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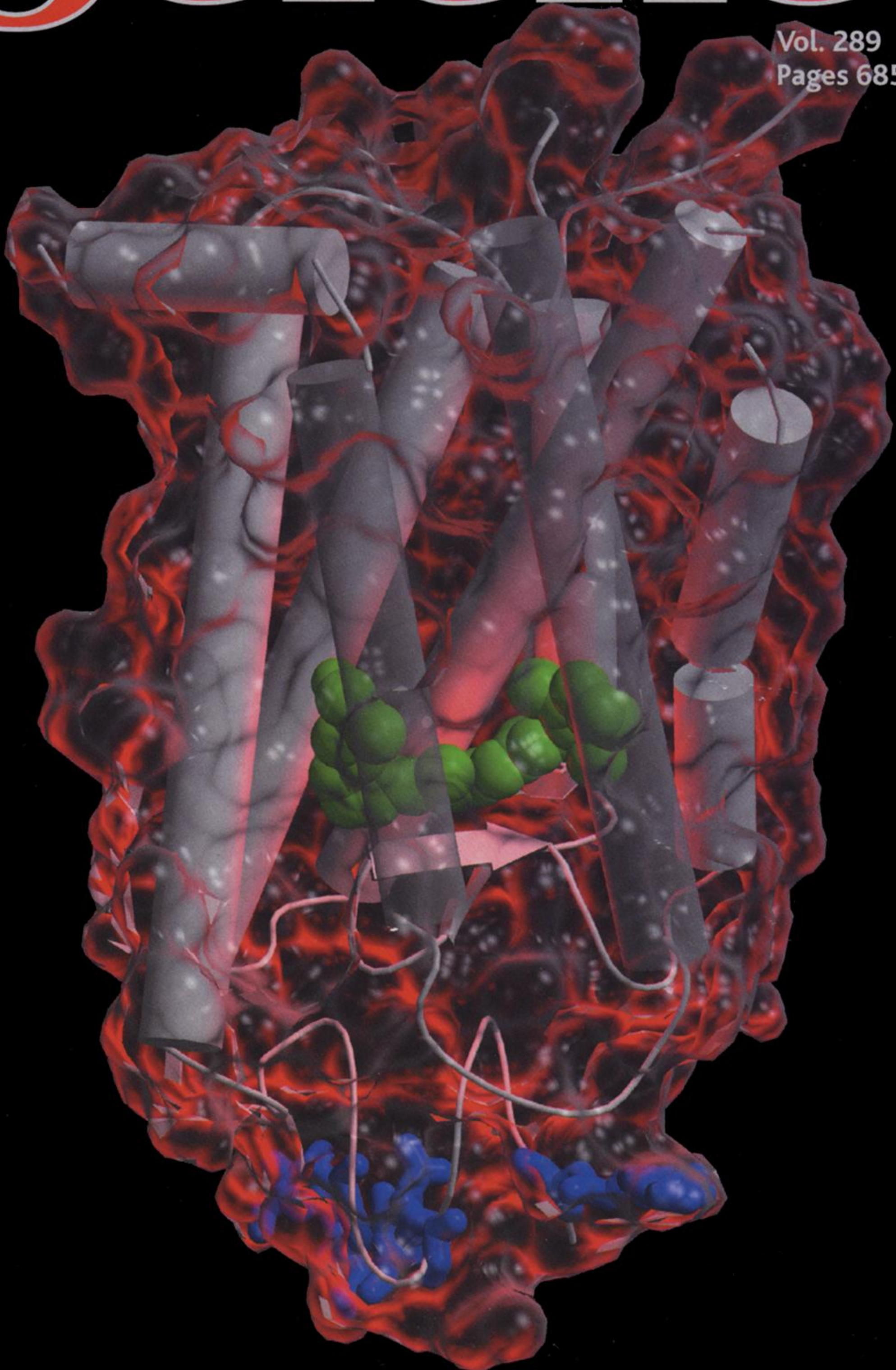

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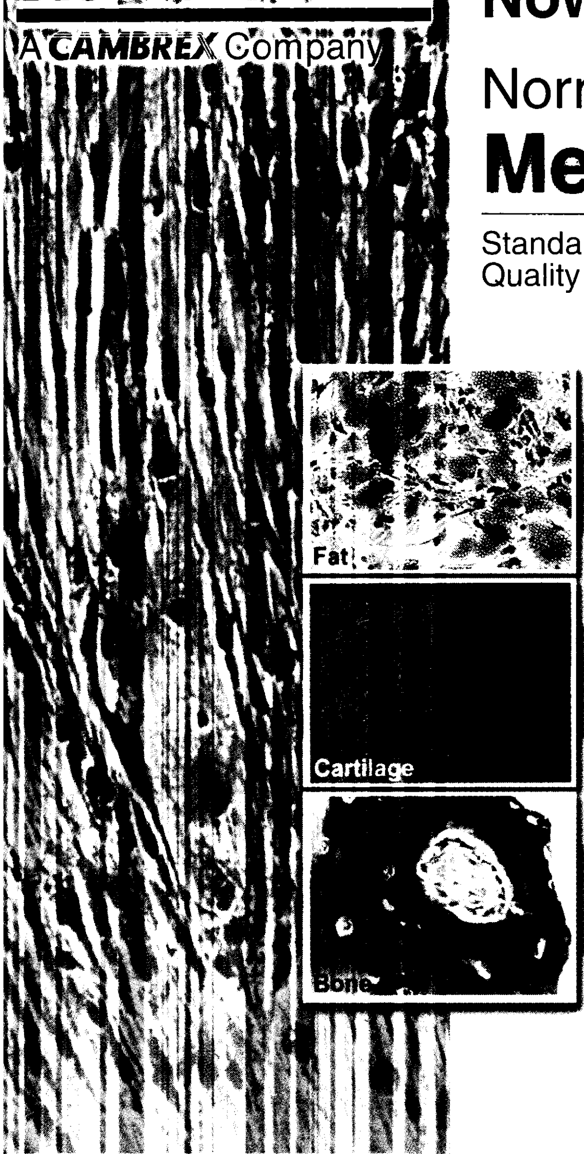

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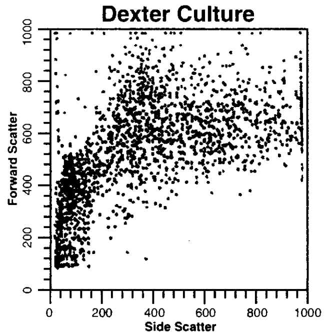

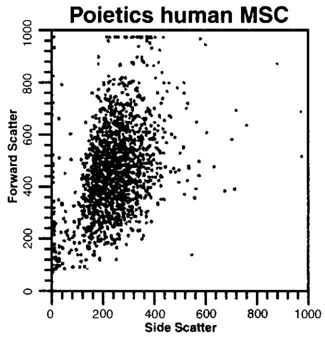

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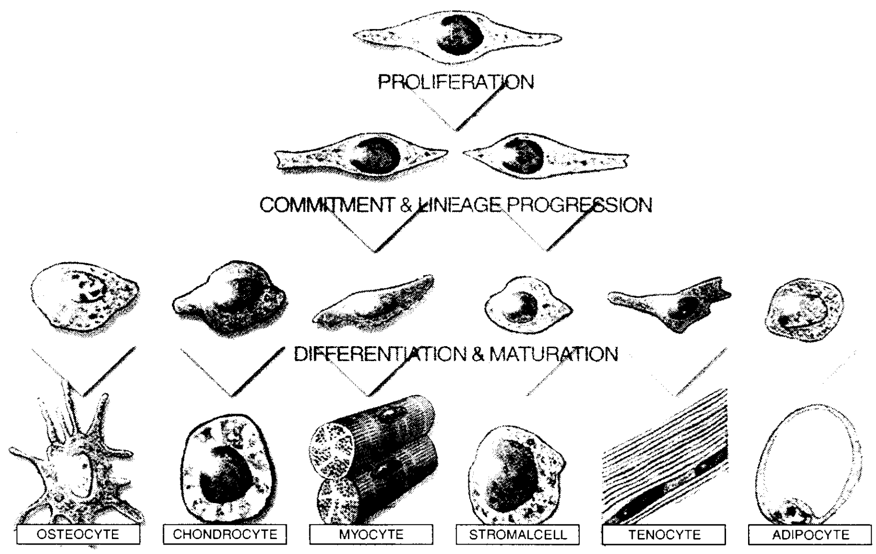

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COVER The three-dimensional x-ray crystal structure of the light-sensitive protein rhodopsin, at 2.8 Å. Members of this family of seven-transmembrane helix G protein–coupled receptors detect environmental signals and transmit them to cells. The protein backbone is shown schematically with a transparent surface. The pigment that absorbs light, 11-*cis*-retinal (a derivative of vitamin A), is shown in green, and the carbohydrate moiety is blue. Shading is in red. [Image: C. A. Behnke]

NEWS

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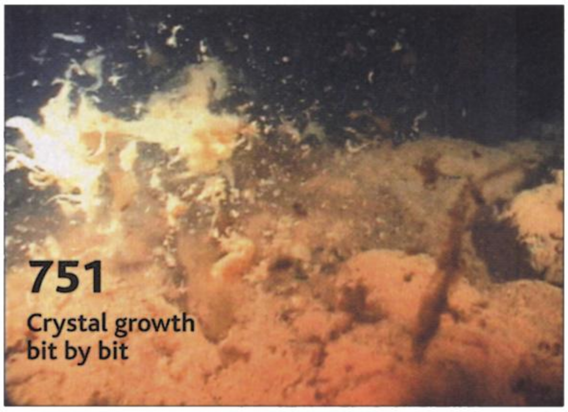
A sign of youth

RESEARCH



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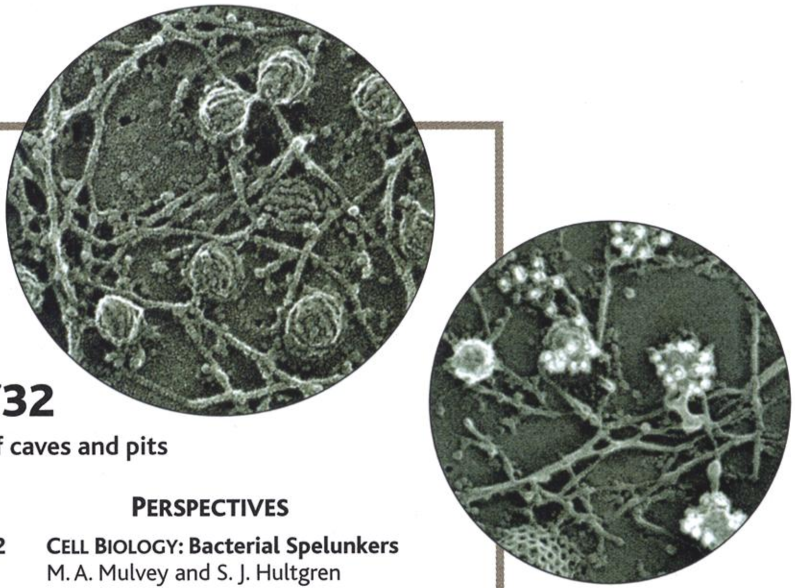

732
Of caves and pits

779
Messages through flowers

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TOLERANT TO RADIATION

Radiation waste disposal is a formidable scientific challenge, not least because the response of materials to radiation is hard to predict. Host materials have to show not only high chemical durability and solubility for the appropriate radionuclides, but also must be resistant to structural breakdown in response to self-radiation. Sickafus *et al.* (p. 748) have modeled the response of complex oxide materials with pyroclore and fluorite structures and conclude that the fluorite structure should be particularly resistant to radiation damage. Preliminary radiation-damage experiments confirm this prediction.

MODULAR CRYSTAL GROWTH

Houses can be built brick by brick or assembled from preformed modular units. Crystal growth in nature is primarily thought to occur through the analog of the first process—atom by atom (or molecule by molecule) attachment to a surface of a preexisting crystal. Banfield *et al.* (p. 751; see the Perspective by Alivisatos) now show that self-assembly of oriented nanocrystals, a process seen in a few laboratory systems and more analogous to the second process, may also occur in nature. The authors used transmission electron microscopy to study the growth patterns of ferrihydrate crystals produced by bacteria and observed several examples of oriented attachment of nanocrystals. Such a mechanism of growth may influence the formation of defects, which affect material properties, and the occurrence of phase transformations.

TRADING INSTABILITIES

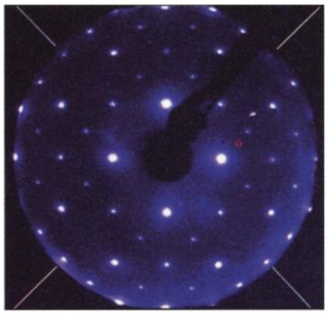
Carbocations—cations bearing positive charge on a carbon atom—are usually very reactive because the central carbon atom is not tetravalent. The same is true for the equivalent negatively charged species, carbanions. Kato *et al.* (p. 754; see the Perspective by Grützmacher) show that when phosphorus substitutes for nitrogen in a diaminocarbocation species, the resulting compound has a carbanionic center. This transformation from carbocation to carbanion is unusual and allows the synthesis of compounds whose nitrogen analog would be extremely unstable.

EARLY ATMOSPHERIC TRANSITION

The nature and oxidation state of Earth's early atmosphere has been widely debated; some records seem to show that it was relatively reducing until about 2 to 2.4 billion years ago. Farquhar *et al.* (p. 756) analyzed sulfur isotopes in a series of ancient rocks spanning much of the Precambrian. Their data show that mass-independent processes in the gas phase controlled sulfur isotope fractionation before about 2.4 billion years ago, whereas mass-dependent processes dominated later. These results support the late oxidation of Earth's atmosphere and have implications for inferring the onset and importance of microbial sulfur processing.

ONLY SKIN DEEP

Not all superconducting perovskite materials contain copper; Sr_2RuO_4 is one exception. It has been proposed that the spin-triplet pairing that leads to superconductivity in this material arises through ferromagnetic spin fluctuations of the nonmagnetic bulk ground state.



Matzdorf *et al.* (p. 746) present structural and theoretical evidence that a bulk soft-phonon mode is frozen at the surface and produces a small rotation of the RuO_6 structural units. This lattice distortion leads to a higher density of states at the Fermi surface and enhances spin fluctuations to such an extent that the ground state of the surface should be ferromagnetic. These results suggest that ferromagnetism and superconductivity may coexist in this material.

AN IRON GRIP ON PRODUCTION

Marine phytoplankton growth depends on adequate supplies of the plant nutrients. In the subtropical North Pacific Ocean, primary production is limited by low concentrations of nitrate, but in the western North Atlantic Ocean, it is limited by phosphate. Wu *et al.* (p 759) have measured very low phosphorus concentrations in the Sargasso Sea and suggest that these values are a result of the ready availability of iron, an element essential for plant growth, which is supplied there in abundance by windblown dust from the Sahara. These results support the idea that iron helps determine whether nitrogen or phosphorus is the limiting nutrient, and they show how iron supply regulates nitrogen fixation, carbon uptake, and the concentration of atmospheric CO_2.

RHODOPSIN'S STRUCTURE REVEALED

G proteins (heterotrimeric guanine-nucleotide bind proteins) that are involved in many different signaling pathways are activated by G protein–coupled receptors (GPCRs), a large family of membrane proteins that respond to a variety of stimuli. Rhodopsins are GPCRs that respond to light and activate the visual transduction pathway. Now Palczewski *et al.* (p. 739; see the cover and the Perspective by Bourne and Meng) have determined the structure of rhodopsin from diffraction data extending to 2.8 angstroms. The structure reveals the interactions of the ground-state chromophore, 11-*cis*-retinal, with residues in the seven α-helix transmembrane domain. The chromophore plays a key role in holding the transmembrane region in the inactive conformation. The structure also provides insight into how isomerization of 11-*cis*-retinal to all-*trans*-retinal may cause conformational changes that could be transmitted to G proteins at the cytoplasmic surface.

INCREASED RESPONSE TIMES

Plant ecologists are focusing increasing attention on the possible consequences of climate change for vegetation. Grime *et al.* (p. 762) report the results of a 5-year experiment on the effects of climate change on two British limestone grasslands that differ in their history and species composition. The experimental treatments, which consisted of different combinations of warming and precipitation, showed that early successional grasslands were much more susceptible—in terms of biomass and species composition—to climate change than were older sites with lower soil fertility. Human activities are steadily replacing the latter type of grasslands with the former, which suggests that whole landscapes will become more responsive to climate change as the proportion of early successional communities increases.

CLOCK COMPONENTS

The core components of the molecular clocks that underlie circardian rhythms in animals, fungi, and bacteria appear to

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THIS WEEK IN *SCIENCE*

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be in hand, but for plants and cyanobacteria, key elements are still being elucidated, including components that respond to changes in day length. Schmitz *et al.* (p. 765) identified a bacteriophytochrome in the cyanobacterium *Synechococcus elongatus* that helps the clock respond to environmental clues. The *cikA* (for circadian input kinase) gene appears to be critical for resetting the phase of the clock after a period of darkness. Working with rhythm mutants in the plant *Arabidopis,* Strayer *et al.* (p. 768) have now cloned the gene *TOC1,* which regulates the period of the circadian cycle in the absence of input from light. Because this gene is itself regulated by a feedback loop subject to circadian influences, it helps the plant respond to changes in day length. The predicted TOC1 protein has some intriguing features, including similarity to transcription factors and two-component signal transduction systems.

HELICASE ACTION AT TELOMERES

Telomeres, the DNA sequences at the ends of chromosomes, play a fundamental role in cellular aging and cancer. Zhou *et al.* (p. 771) characterized the mode of action of Pif1p, a 5′ to 3′ DNA helicase in yeast that had been linked previously to the control of telomere length. Pif1p associates with telomeres in vivo and acts by inhibiting the enzyme that synthesizes telomeres (telomerase) rather than by inhibiting recombination-mediated lengthening of telomeres, as had been suspected. The authors hypothesize that Pif1p, a highly conserved enzyme, promotes genetic stability by suppressing telomerase-mediated healing of double-strand breaks.

A POLYMERASE FOR CHROMATID COHESION

The cohesion of newly duplicated sister chromosomes, or chromatids, is established during the replicative-, or S phase, of the cell cycle. This cohesion is critical for their subsequent, accurate segregation during anaphase into the two presumptive daughter cell nuclei. Wang *et al.* (p. 774; see the Perspective by Takahashi and Yanagida) identify the topoisomerase-related function (Trf4) protein as being an essential component of the machinery that holds the pairs of sister chromatids together. Furthermore, Trf4 turns out to be a previously unidentified DNA polymerase, thus providing a link between the establishment of sister chromatids cohesion and DNA replication.

MOVED IN AND AT WORK

Certain transcription factors have an unusual ability to mobilize themselves into cells other than those where they were synthesized. Do these peripatetic factors actually find relevant gene targets in their adopted homes? Sessions *et al.* (p. 779) now construct mosaic plants to analyze the functions of mobile transcription factors. One transcription factor important in control of flower development not only moves but acts directly on target genes in other cells. Such sharing of regulatory molecules may serve to keep a group of cells acting in concert.

MAINTAINING MITOCHONDRIAL DNA INTEGRITY

Autosomal dominant progressive external ophthalmoplegia (adPEO) is an adult-onset mitochondrial disease that shows Mendelian inheritance but is also characterized by multiple deletions in mitochondrial DNA (mtDNA). Kaukonen *et al.* (p. 782) show that a subset of families with adPEO have mutations in *ANT1*, a nuclear gene that encodes the heart/skeletal muscle isoform of the adenine nucleotide translocator, a channel in the inner mitochondrial membrane that regulates cellular respiration and apoptosis. Analogous mutations in the yeast homolog of *ANT1* produce respiratory defects. The mechanism by which *ANT1* mutations lead to loss of mtDNA integrity remains to be established, but this surprising result may lead to a better understanding of the relationship between the nuclear and mitochondrial genomes.

CELLULAR INVASION

Some pathogenic bacteria invade cells and set up residence inside the cell in a cellular vacuole. Cellular invasion represents a risky strategy because host cells contain an arsenal of destructive enzymes in their lysosomes that could attack and destroy these invaders. However, in order to avoid such attack, invading bacteria select and modify the engulfing membrane to form a vacole that resists fusion with the lysosome. Shin *et al.* (p. 785; see the Perspective by Mulvey and Hultgren) provide evidence for the existence of caveolae in a hematopoetic cell, in this case mouse mast cells, and the role they play in facilitating the entry of *Escherichia coli.*

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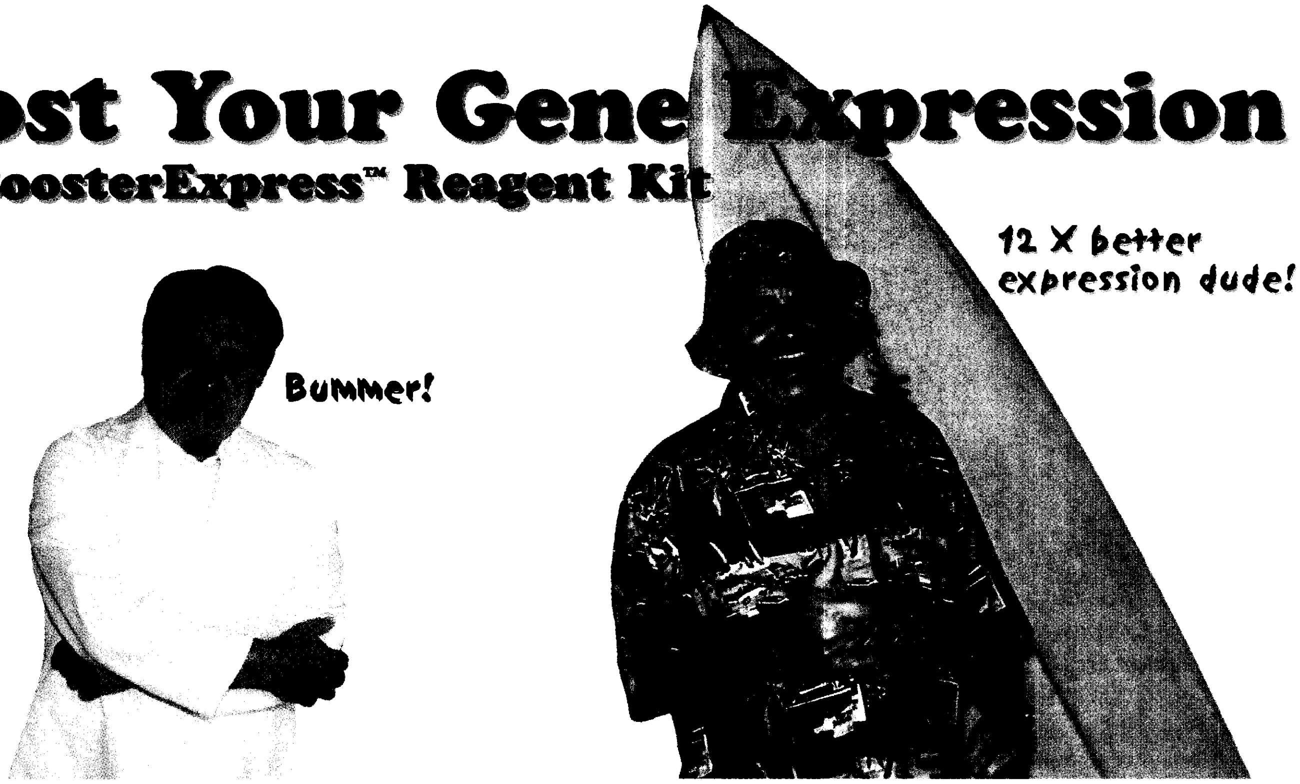

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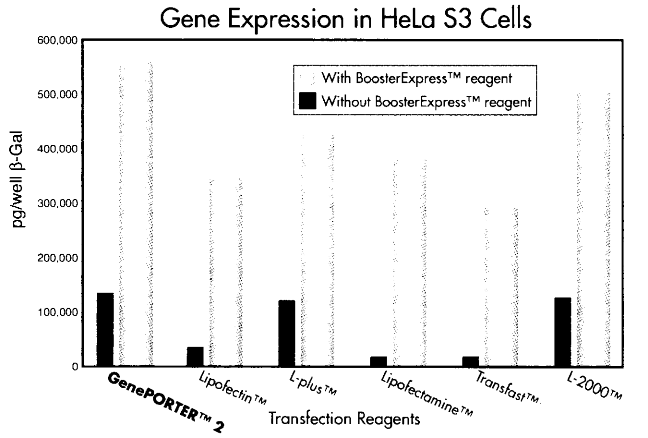

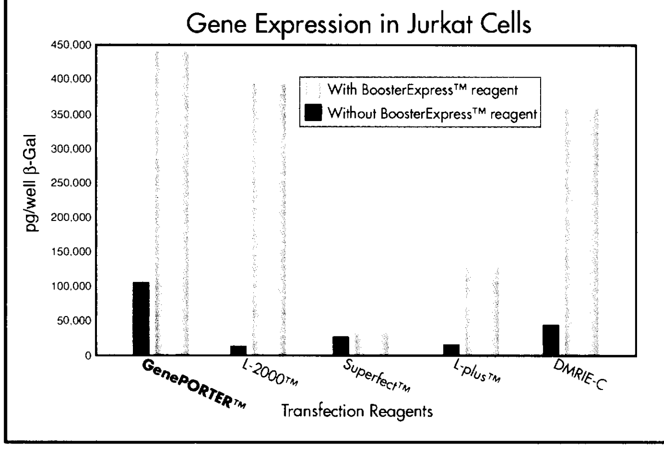

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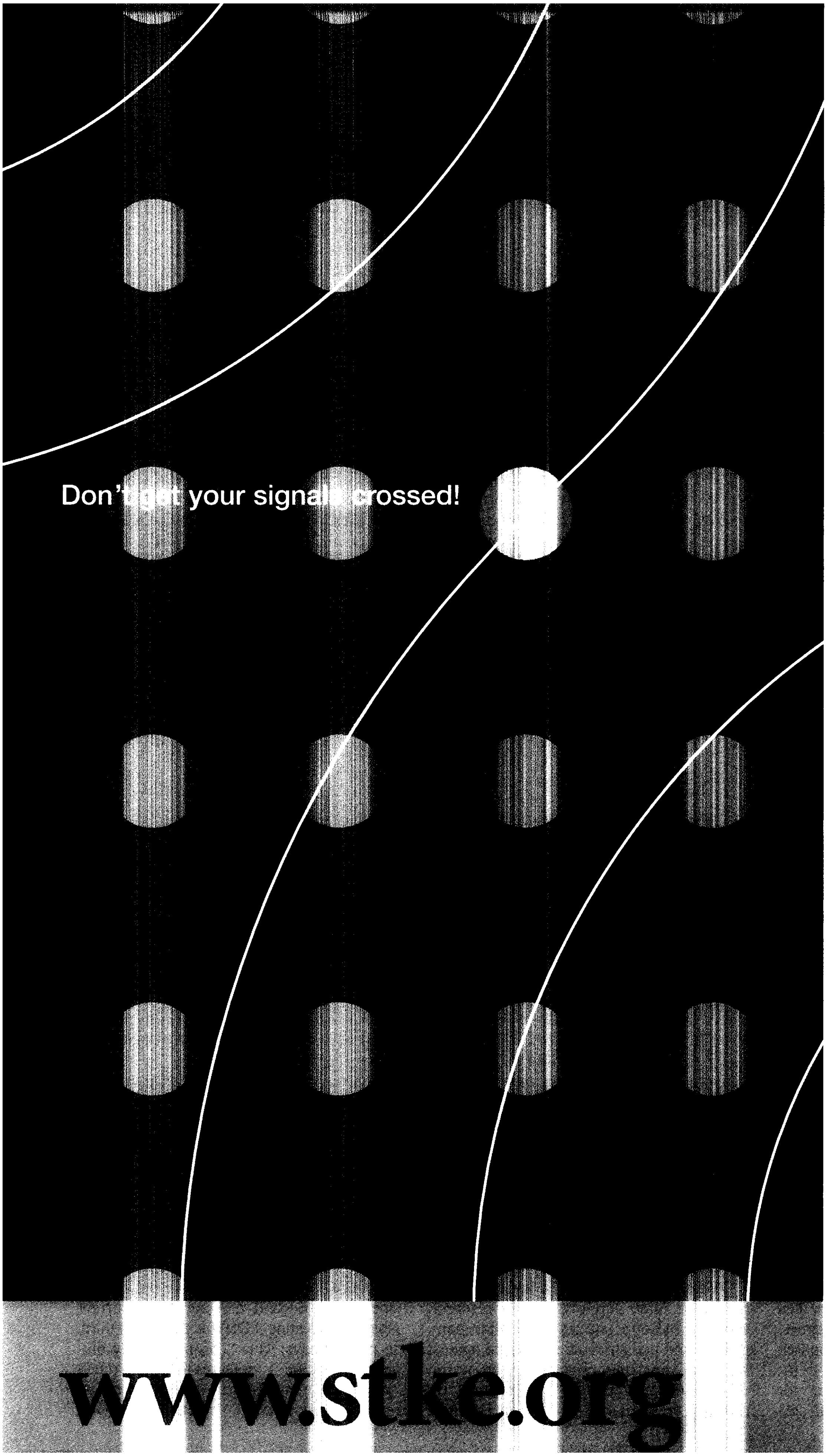
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