13 August 1999

# Science

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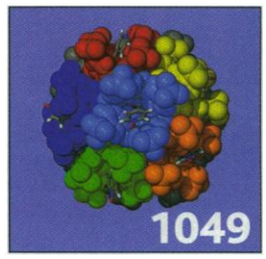



**COVER** Twelve *p*-sulfonatocalix[4]arene anions (six are shown in colored space-fill mode), located at the vertices of an icosahedron, form a spherical supramolecular assembly (diameter, 2.8 nm). The sphere core (not shown) has a volume of 1700 Å$^3$ and contains a cluster made up of two sodium ions and 30 water molecules. Lanthanide ions and pyridine *N*-oxide molecules (shown in stick mode) are important in determining the overall geometry. [Image: G. W. Orr, L. J. Barbour, J. L. Atwood]

**990**

**The world's most primitive flowering plant**



## NEWS

### NEWS OF THE WEEK



### NEWS FOCUS



## RESEARCH

### RESEARCH ARTICLE

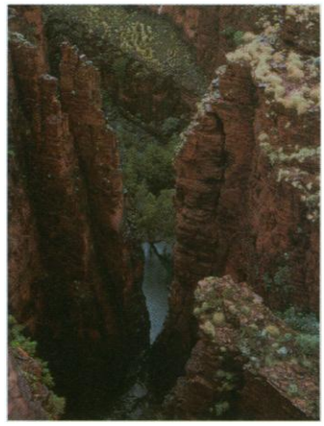


### REPORTS



**1033**

**Eukaryote origins put back a million years**





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## SCIENCE'S COMPASS

### EDITORIAL



### LETTERS



### BOOKS *ET AL.*



### PERSPECTIVES





### REVIEW





### TECHNICAL COMMENTS



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**1026**

Taking a close look at minerals

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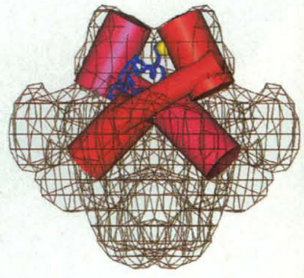

**1077**

Modeling piecemeal a ligand-receptor complex


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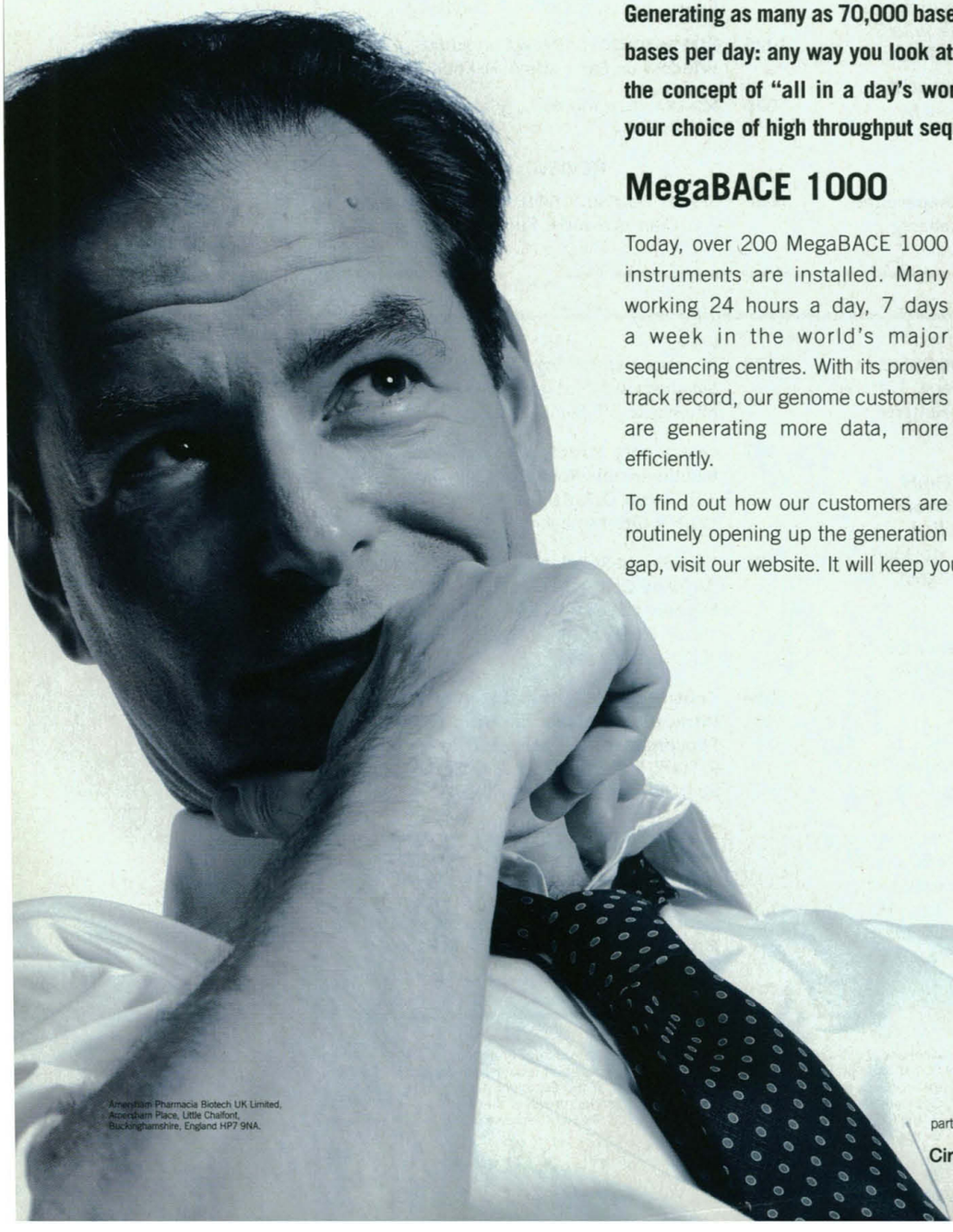

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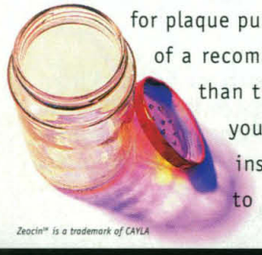

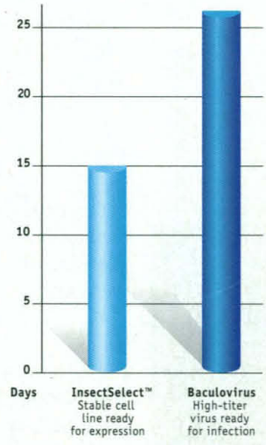


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### CLARIFYING POPULATION CYCLES

Two reports address the underlying causes of well-known animal population cycles (see the Perspective by Ranta *et al.*). Turchin *et al.* (p. 1068) used an elegant combination of theory and experiment to show that predators are implicated in the cycle of the southern pine beetle, whose

periodic outbreaks cause immense damage to pine forests in the southern United States and Mexico. From an analysis of 30 years of time-series data on beetle outbreaks, they formulated hypotheses which were then tested in a 5-year replicated experiment in a Louisiana loblolly pine forest using exclusion cages. Records of the population fluctuations of the Canada lynx date to early 1800s. Stenseth *et al.* (p. 1071) used a new statistical approach that has revealed three structural groupings in the lynx population dynamics that broadly coincide with the east-west geoclimatic zonation across Canada rather than the north-south ecological zonation. This result suggests a role for the North Atlantic Oscillation in determining these regional patterns.

### IN THE LOOP

Quantum computers offer the possibility of performing massively parallel and complex calculations that classical computers cannot do. Much of the work at present is concentrated on the theoretical development of the components that will make up the quantum computer—qubits. Mooij *et al.* (p. 1036) introduce a design for a solid state qubit based on a superconducting loop with several Josephson junctions. In contrast to other solid state implementations, this approach would work in the magnetic regime and should be robust against external electrical noise and thus provide very long coherence times (the time that determines how long a calculation can be done).

### NANOSCALE ORGANIC SPHERES AND TUBES

Interactions between molecules can lead to their assembly into larger aggregates, but controlling such aggregation can require several competing effects. Amphiphilic, polyhedron-shaped *p*-sulfonatocalix[4]arene building blocks, which have been shown previously to assemble into bilayers in an antiparallel fashion, have now been assembled in a parallel alignment by Orr *et al.* (p. 1049; see the cover). Spherical and helical tubular structures resulted through the addition of pyridine *N*-oxide and lanthanide ions. The relative amount of pyridine *N*-oxide added changed the curvature of the assembling surface and controlled whether spheres or extended tubules formed.

### IRON BATTERIES FORGE AHEAD

The alkaline batteries that power portable electronics and flashlights use a zinc anode and a manganese oxide ($MnO_2$) cathode. Their energy capacity is cathode limited. Licht *et al.* (p. 1039; see the news story by Hellemans) show that an unusual iron oxidation state couple, from Fe(IV) to Fe(VI), can provide a 50% increase in energy capacity, mainly by using a three-electron couple instead of just two. The ferrate ($FeO_4^{2-}$) species used for the cathode is a known species that has often been considered unstable; the authors show that this instability can be avoided by eliminating metal impurities, such as nickel or cobalt, that catalyze ferrate decomposition. The cells show significant rechargeability, and batteries in the "AAA" configuration have been made.

### DIFFERENT WAYS OF TAKING THE HEAT

Even for simple surface reactions, such as the catalytic oxidation of carbon monoxide (CO) to $CO_2$ on transition metal surfaces, the role of the surface in activating molecules is unclear. If CO and O atoms are coadsorbed on a flat ruthenium metal surface and then heated in a vacuum, CO desorbs and no reaction occurs. Nonetheless, Bonn *et al.* (p. 1042) found that if they rapidly heated the surface with femtosecond infrared laser pulses, $CO_2$ was formed. Although desorption of this final product was caused by thermal energy (phonons, the vibrations of the surface), the hot surface also generated electrons that initiated the oxidation reaction before the phonons could cause the CO could desorb.

### STILL WATERS RUNNING DEEP

Manganese crusts in the ocean are providing valuable geochemical records of past ocean chemistry that can be used to infer past rates and locations of continental weathering, ocean circulation, and climate change. Chemical tracers with short residence times are poorly mixed and reflect local processes and fluxes. Lee *et al.* (p. 1052) now present an ocean hafnium isotope record from two widely separated manganese crusts in the Pacific Ocean. Hafnium has a longer residence time than that of more commonly used lead and neodynium tracers. The data imply that, particularly after 20 million years ago, the Pacific Ocean bottom waters became more isolated from the Atlantic Ocean, probably because of increasing separation of Australia from Antarctica.

### SEPARATIONS THROUGH FLUCTUATIONS

Thermal fluctuations, or Brownian motion, normally randomize particles and molecules, but the application of time-dependent asymmetric forces can bias diffusion processes and lead to the transport of molecules and even separations. Van Oudenaarden and Boxer (p. 1046) have experimentally realized a geometrical Brownian ratchet in which charged lipids are driven over an asymmetrical barrier by an applied electric field. Different diffusion rates over this barrier leads to a separation in the direction orthogonal to the applied field of two phospholipids bearing either a single or a double negatively charged head group; no separation was seen in the absence of the barrier. Such an approach may allow membrane-bound molecules to be separated without extraction from their native membrane.

### EARLIER EMERGENCE OF EUKARYOTES

Fossils need not be bones and teeth or even preserved soft tissues—organisms can leave their signature in the fossil record through characteristic biomolecules. Brocks *et al.* (p. 1033; see the Per-

CONTINUED ON PAGE 983

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CONTINUED FROM PAGE 981

spective by Knoll) report the discovery of the oldest molecular fossils. Hydrocarbons (2α-methylhopanes), preserved in northwestern Australian sediments 2700 million years old, are biomarkers that indicate the existence of eukaryotes (cyanobacteria) half a billion years earlier than hitherto recognized. They also find evidence for cyanobacterial oxygenic photosynthesis 600 million years before the atmosphere became oxidizing. These findings will necessitate a radical overhaul of current ideas about the evolution of early life and a recalibration of the eukaryotic molecular clock.

### THE MISSING PIECE FOR THE PILUS

An important structure involved in the pathogenesis of enteric and urogenic *Escherichia coli* are their pili. Two reports present detailed structural evidence that gives insight into pili assembly (see the Perspective by Eisenberg). Choudhury *et al.* (p. 1061) have solved the crystal structure of the FimH-FimC complex, where FimH is the adhesin at the tip of the type I pilus and FimC is the chaperone that regulates where and when it is added. Sauer *et al.* (p. 1058) solved the structure of the PapK-PapD complex, in which the chaperone PapD is bound to the "joint" protein at the top of the rod of the P pilus, PapK. Both of these complexes have a similar structure in that the chaperone "donates" a strand to form an atypical immunoglobulin-like fold for the structural protein, a process termed donor strand complementation. The model proposes that these folded structural proteins, and those that comprise the rods of the pili, all fit together during pilus formation through donor strand exchange, in which each subunit completes a typical immunoglobulin-like fold of its neighbor.

### COCAINE AND CLOCKS

The circadian clock comprises a protein-based feedback loop that marks the passage of approximately 24-hour periods. *Drosophila* engineered to lack each of these genes—*period*, *clock*, *cycle*, *timeless*, and *doubletime*—were tested by Andretic *et al.* (p. 1066) for cocaine sensitization, in which a second exposure to the drug produces an exaggerated response. Cocaine sensitization was absent in all but the mutant fly strains missing the *timeless* gene. This implication of a subset of the circadian clock genes in drug responsiveness echoes recent suggestions that at least some of these genes may act in more places and in more functions than just the brain's clock.

### CATALYZING FUSION

Intracellular transport of vesicles is regulated at several distinct steps. A transport vesicle must first recognize its target membrane. Once docked in the appropriate place, the two membranes fuse and the contents are mixed. Although several proteins have been identified that ensure the specificity of the early steps in this process, regulation of the final membrane fusion event has not been so clear. Peters *et al.* (p. 1084) report that an enzyme, protein phosphatase 1 (PP1), catalyzes intracellular membrane fusion. PP1 was also found in a complex with the calcium binding protein calmodulin. Hence, it appears that a distinct cellular machinery is at work to drive bilayer mixing.

## TECHNICAL COMMENT SUMMARIES

### $(Mg,Fe)SiO_3$-Perovskite Stability and Lower Mantle Conditions

The full text of these comments can be seen at www.sciencemag.org/cgi/content/full/285/5430/983a

G. Serghiou *et al.* (Reports, 26 June 1998, p. 2093) studied $(Mg,Fe)SiO_3$-perovskite, under high temperature and pressure in "three different experiments." They observed that perovskite remained as a single stable phase (to the pressure and temperature limits of their experiments) and did not decompose. This result supports the idea that perovskite is "the major component of the lower mantle" of the Earth.

L. S. Dubrovinsky *et al.* comment that their own earlier study and one other "show that perovskite may not be stable in the lower mantle and dissociates into its component oxides." They discuss details of the methods used in the report, and state that the results therein "appear to be mostly the result of different ways of characterizing the conditions of experiments and specimens."

In response, Serghiou *et al.* state that "the previously observed decomposition is most likely the result of large temperature (and possibly pressure) gradients present in those experiments, resulting from the use of a [Nd–yttrium-aluminum-garnet] Nd-YAG laser and, more important, the lack of a thermally insulating, soft pressure medium."

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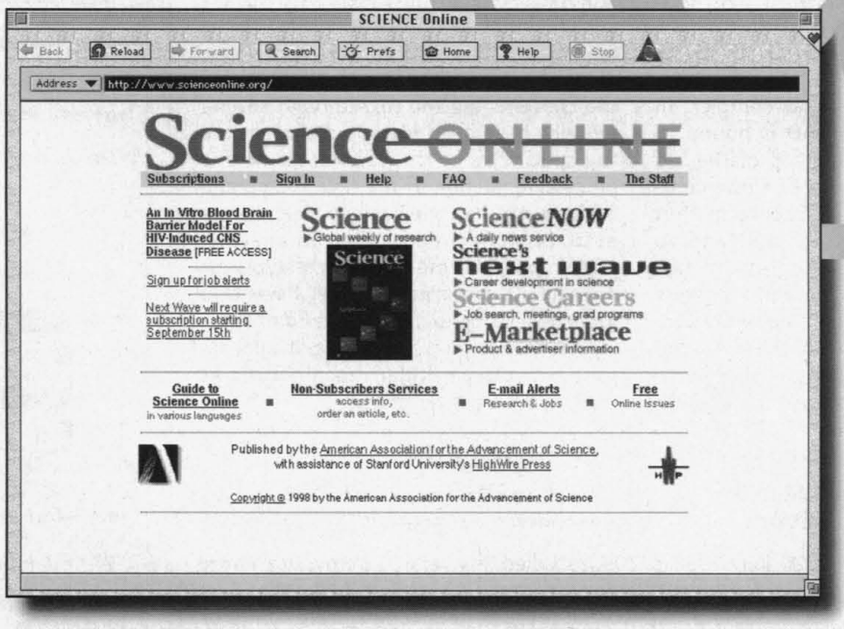


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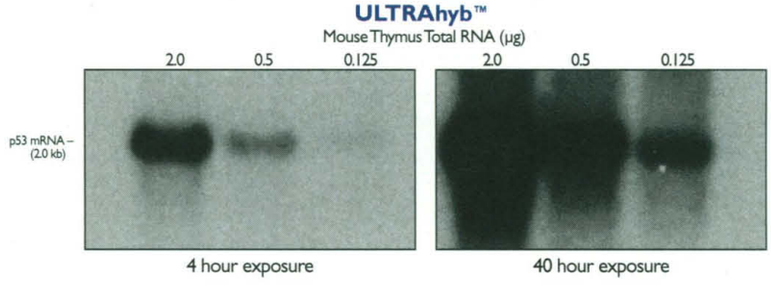


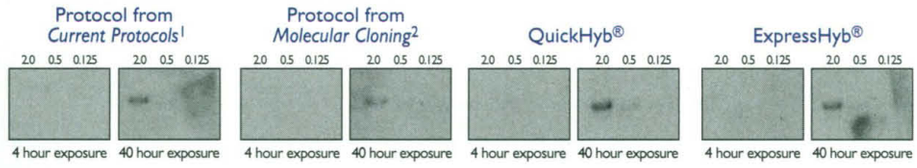


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1. *Current Protocols in Molecular Biology*, 1994. Ausubel, F.M. and others, editors. John Wiley & sons, Inc.
2. *Molecular Cloning: A Laboratory Manual*, 1989. Sambrook, J. Fritsch, E.F., Maniatis, T. Cold Spring Harbor Laboratory Press.

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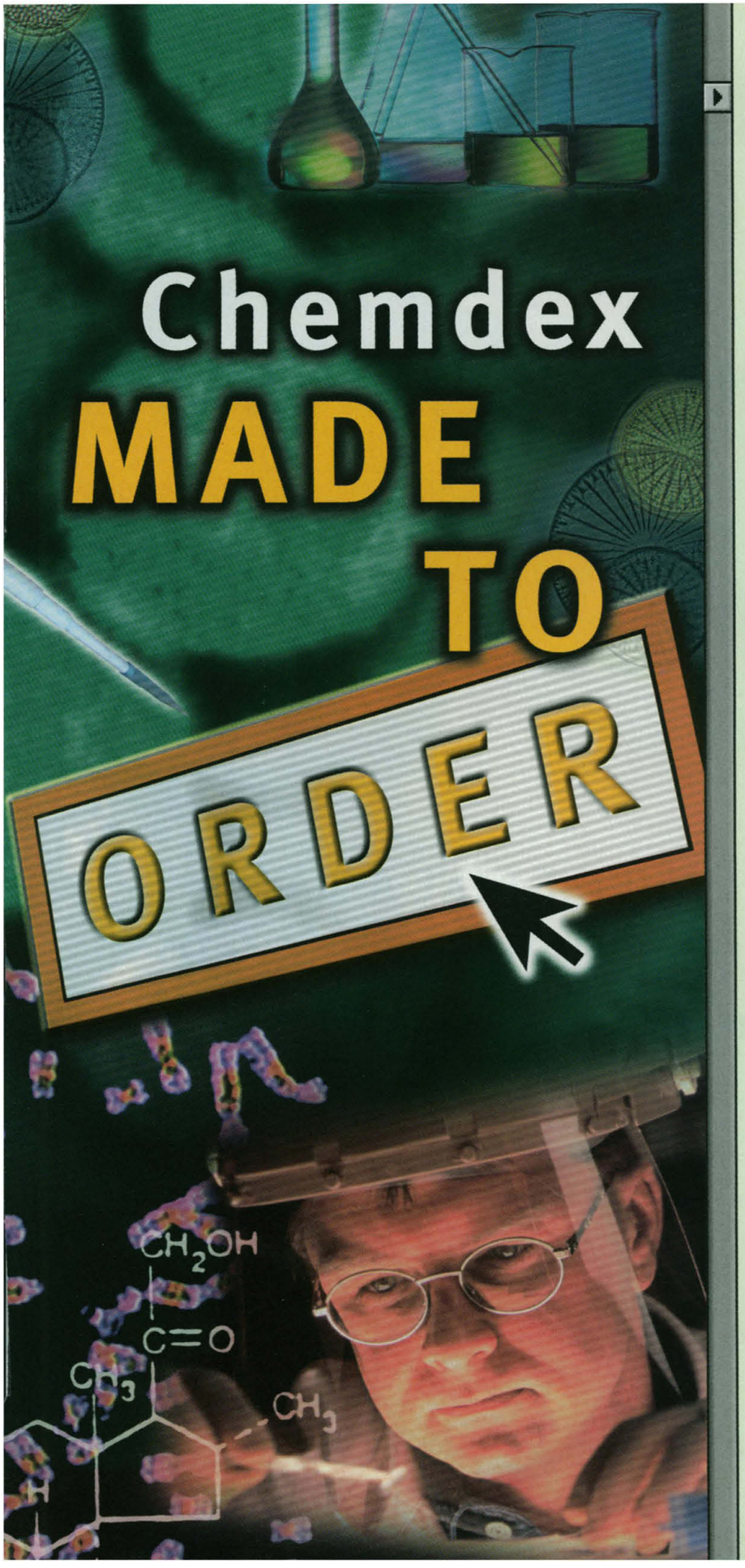


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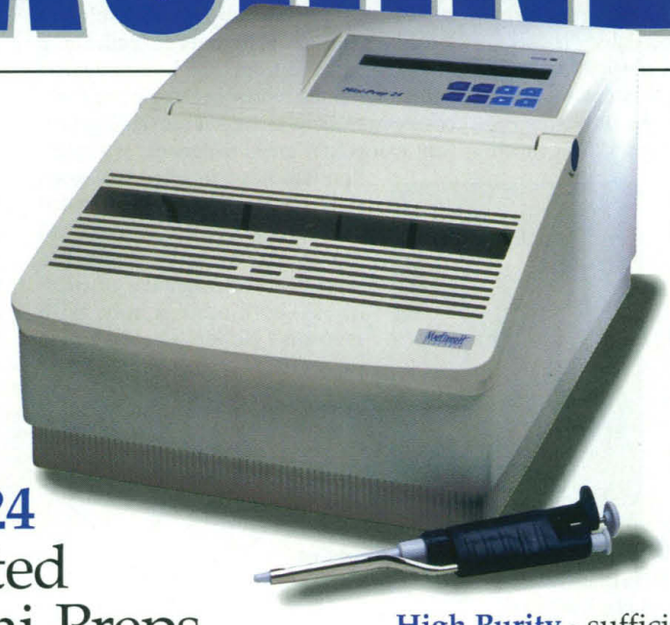
# TIME MACHINE



## The New **Mini-Prep 24** for Automated Plasmid Mini-Preps

The Mini-Prep 24 uses a new method of plasmid purification based on agarose gel electrophoresis and subsequent recovery by electroelution.

The Mini-Prep 24 uses premanufactured sample cassettes that come ready for direct loading of up to 2 ml of culture.

Call now to learn how the New Mini-Prep 24 can give you with quality DNA while saving you lots of time.

**High Purity** - sufficient for automated fluorescent and manual sequencing.
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**Consistent Results** - up to 6 µg of plasmid per ml.
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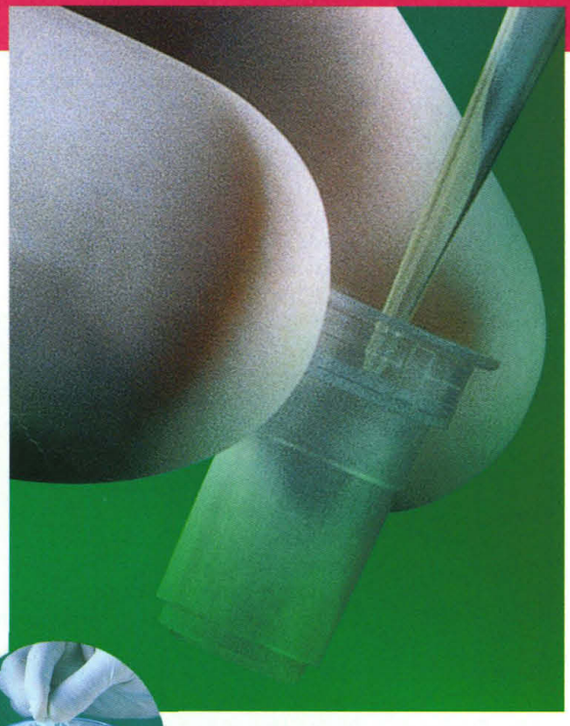
High-Performance Dialysis



# Introducing our smallest breakthrough yet.

**Pierce Slide-A-Lyzer® MINI Dialysis Units quickly and efficiently dialyze samples as small as 10 µl.**

- **100% Leak Tested:** Soon-to-be patented design prevents wicking around the membrane that can occur in homemade devices.
- **Excellent Sample Recoveries:** Slide-A-Lyzer® MINI Dialysis Units generally recover 9-10 µl after dialysis of a 10 µl sample.
- **Drastically Reduced Dialysis Time:** In less than 10 minutes, 100 µl of pH 2.8 buffer is converted to pH 9.4 dialyzing against a liter of bicarbonate buffer, pH 9.4.
- **Ready to Use:** No membrane treatment or assembly is required. Caps are provided to seal each unit to prevent evaporation and airborne contamination.

**Slide-A-Lyzer® MINI Dialysis Units**

**SnakeSkin™ Dialysis Tubing**

**Slide-A-Lyzer® Dialysis Cassettes**

## Trust the entire family of Pierce Dialysis Products.

**Slide-A-Lyzer® MINI Dialysis Units**

- Very economical and very fast
- Perfect for small (10-100 µl) samples
- Excellent sample recovery (90-100%)

**Slide-A-Lyzer® Dialysis Cassettes**

- 95%+ sample recovery
- Very high surface area/sample volume ratio for rapid dialysis
- For 100 µl-15 ml sample sizes

**SnakeSkin™ Dialysis Tubing**

- *Very* easy to fill: The first truly tubular dialysis tubing!
- *Very* easy to use: No preparation or presoaking necessary
- *Very* easy to dispense: Snip what you need
- For 15-100 ml sample sizes

**For detailed technical information, visit the Pierce web site at *www.piercenet.com*.**
**Call 800-874-3723 or, outside the U.S., 815-968-0747 for the name of your local distributor.**

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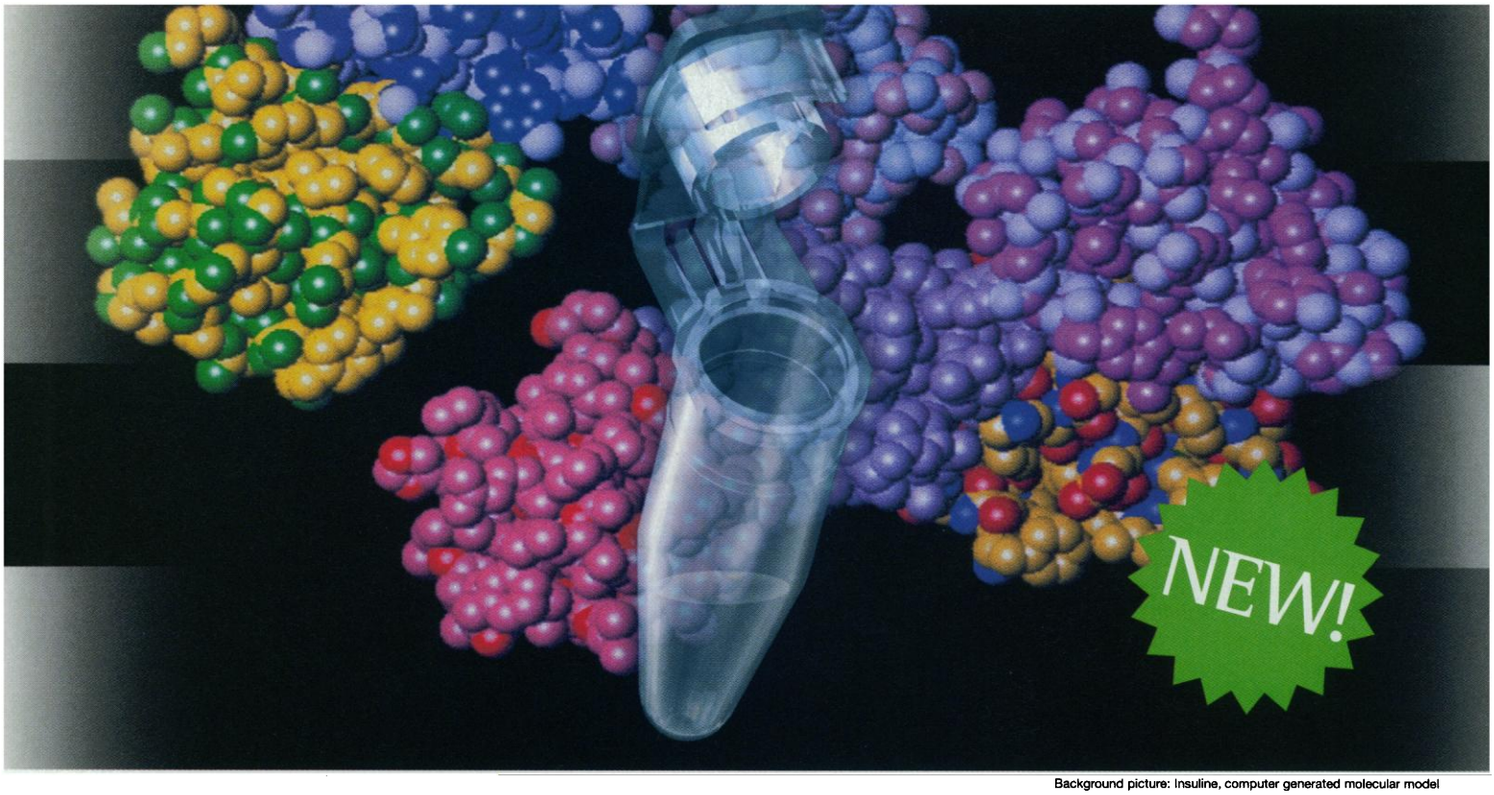



Background picture: Insuline, computer generated molecular model

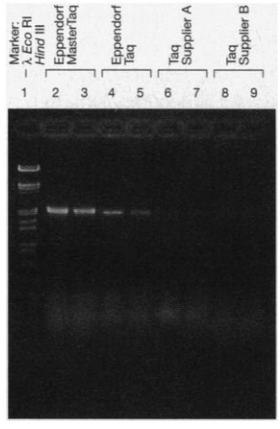
# When the going gets tough, MasterTaq gets going

**LICENSED FOR PCR**

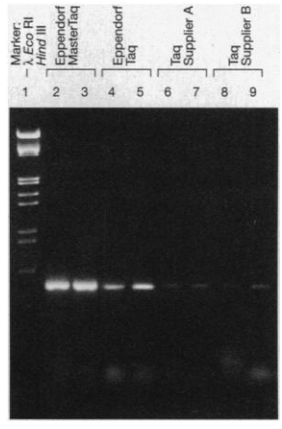
The Eppendorf **MasterTaq Kits** are designed to ensure improved yield and reliable PCR products.
The TaqMaster (5x PCR Enhancer) has been specially developed to improve the amplification of difficult templates by stabilizing the enzyme during the reaction procedure. TaqMaster improves the thermostability of the Eppendorf Taq DNA Polymerase and makes it less sensitive to exogenous PCR-inhibiting contaminations. Impure and GC-rich templates show increased yields and reproducible results.

The Eppendorf MasterTaq Kit includes the TaqMaster (5x PCR Enhancer), Eppendorf Taq DNA Polymerase, Reaction Buffer (10x) and $MgCl_2$ Solution.

The Polymerase Chain Reaction (PCR) is protected by patent. The patent is held by Hoffmann-La Roche. Products marked "licensed for PCR" are sold under licensing arrangements with F. Hoffmann-La Roche Ltd., Roche Molecular Systems, Inc. and The Perkin-Elmer Corporation.




**● Fig.1: Amplification of a SSU rRNA gene from total genomic algae DNA**
PCR was performed from genomic algae using different Taq DNA Polymerases. Equal volumes of the PCR reactions were analyzed by gel electrophoresis.




**● Fig. 2: Amplification of a GAPDH specific DNA fragment from genomic blood DNA**
PCR was performed from human genomic blood with different Taq DNA Polymerases. Equal volumes of the PCR reactions were analyzed by gel electrophoresis.

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# Cell Death/Survival Signaling

## FOR ANALYSIS OF Akt & Bad

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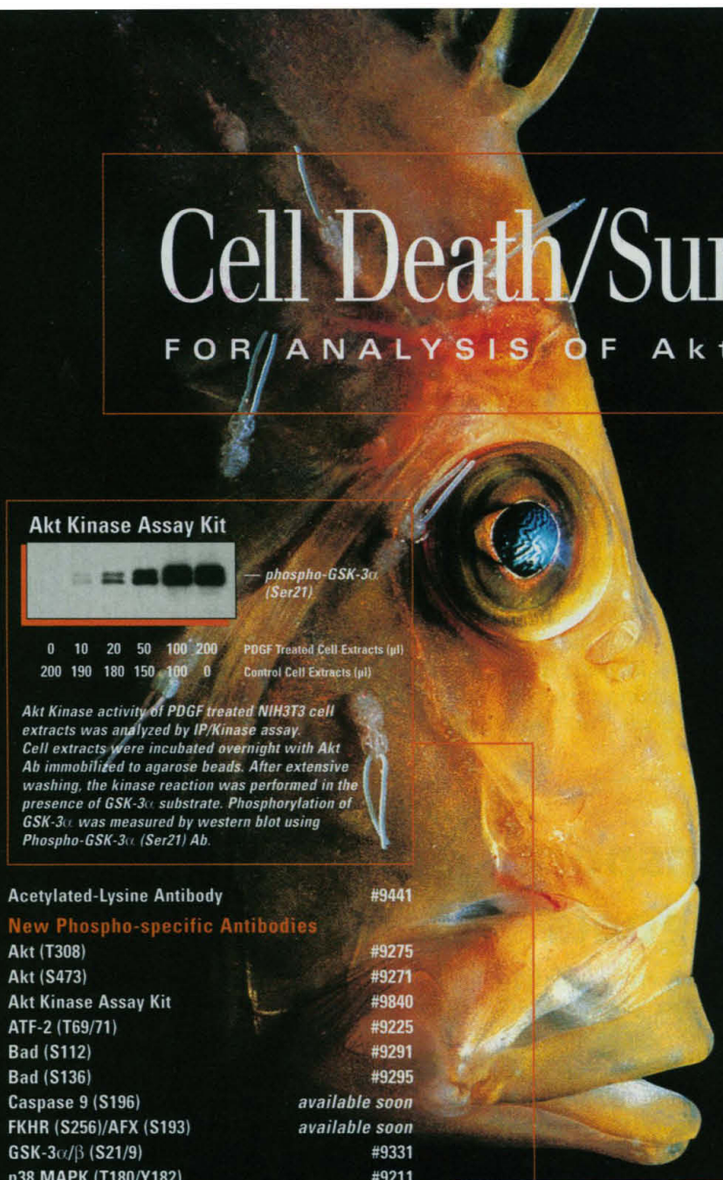
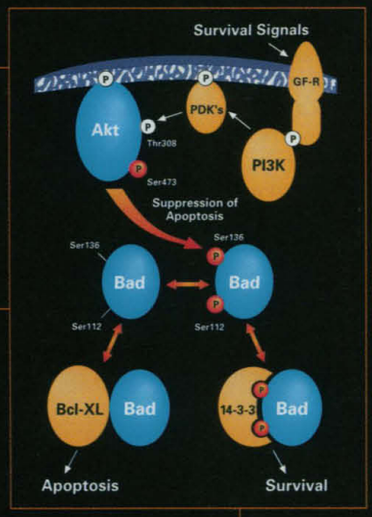


### Akt Kinase Assay Kit




| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 10 | 20 | 50 | 100 | 200 | PDGF Treated Cell Extracts (µl) |
| 200 | 190 | 180 | 150 | 100 | 0 | Control Cell Extracts (µl) |

*Akt Kinase activity of PDGF treated NIH3T3 cell extracts was analyzed by IP/Kinase assay. Cell extracts were incubated overnight with Akt Ab immobilized to agarose beads. After extensive washing, the kinase reaction was performed in the presence of GSK-3α substrate. Phosphorylation of GSK-3α was measured by western blot using Phospho-GSK-3α (Ser21) Ab.*




| | |
|---|---|
| Acetylated-Lysine Antibody | #9441 |

**New Phospho-specific Antibodies**

| | |
|---|---|
| Akt (T308) | #9275 |
| Akt (S473) | #9271 |
| Akt Kinase Assay Kit | #9840 |
| ATF-2 (T69/71) | #9225 |
| Bad (S112) | #9291 |
| Bad (S136) | #9295 |
| Caspase 9 (S196) | *available soon* |
| FKHR (S256)/AFX (S193) | *available soon* |
| GSK-3α/β (S21/9) | #9331 |
| p38 MAPK (T180/Y182) | #9211 |
| p44/42 MAPK monoclonal (T202/Y204) | #9106 |
| SAPK/JNK monoclonal (T183/Y185) | #9255 |
| Phospho-MAPK Antibody Sampler | #9910 |
| p53 (S15) | #9284 |
| p53 (S392) | #9281 |
| p70 S6 Kinase (T389) | #9205 |
| p90RSK (S381) | #9341 |
| PKC pan | #9371 |
| PKCδ (T505) | #9374 |
| Stat5 (Y694) | #9351 |
| Stat6 (Y641) | #9361 |
| Tyk2 (Y1054/1055) | #9321 |

***NOW AVAILABLE***

**General Phospho-specific Antibodies**

| | |
|---|---|
| Phospho-Threonine-Proline monoclonal (P-Thr-Pro-101) | #9391 |
| Phospho-Tyrosine monoclonal (P-Tyr-100) | #9411 |

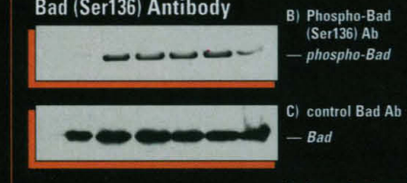
### Bad (Ser112) Antibody

A) Phospho-Bad (Ser112) Ab — *phospho-Bad*

### Bad (Ser136) Antibody

B) Phospho-Bad (Ser136) Ab — *phospho-Bad*

C) control Bad Ab — *Bad*



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| - | + | + | + | + | + | + | Bad transfection |
| 0 | 0 | 0.25 | 1 | 2 | 6 | 24 | TPA (hours) |

*Western analysis of 293 cell extracts transfected with GST-Bad and treated with TPA using (A) Phospho-Bad (Ser112) Antibody (B) Phospho-Bad (Ser136) Antibody and (C) control Bad Antibody.*

### Akt (Thr308) Antibody

A) Phospho-Akt (Thr308) Ab — *phospho-Akt*

B) control Akt Ab — *Akt*

| | | | | | |
|---|---|---|---|---|---|
| 0 | 5 | 15 | 60 | 90 | PDGF (min) |

*Western analysis of NIH 3T3 cell extracts treated with PDGF (100 ng/ml) using (A) Phospho-Akt (Thr308) Antibodies or (B) control Akt Antibodies.*

### Akt (Ser473) Antibody

A) Phospho-Akt (Ser473) Ab — *phospho-Akt*

B) control Akt Ab — *Akt*

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0.25 | 1 | 3 | 6 | 17 | PDGF (hours) |

*Western analysis of NIH 3T3 cell extracts treated with PDGF (50 ng/ml) using (A) Phospho-Akt (Ser473) or (B) control Akt Antibodies.*

*See the new NEB catalog and web site for a complete list of phospho-specific antibodies for Protein Kinases, Transcription Factors and Receptors.*

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CELL SIGNALING


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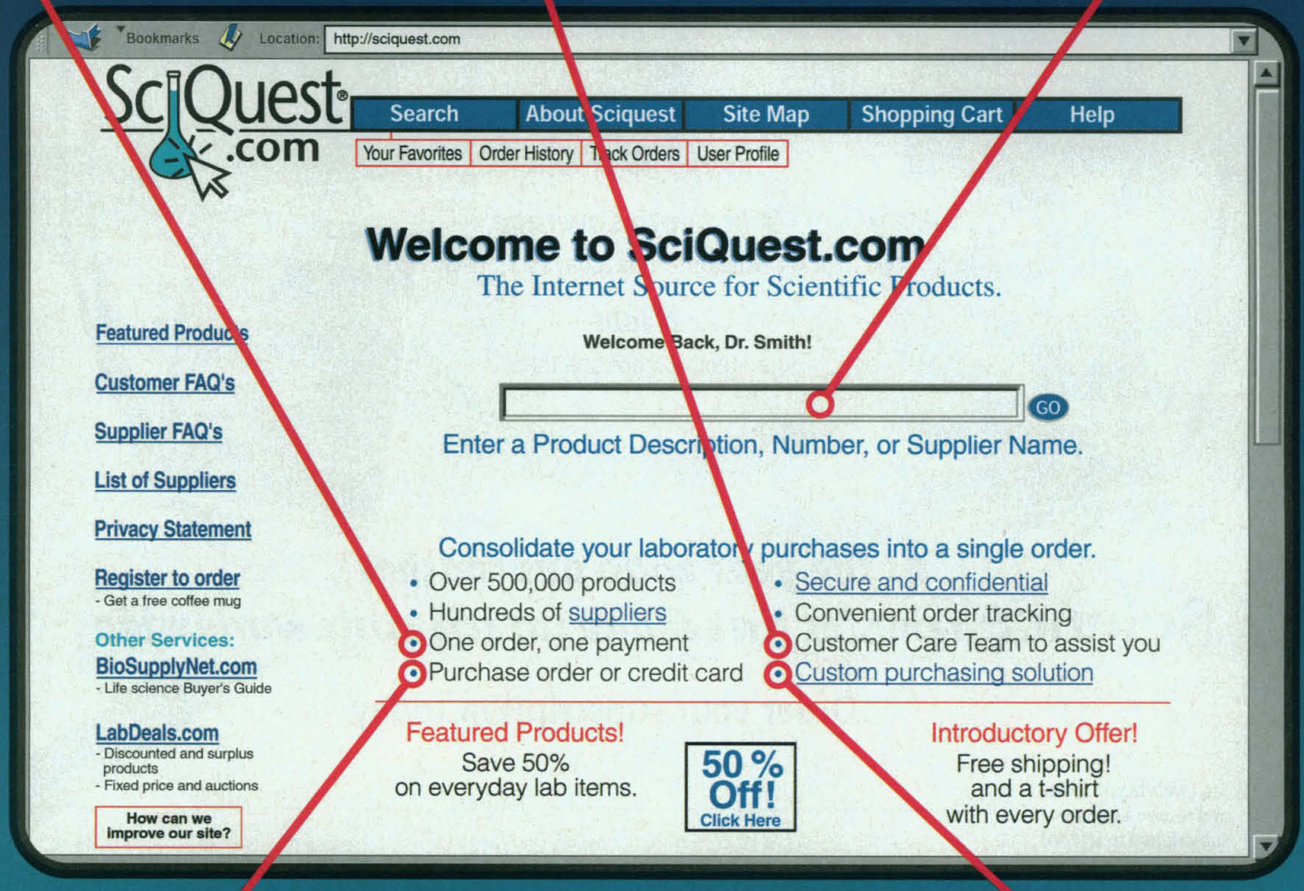


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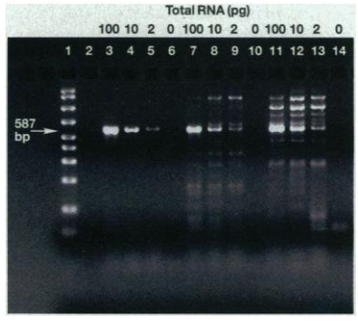


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Lanes 7, 8, 9, 10: RNA PCR; with MuLV and Taq DNA Polymerase, no Hot Start

Lanes 11, 12, 13, 14: RNA PCR; AMV and enzyme blend, no Hot Start

Lane 1: Size Standard

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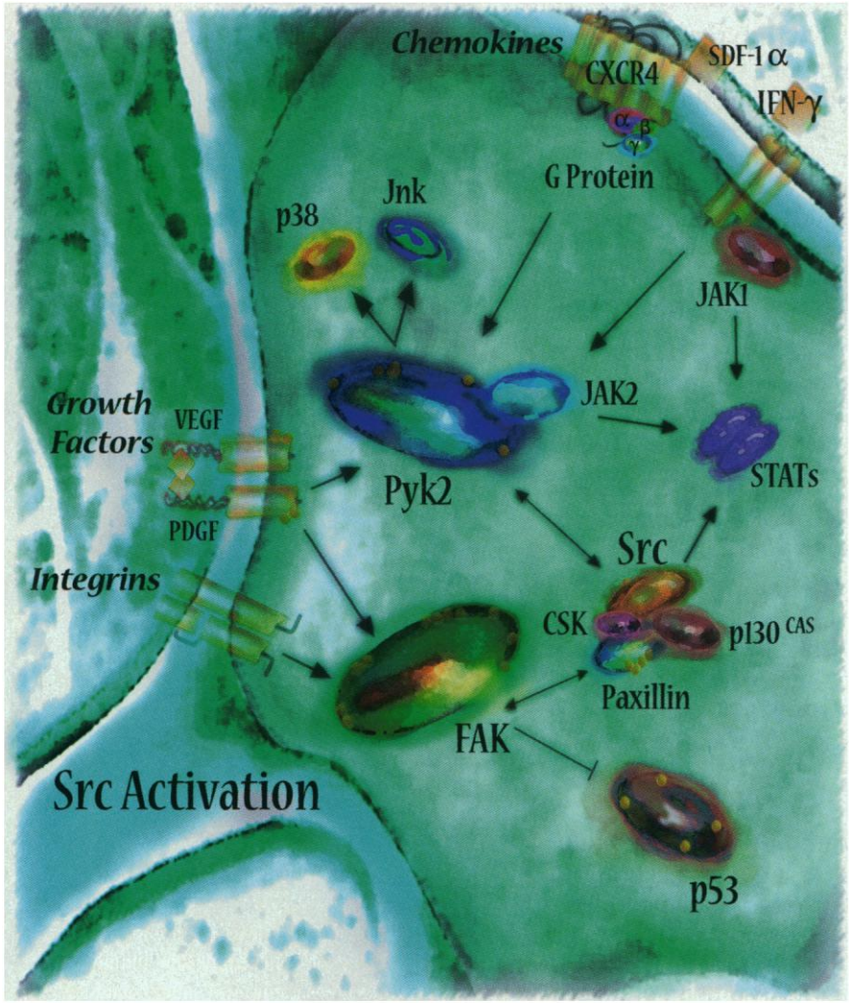
# The Power to Understand Src Activation




## Phosphorylation State-Specific Antibodies from BioSource

### Src [pY$^{215}$], Src [pY$^{418}$], Src [pY$^{529}$]

- Pre-adsorbed against non-phosphopeptide
- Affinity purified with target phosphopeptide
- Qualified in multiple cell lines
- Pan antibody available

Src amino acid numbering scheme is based on human isoforms.

**Also Available:**

FAK [pY$^{397}$], [pY$^{407}$], [pY$^{576}$], [pY$^{577}$], [pY$^{861}$], [pY$^{925}$]
Pyk2/CAKβ/FAK2 [pY$^{402}$], [pY$^{579}$], [pY$^{580}$], [pY$^{881}$]

***Sample sizes available.***

Figure 1

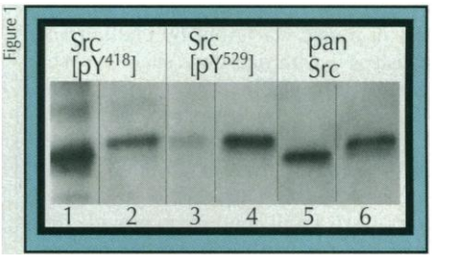



Figure 2

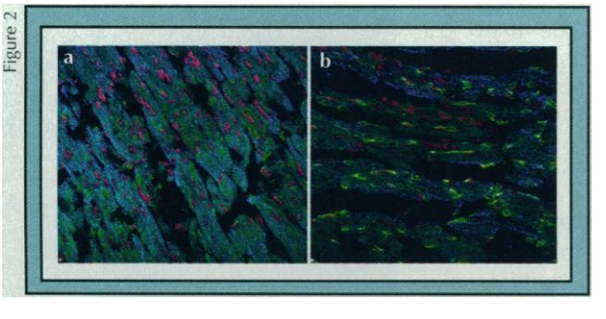
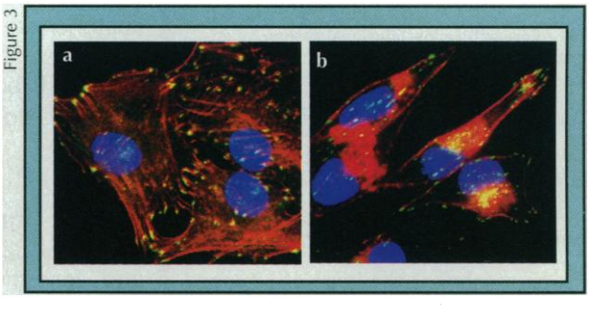



Figure 3




***Show me!*** ***Figure 1:*** *Western blot detection of Src phosphorylation in extracts of chick embryo fibroblasts expressing wild-type (lanes 2,4,6) or mutant (lanes 1,3,5) pp60src. Truncation of Src at position 518 eliminated phosphorylation at the negative regulatory site [pY$^{529}$], while increasing phosphorylation at the catalytic site [pY$^{418}$].* ***Figure 2:*** *Immunostaining of normal (a) and dilated cardiomyopathy (b) mouse tissue sections with anti-Src [pY$^{418}$]. Green=Src, Blue=actin, and Red=nuclei.* ***Figure 3:*** *Immunostaining of human melanoma cells (a) and melanoma cells expressing constitutively active Src (b) with anti-FAK [pY$^{397}$] and actin antibodies. Green=FAK [pY$^{397}$], Red=actin, Blue=nuclei, and Yellow=co-localization of FAK [pY$^{397}$] and actin (Note: Src staining images in progress). Figure 1 cell extracts provided by Dr. Mark Schaller, UNC. Figure 2 image courtesy of Dr. Mark Sussman, Children's Hospital Research Foundation, Cincinnati, OH. Figure 3 image courtesy of Drs. Ducko Ilic and Caroline Damsky, UCSF.*

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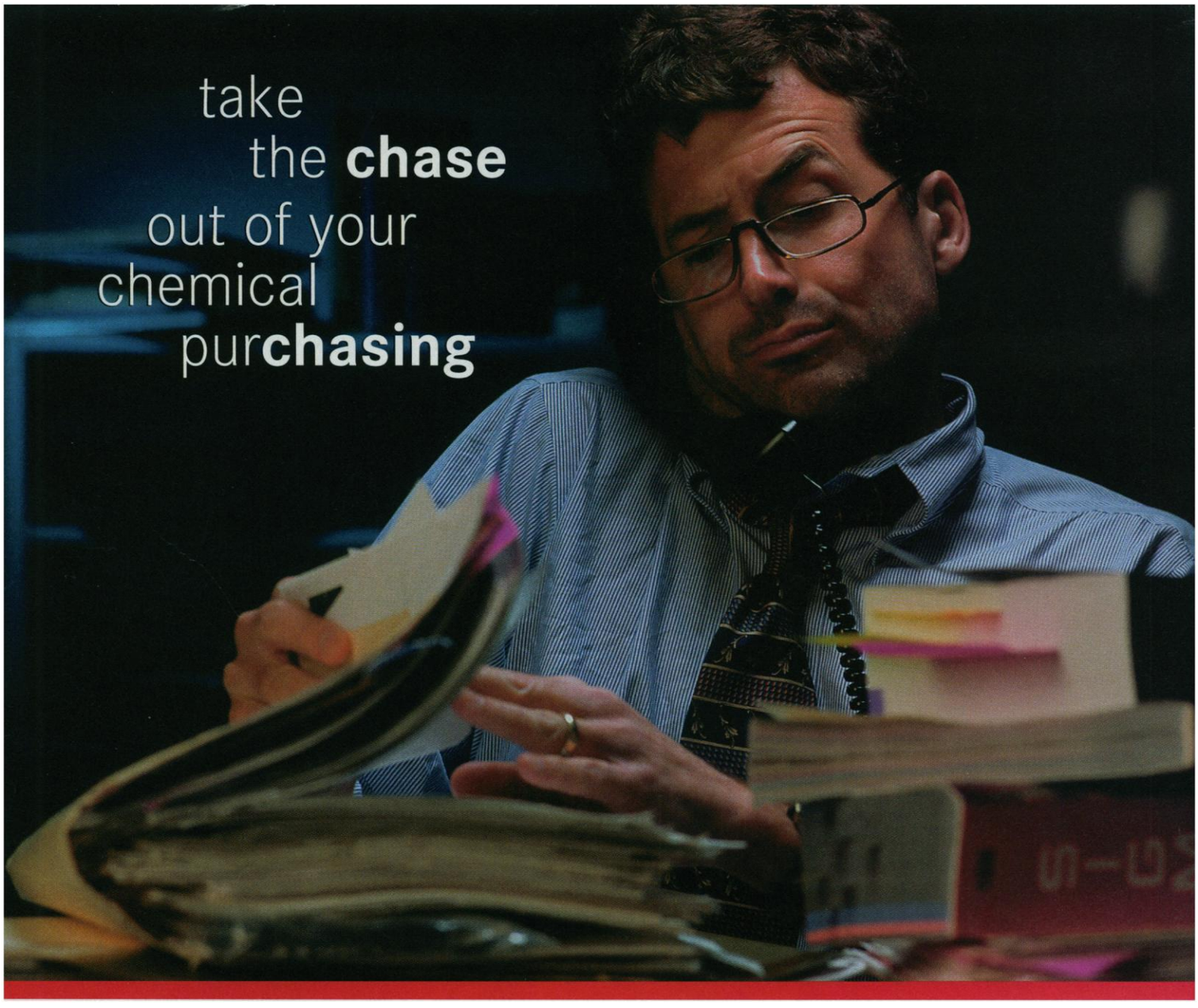


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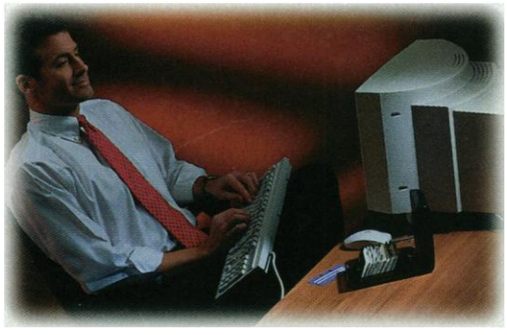

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