Science

14 August 1998

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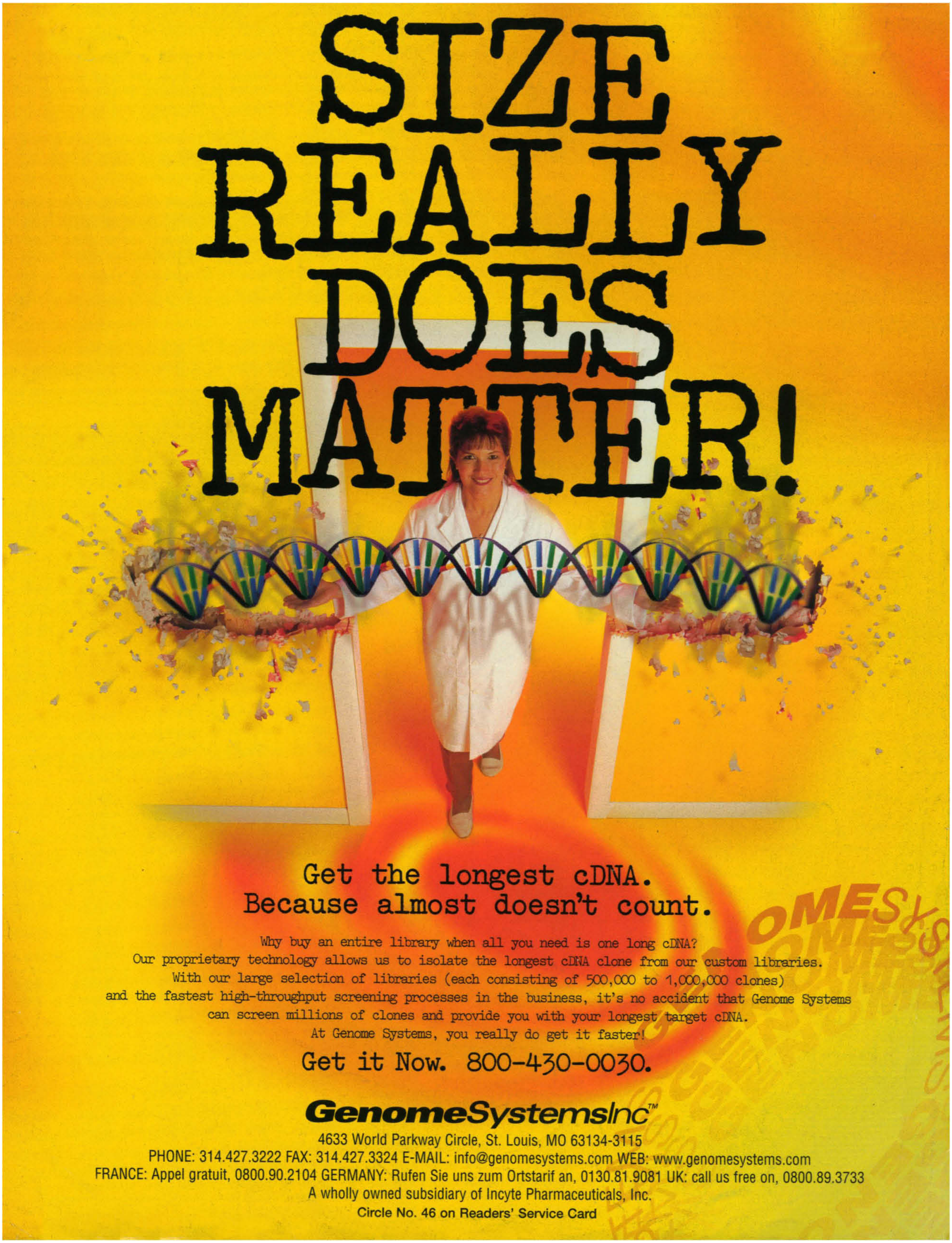
Control and Use of
Defects in Materials

American Association for the Advancement of Science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COVER Colored scanning tunneling microscope image (75 nanometers wide) of the (000$\bar{1}$) surface of gallium nitride, a semiconductor used in the development of intense blue and green lasers and light-emitting diodes. Two growth fronts spiral away from a point at which a screw dislocation intersects the surface. See H. J. Queisser *et al.* and the special section beginning on p. 939. [Photo: A. R. Smith, R. M. Feenstra, D. W. Greve]

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Salt and diet: The balance of evidence

NEWS

NEWS OF THE WEEK

NEWS FOCUS

CONTROL AND USE OF DEFECTS IN MATERIALS

NEWS

REVIEW

See related Reports on pp. 969, 971, and 973.

RESEARCH

REPORTS

DEPARTMENTS

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BOOKS AND NEW MEDIA

PERSPECTIVES

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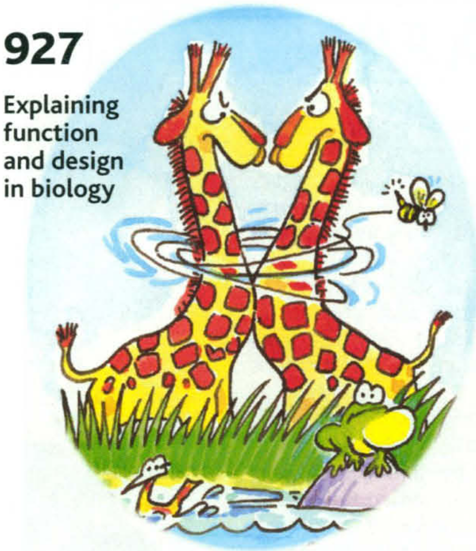
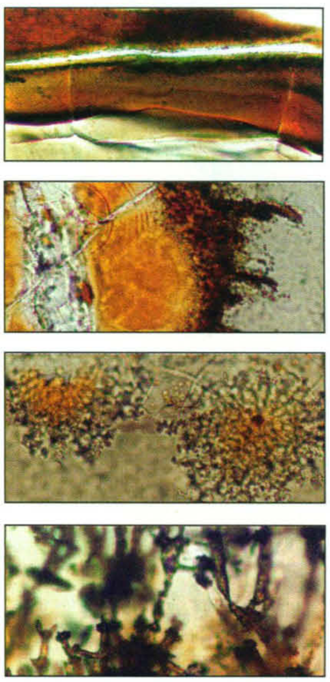
Explaining function and design in biology





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Microbes and weathering beneath the sea floor

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Factor in the chick converts ectoderm to neural crest

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TOWARD TINY COAXIAL CABLES

In the effort to minimize electronic elements in devices, particular attention has been given recently to the unusual electronic properties of nanotubes and nanowires. The utility of these materials can be further enhanced if a layered structure can be achieved that would combine uniform electronic properties in the axial direction with a heterojunction built from combinations of semiconducting, insulating, or metallic layers in the radial direction. Zhang *et al.* (p. 973) have succeeded in synthesizing such a "nanocable" consisting of a silicon carbide core, an amorphous silicon dioxide layer, and an outer sheath of carbon and boron nitride by modifying the traditional laser ablation method for producing nanotubes.

DO NOT LIVE BY HYDROGEN ALONE

Microorganisms living in deep aquifers lack a source of light to drive their metabolism. It has been suggested that hydrogen produced from the interaction of basalt with ground water could be an energy source for these bacteria. Anderson *et al.* (p. 976) conducted laboratory experiments and found that hydrogen cannot be produced by basalt–ground-water interactions at pH 6. They could produce hydrogen for a short time in experiments with a phosphate buffer at pH 8, but this pH is not appropriate for deep subsurface conditions. The authors suggest that organic matter provides a more likely energy source for these extreme organisms.

LIFE UNDER THE OCEANS

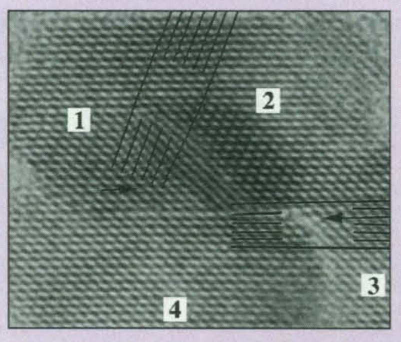
Recent work has indicated that an extensive biosphere may be present at depth in the ocean crust in the pore spaces in the basalt. Fisk *et al.* (p. 978) survey basalts obtained from drill cores into the oceanic crust from several locations globally. Evidence of biological activity is present along the weathering interface where basalt glass is altered to clays and other minerals. The weathering front is typically a series of channels several micrometers across. Despite the huge extent of their habitat, these organisms constitute less than 1 percent of the planet's biomass.

RECENT WARM SPELLS

Climate records have pointed to a variable Holocene climate. Rietti-Shati *et al.* (p. 980) now provide a record from Mount Kenya, East Africa, that extends back to about 4000 years ago, overlapping the time of major civilizations to the north. The record is from biogenic opal in a glacial lake and implies that temperatures were warmer than at present between 2300 and 1500 years ago. A similar warm period is seen in some records elsewhere in Africa and for other parts of the globe.

GROWING IMPERFECTLY TOGETHER

Most studies of crystal growth have focused on nucleation and ripening of individual grains. Penn and Banfield (p. 969) have looked at the later stages of this process where growing crystallites coalesce. Defect-free nanoparticles of titanium dioxide (anatase) were coarsened under hydrothermal conditions;



defects observed in transmission electron microscopy could then be attributed to further growth processes. They find that particles tend to attach to one another on relatively flat low-index surfaces such as {112} but with small misorientations that produce dislocations. Interwoven spiral growth at two dislocations can produce complex polymorphic structures.

FAST SPINS

Electron transfer reactions involving transition metal compounds are important in bioinorganic chemistry and homogeneous catalysis and often occur on very short time scales. Understanding the interaction between spin relaxation and electron transfer in those reactions has been limited because of experimental constraints in this time regime. Gilch *et al.* (p. 982) combined the use of high magnetic fields with femtosecond pump-probe spectroscopy to influence the spin dynamics of such compounds on picosecond time scales. This approach allowed the determination of kinetic reaction schemes as a function of the different spin states that the system can adopt and allowed the electron transfer rates and spin relaxation times to be determined accurately.

INHIBITING THE INHIBITOR

A number of neurotransmitters in the brain are considered to act as modulators, but this term is not well defined and the mechanism of neuromodulation is still often unclear. Xiang *et al.* (p. 985) describe the effect of the neurotransmitter acetylcholine on action potential firing of inhibitory interneurons in the neocortex. While one type of interneuron gets depolarized and thus activated, another type gets hyperpolarized and silenced. This differential activity is achieved through different subtypes of acetylcholine receptors with antagonistic effects on the cellular membrane potential. Because these types of interneurons also have different patterns of synaptic innervation, this observation indicates how a modulator can switch and redirect the flow of information in the brain.

FLIES IN WAITING

In mammals, caloric restriction (that is, a starvation diet) alters the metabolic state of the animal dramatically and ultimately leads to slowing of the aging process. Similarly in *Caenorhabditis*, worms under stressful conditions (lack of nutrients, for example) enter a metabolically inactive state (dauer) that prolongs life. Mutations in dauer control genes slow aging. Now Carey *et al.* (p. 996) show that the Mediterranean fruit fly can also be coaxed by protein deprivation into an alternative metabolic state (waiting mode) in which lifespan is extended. Marrying the genetics of flies and this manipulation of lifespan may ultimately provide new information about the basis of aging that is more general than that from worms.

IDENTITIES THROUGH ID2

In developing vertebrates, cells of the neural crest scatter from the rim of the developing central nervous system to migrate throughout the body. These cells differentiate into a variety of tissues, including autonomic ganglia, pigment cells, and certain types of bone. Martinsen and Bronner-Fraser (p. 988) have identified a protein in chickens that is homologous to Id2 transcription factors. This version of Id2 is expressed specifically in the rostral neural crest cells and seems to support a balance between cellular fates leading to more proliferation or to differentiation.

CONTINUED ON PAGE 883

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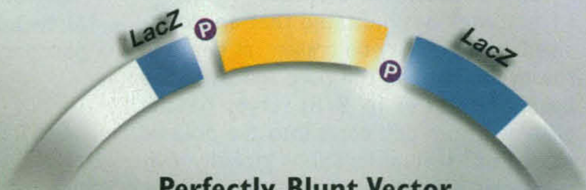

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References

1. Brownstein, J.M., *et al.* (1996) *BioTechniques* **20**, 1004–1010.
2. Magnuson, V.L., *et al.* (1996) *BioTechniques* **21**, 700–709.
3. Novy, R.E., Yaeger, K.W., and Kolb, K.M. (1996) *InNovations* **6**, 7–11.

*The Polymerase Chain Reaction (PCR) process is covered by patents owned by Hoffmann-La Roche.
†Conditions that use DNA polymerases lacking 3'→5' exo-activity (*e.g., Taq, Tth*)

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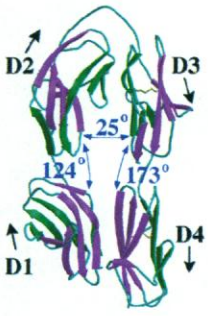
THIS WEEK IN *SCIENCE*

CONTINUED FROM PAGE 881

HEMOLIN HORSESHOES

When insects become infected, their hemolin protein is increased about 20 to 50 times and can bind hemocytes (leukocyte-like cells in insect hemolymph), bacteria, and lipopolysaccharide (LPS). Hemolin resembles adhesion molecules in the L1 (neuroadhesion) family of the immunoglobulin superfamily. Su *et al.* (p. 991) have determined the crystal structure of hemolin and found



that it adopts a horseshoe configuration, unlike other superfamily single-chain proteins. The authors have developed a "domain-swapping" model of cell homophilic adhesion that may apply to the neuroadhesion molecules as well.

PROTECTION PATHWAY

When cells are exposed to tumor necrosis factor–α (TNF-α), both an apoptotic (cell death) pathway and a survival pathway are initiated, the latter through the transcription factor NF-κB. Determining the mechanism of protection may allow the manipulation of cell death—to promote tumor destruction, for example. Wu *et al.* (p. 998) have found that NF-κB turns on a gene, *IEX*-1L, of previously unknown function that is protective against apoptosis induced by TNF-α and by Fas, another promoter of cell death.

NEGATIVE FEEDBACKS WITH ZINC FINGERS

Mice lacking tristetraprolin (TTP), a protein with a distinctive zinc finger motif, show multiple signs of enhanced inflammation. Carballo *et al.* (p. 1001) uncovered a biological role for TTP in the regulation of tumor necrosis factor–α (TNF-α), a key mediator of the mammalian inflammatory response. The binding of TTP to TNF-α messenger RNA was correlated with the destabilization of this messenger RNA. Synthesis of TTP was increased by stimuli that enhanced synthesis of TNF-α, such as lipopolysaccharide or TNF-α itself. Thus, TTP appears to provide negative feedback that modulates the amount of TNF-α produced by macrophages. TTP is a member of a family of related proteins that share the Cys-Cys-Cys-His zinc finger motif and might have similar RNA-binding functions.

SEQUENCE-SPECIFIC INITIATION IN MAMMALS

DNA replication in prokaryotes has long been known to initiate from defined sequences. Initiation of DNA replication in higher eukaryotes has, however, yielded less clear results. Aladjem *et al.* (p. 1005; see the Perspective by Huberman) have demonstrated that defined sequences from within the human β-globin locus, known to be sites of DNA replication initiation in the globin locus, can also direct initiation of DNA replication when transferred to other chromosomal locations in simian cells.

BRCA1 AND DNA REPAIR

Germline mutations in the *BRCA1* gene are found in about 50 percent of women who have an inherited predisposition to breast and ovarian cancer. Although the BRCA1 protein has been shown to bind to several proteins involved in DNA repair or transcription, its precise cellular role or roles remain unclear. Data from Gowen *et al.* (p. 1009) indicate that BRCA1 is required for transcription-coupled repair of oxidative DNA damage. Defects in this repair process could lead to inefficient transcription and the accumulation of mutations in critical genes controlling cell growth.

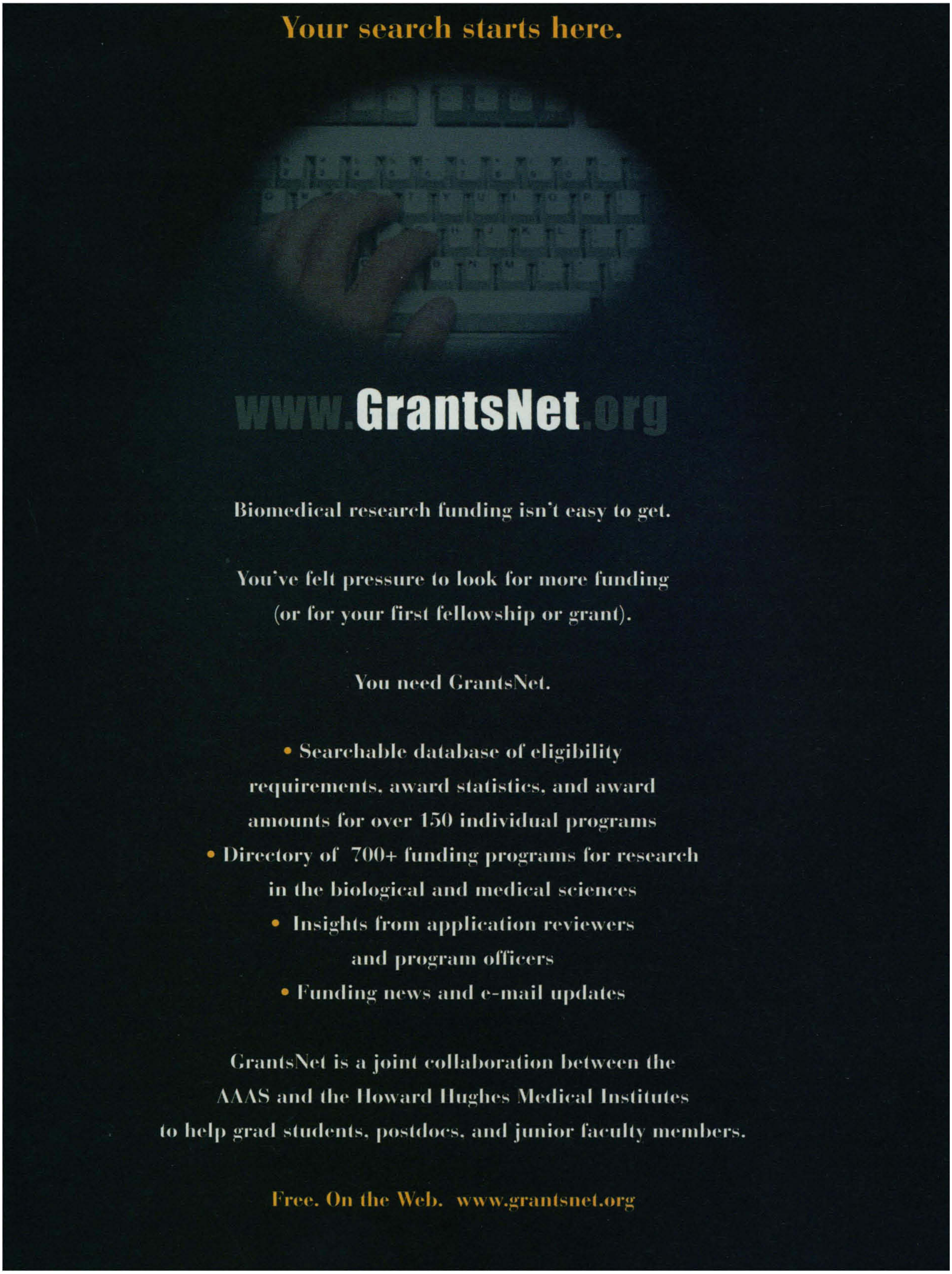
TECHNICAL COMMENT SUMMARIES

Ion Discrimination in Proteins and DNA

The full text of these comments can be seen at www.sciencemag.org/cgi/content/full/281/5379/883a

D. A. Doyle *et al.* (Research Articles, 3 Apr., p. 69) studied the molecular structure of the potassium (K^+) channel with the use of x-ray crystallography. The data revealed how the K^+ channel, a protein, selectively allows K^+ ions (but not Na^+ ions) to "diffuse rapidly across cell membranes."

K. Phillips and B. Luisi comment that they have observed ion binding "in the high-resolution crystal structure of a DNA tetraplex" that has features similar to "the metal coordination by the protein [the K^+ channel]" as described in the article and that supports the proposals of Doyle *et al.* "with regard to the K^+ channel's remarkable selectivity."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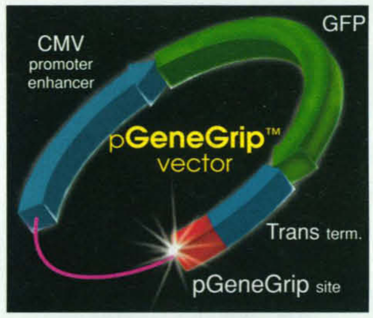

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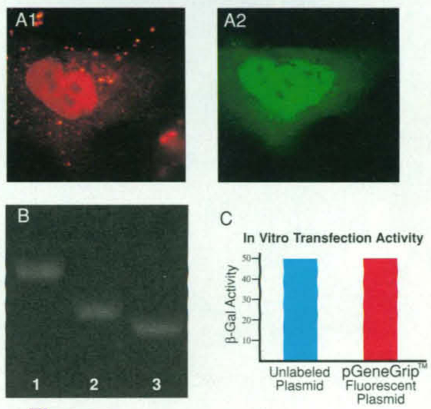

Figures:

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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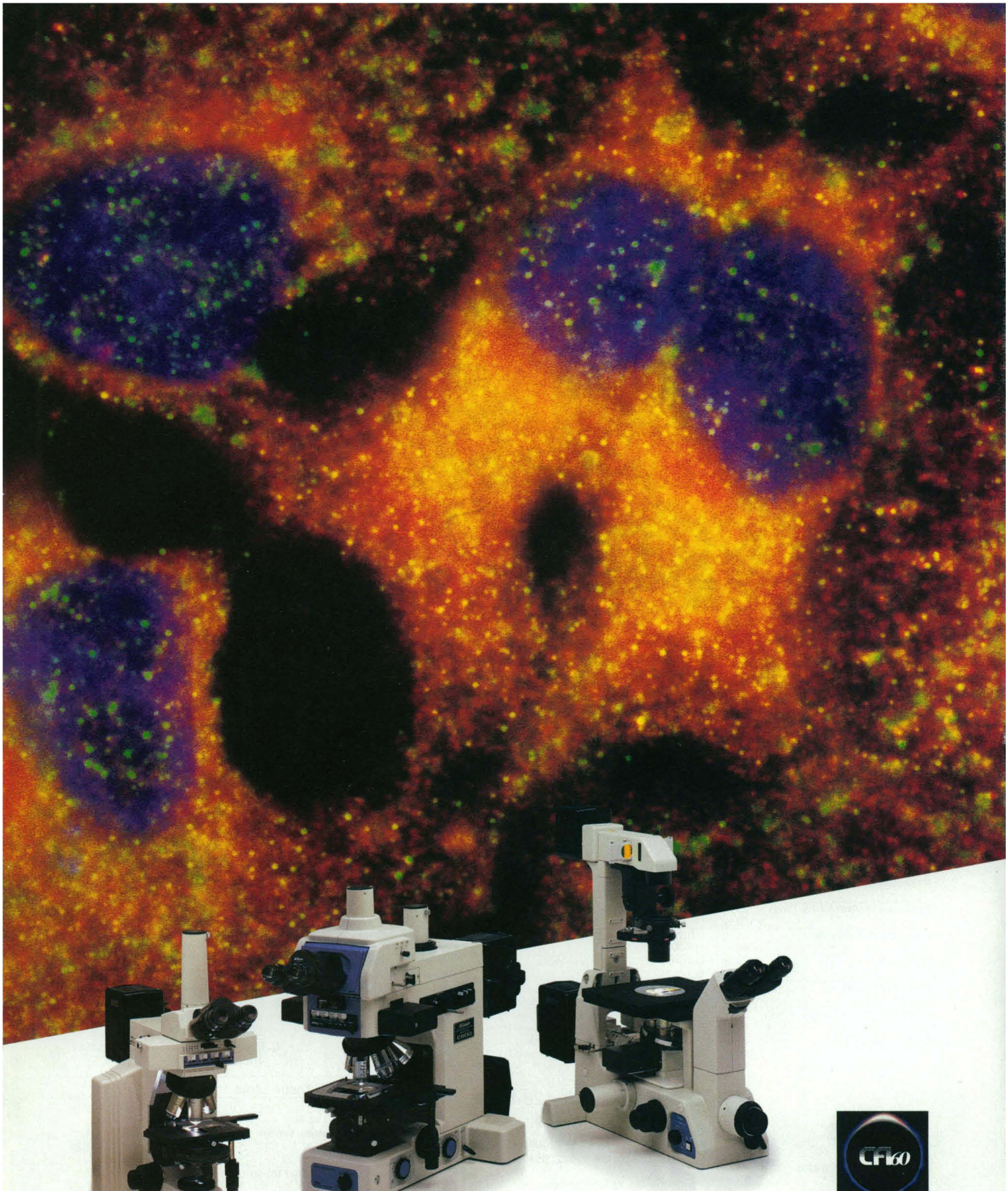
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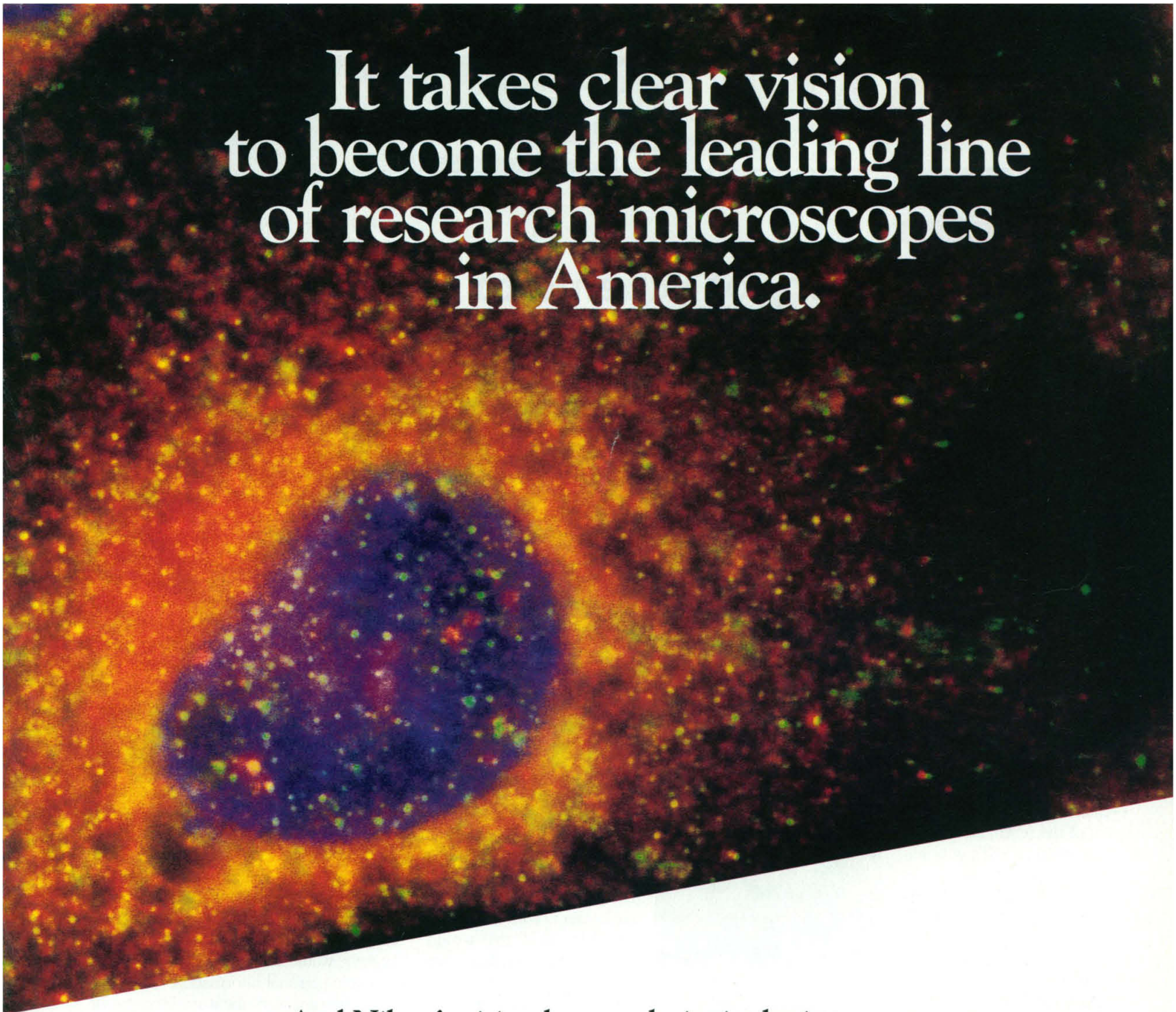

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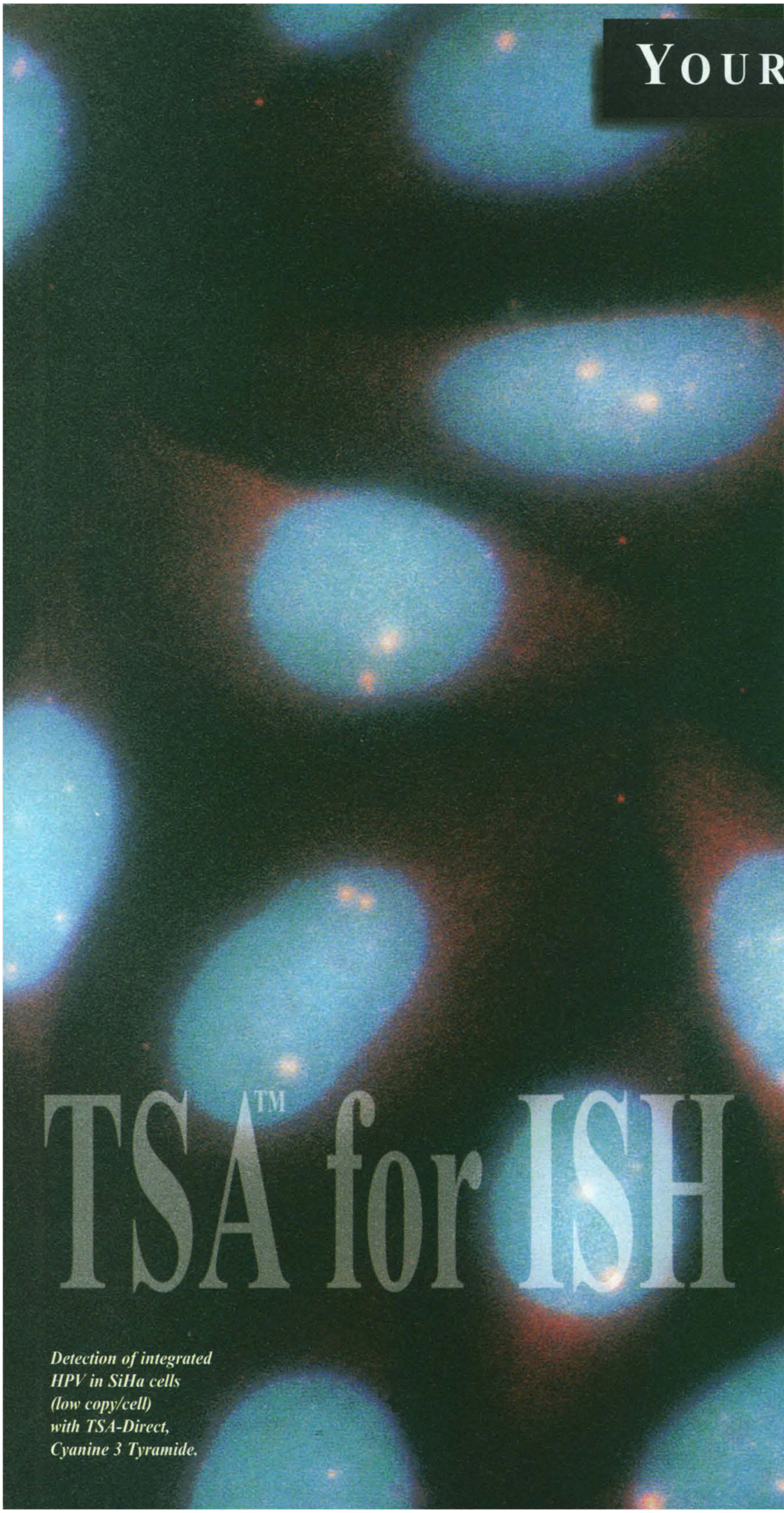

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