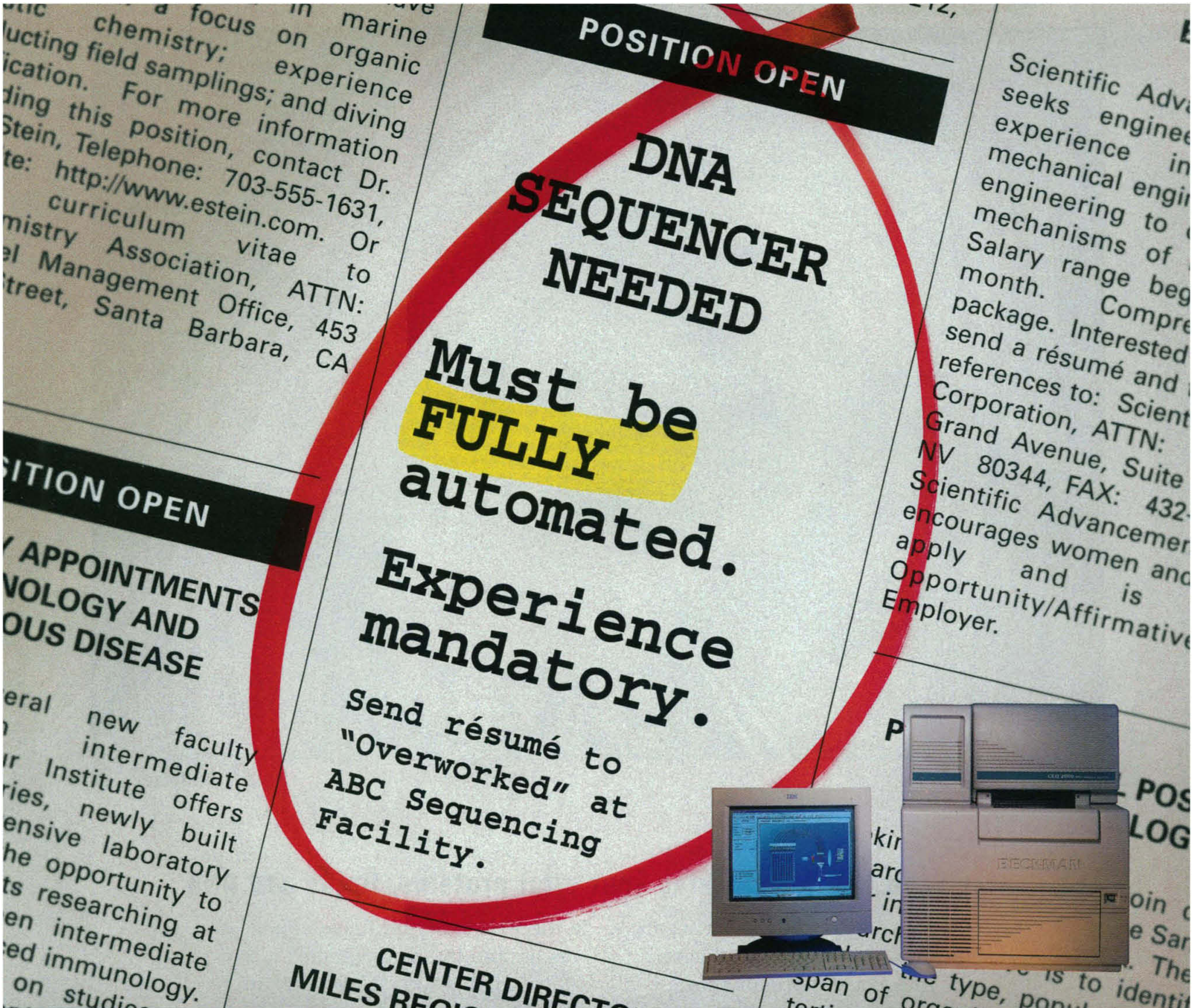
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