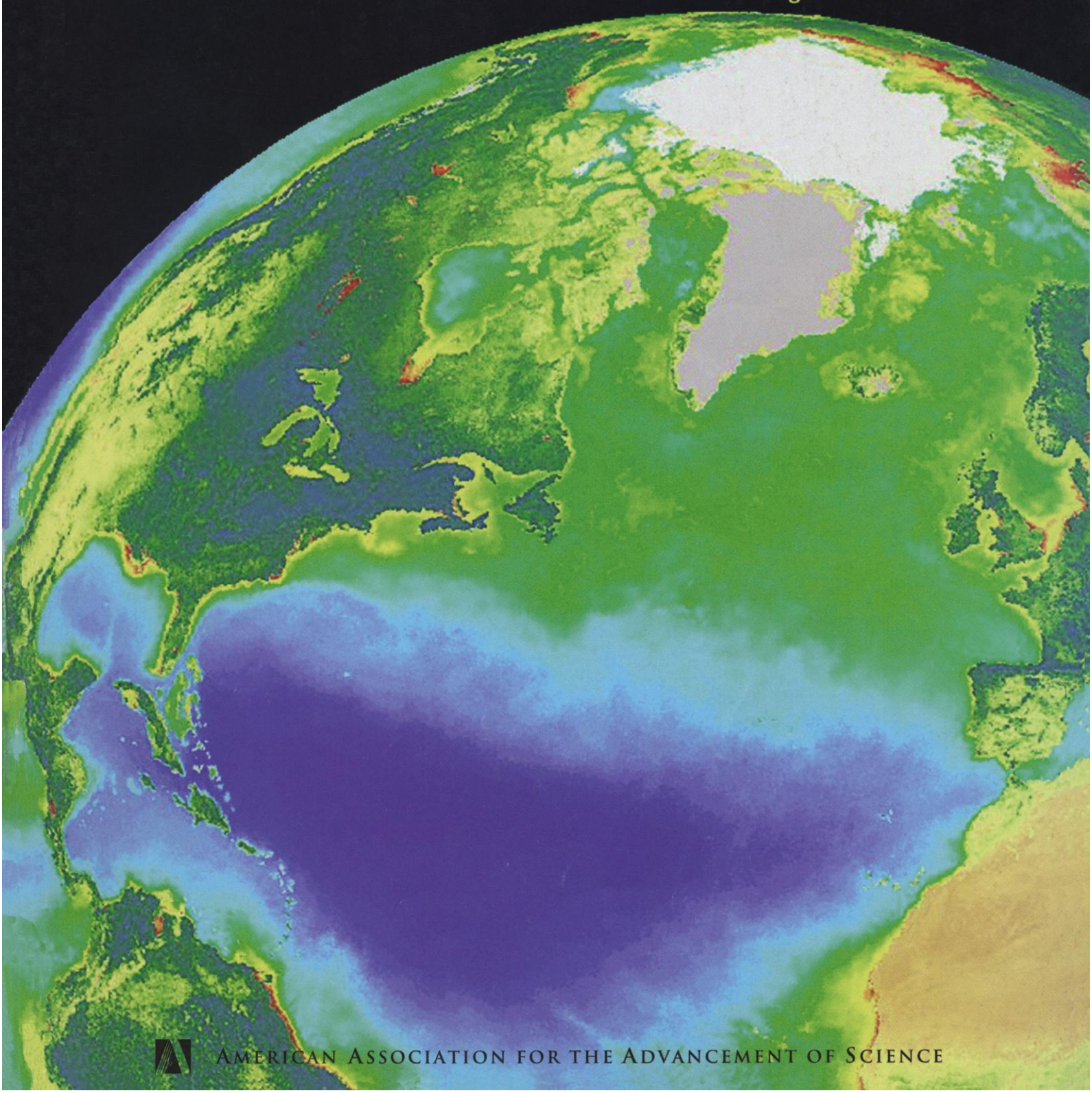
30 March 2001

Science

Vol. 291 No. 5513
Pages 2503–2658 $9



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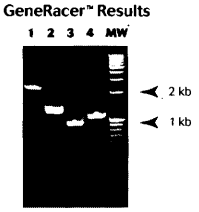

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Volume 291 30 March 2001 Number 5513

2536
Beyond fat

NEWS

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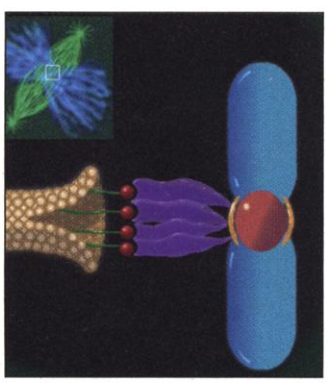
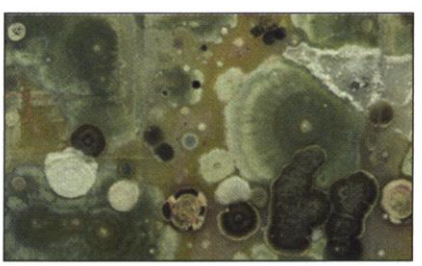


2555
Connecting microtubules to chromosomes



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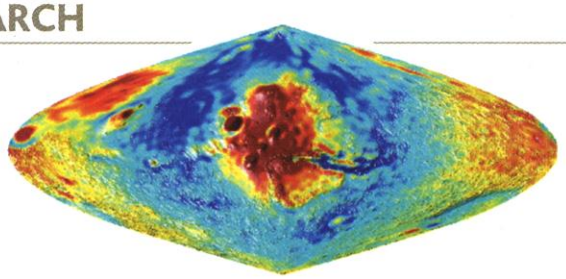
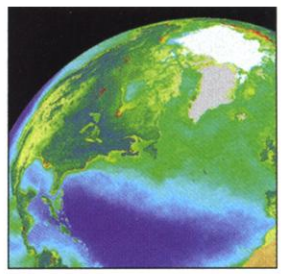
Microbiological beauty

RESEARCH



2587
Massive volcanism on Mars



COVER 2594

False-color image of plant life on Earth as observed from space with the Sea-viewing Wide Field-of-view Sensor (SeaWiFS). On land, greens indicate abundant vegetation, and tans show relatively sparse plant cover. In the oceans, blue areas are the least biologically productive, whereas green, yellow, and red areas represent progressively greater productivity. Since September 1997, SeaWiFS has measured light absorption by land plants and phytoplankton chlorophyll biomass in the oceans, providing a basis for quantifying biospheric photosynthesis. [Image: SeaWiFS Project, NASA/GSFC, and ORBIMAGE]

2603
Spider silk strength through sequence

The whole ribosome and more 2509

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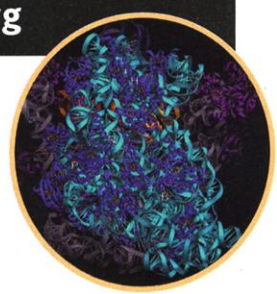

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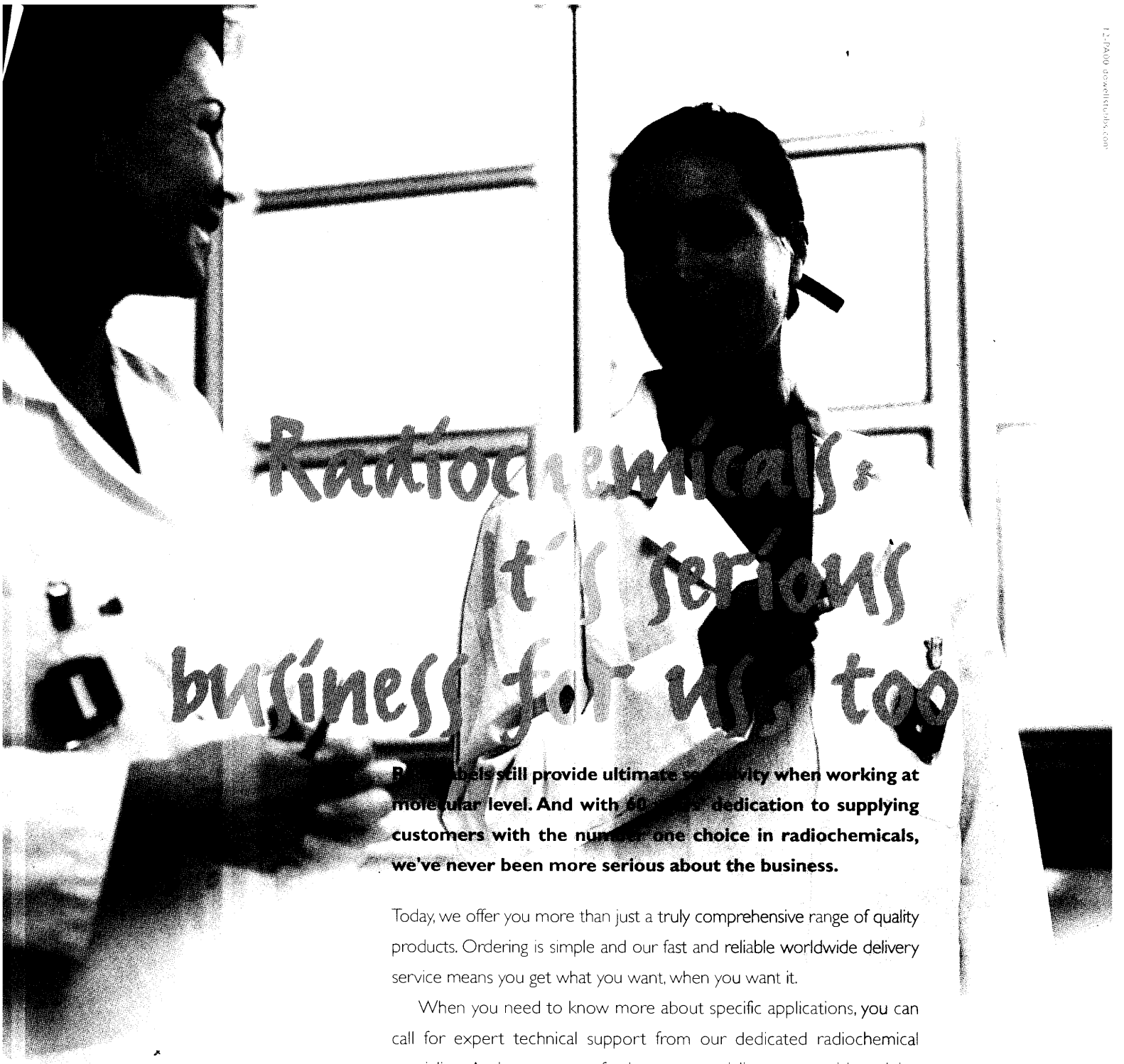

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Selective Bond Dissociation and Rearrangement with Optimally Tailored, Strong-Field Laser Pulses R. J. Levis, G. M. Menkir, H. Rabitz

Strong-field laser pulses can be optimized so that different bonds in a molecule can be selected and cleaved.

Crystal Structure of the Ribosome at 5.5 Å Resolution M. M. Yusupov *et al.*

2526 A view of how the whole ribosome binds three transfer RNAs and one messenger RNA.

^{14}C-Dead Living Biomass: Evidence for Microbial Assimilation of Ancient Organic Carbon During Shale Weathering S. T. Petsch, T. I. Eglinton, K. J. Edwards

The discovery of kerogen-eating microbes in a Devonian shale suggests that bacterial consumption of organically rich sediments may contribute significantly to weathering and the global carbon cycle.

Cooperation and Competition in the Evolution of ATP-Producing Pathways T. Pfeiffer, S. Schuster, S. Bonhoeffer

PERSPECTIVE: **The Advantages of Togetherness** E. Cox and J. Bonner

The evolution of ATP-producing pathways provides clues to the origins of multicellularity.

TECHNICAL COMMENTS

Subatomic Features in Atomic Force Microscopy Images

Using "a force-detection scheme with superior noise performance and enhanced sensitivity to short-range forces," Giessibl *et al.* (Reports, 21 July 2000, p. 422) reported that they could resolve subatomic features on a silicon surface with atomic force microscopy. Hug *et al.* comment that the frequency shift (Δf) at which the experiments were performed suggests that "more than 95% of Δf is due to long-range ... forces," at variance with the claim of an enhanced sensitivity to short-range forces. Hug *et al.* conclude that the structures observed by Giessibl *et al.* were actually due to feedback artifacts. Giessibl *et al.* respond that "both theoretical and experimental considerations argue against" a feedback explanation and present additional topography and error signal data that "show clearly that feedback tracking errors are negligible."

The full text of these comments can be seen at www.sciencemag.org/cgi/content/full/291/5513/2509a

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Meeting Report: Signal Transduction Pathways as Targets for Therapeutics N. R. Gough

Report on an STKE-hosted symposium at the 2001 AAAS Annual Meeting.

science's next wave www.nextwave.org

US: The Authorship Debates Editor: K. Cottingham

What grad students and postdocs should know about the vexing topic of authorship.

US: Grad Student Unionization—Dire Consequences Unmet? R. Tuma

Does unionization interfere with student-mentor relationships and lead to decreases in grad student admissions? The data are sketchy, but the answer seems to be no.

UK: How to Click with a Supervisor K. Urquhart

Findaphd.com is a new Web service that allows would-be Ph.D. students and postdocs to search online for suitable projects.

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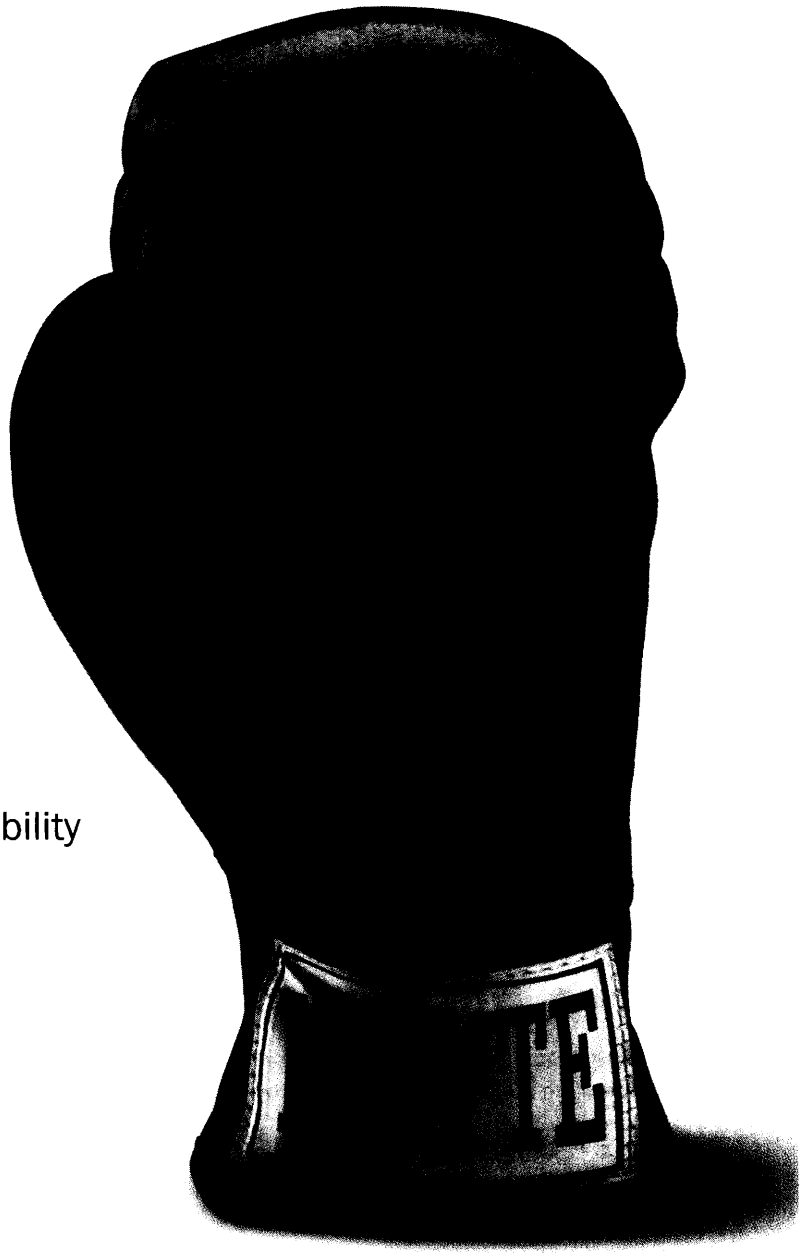

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THIS WEEK IN Science

edited by Phil Szuromi

Bosons Help Cool Fermi Gases

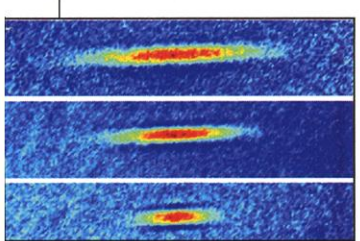
Evaporative cooling of an atom gas of bosons, whereby the hottest atoms are progressively removed, is an effective and widely used method for forming Bose-Einstein condensates. For Fermi gases, however, collisions between identical fermions are forbidden, and new tricks, such as mixing two Fermi gases with different spin states, have been used to form Fermi condensates. Truscott *et al.* (p. 2570; see the Perspective by O'Hara and Thomas) now create quantum-degenerate Bose and Fermi condensates simultaneously from a boson-fermion mixture. Heat is removed from the fermions through elastic collisions with the bosons, a process called sympathetic cooling. They show that different statistics associated with the two types of gases can actually be visualized.

2573 Magnetic Frustration

When a current is passed through a metal or semiconductor in the presence of a magnetic field, carriers deflected from their trajectory generate an electric field transverse to the direction of current flow that leads to the voltage drop known as the Hall effect. Measurements of this Hall effect for some magnetic materials—particularly spin-frustrated systems—have revealed an anomalous Hall effect in which the change in transport parameters are opposite to those found for normal materials. Taguchi *et al.* (p. 2573) combine experimental data from neutron scattering and transport measurements with theoretical work to suggest that geometrical (Berry phase) and spin-chirality effects are responsible for the anomaly.

Mapping Out Bond Formation

Several atomic force microscopy (AFM) studies have determined the force necessary to rupture a chemical bond. Lantz *et al.* (p. 2580; see the Perspective by de Lozanne) have used low-temperature, high-resolution AFM to map out the change in force versus distance for the formation of a chemical bond at a surface. Their atomic-resolution studies of the interaction of a single atom at the end of a silicon (Si) tip with different adsorption sites on the Si(111) 7×7 reconstructed surface allowed them to determine the change in short-range chemical force with distance from the surface.



SOURCE: M. A. LANTZ *ET AL.*

Tharsis Rise and Water Fall

The Tharsis rise on Mars is a region of thick crust and high topography related to voluminous volcanism and includes the largest volcano identified in our solar system, Olympus Mons. Phillips *et al.* (p. 2587) have produced a model of the effect of the localized mass load of the Tharsis rise on the global geoid and topography that is consistent with data from Mars Global Surveyor. Their results suggest that the Tharsis rise was formed between 4.0 to 3.6 billion years ago and that about half of the valley networks may be related to hydrologic processes. The release of CO_2 and water during this intense period of volcanism may have produced a wetter and warmer martian climate.

Signs of Hydration

The isotopic composition of oxygen in atmospheric CO_2 is determined largely by the interaction of CO_2 and liquid water in the ocean, in soils, and in the leaves of plants. Because of the role of leaf water, oxygen isotopes contain important information about the sources and sinks of atmospheric CO_2. Gillon and Yakir (p. 2584; see the Perspective by Woodward) show that variations in the activity of the enzyme carbonic anhydrase, which catalyzes the hydration of CO_2—and its equilibration with leaf water—in plants cause a wide range of CO_2 oxygen isotopic fractionation in different types of vegetation. This information could lead to better estimates of the relative contributions of C_3 and C_4 plants (defined by their use of the two major photosynthetic pathways) to global productivity.

Alignment Without the Rub

The application of liquid crystal (LC) materials to display technology is often limited by the ability to design and produce a substrate that can generate the desired surface alignment. Most techniques for generating substrates, such as rubbing, create rough textured surfaces that lead to defects in the orientation of the LC. Lee and Clark (p. 2576) have used smooth neighboring substrates that have different surface treatments to control the LC without any of the angular orientational degeneracies that usually accompany planar isotropic surfaces. Surface treatment was achieved by using self-assembled monolayers that were exposed selectively to ultraviolet light to alter their surface characteristics. More complex devices could be produced through microcontact printing.

First Glimpse from SeaWiFS

The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) has been orbiting Earth for 3 years, gathering data on global fluctuations in oceanic and land photosynthesis (net primary production, or NPP). This period included an El Niño–to–La Niña transition, and Behrenfeld *et al.* (p. 2594; see the cover) report that substantial increases in oceanic chlorophyll levels were observed that indicate a shift in nutrients available to phytoplankton. No corresponding increase was seen for land plants, but overall NPP from 1997 to 2000 was estimated to have increased by 4.5%.

Disrupted Schedules

A potential impact of global climate change is a shifting of seasonal changes. Thomas *et al.* (p. 2598; see the news story by Pennisi) expose the energetic and fitness costs that birds (in this case, blue tits in Corsica) incur when breeding is not perfectly synchronized with food availability in the local environment. Foraging costs increase as breeding becomes mismatched with food supply, which forces the parents to work beyond their sustainable

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CONTINUED ON PAGE 2513

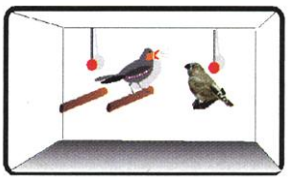
maximum metabolic rate and leads to low survival. These findings provide mechanistic detail for the selective forces acting on the timing of breeding in birds and have implications for the responses of birds to global climate change.

Mutating Mutators

When bacteria reach the gut of a new host, they must adapt rapidly to these new conditions. Giraud *et al.* (p. 2606) have analyzed the advantages and disadvantages of the ability of the ubiquitous gut commensal, *Escherichia coli*, to accelerate mutation rates while colonizing the guts of germ-free mice. Although mutator populations were established in a new mouse and became dominant more quickly than strains that do not have the potential to generate adaptive mutations so rapidly, in the long term, mutators lose their advantage because it is too risky to maintain a high mutation rate. Although only neutral or beneficial mutations will be selected in the gut, any of these may become disadvantageous when the bacteria are flushed out of the gut and are exposed to a different environment before finding a new host.

How Practice Makes Perfect

During a period of a few months, young songbirds listen to adult birds singing, begin to produce their own unpolished and fragmentary sounds, and gradually hone their skills until they, too, become master singers. How these skills are learned has been difficult to understand. Tchernichovski *et al.* (p. 2564; see the Perspective by Margoliash) have developed a training regimen in which they can record songs throughout the learning period. They then applied a sophisticated analysis that makes it possible to track from the final, polished song backward to the off-key and monosyllabic precursors. They find, for example, that when the target tone is slightly lower in pitch than the precursor, the young songbird increases the pitch of its note until an abrupt halving of the frequency puts it precisely on-key.



SOURCE: O. TCHERNICHOVSKI *ET AL.*

Fat-Burning Mice

Malonyl–coenzyme A is a key regulator of fatty acid metabolism in mammals and is generated by the action of two acetyl–coenzyme A carboxylases, ACC1 and ACC2. Abu-Elheiga *et al.* (p. 2613; see the Perspective by Ruderman and Flier) show that mice deficient in ACC2 are fertile and have a normal life-span but also exhibit a persistently elevated rate of fatty acid oxidation. The mice can consume normal amounts of food but store only half the amount of fat as wild-type mice. The identification of ACC2 as a potential therapeutic target for obesity may come as good news to those humans who wish to lose weight without modifying their diet or exercise habits.

Pathfinding Virus

The decision to begin eating requires the integration of a variety of motivational and metabolic signals emanating from distinct regions of the brain. DeFalco *et al.* (p. 2608) traced these neural pathways in a rodent model by creating a genetically modified herpes virus (that also encodes a green fluorescent protein) that replicated only in neurons that expressed a gene product of interest and in neurons making synaptic contact with the initially infected cells. They find that hypothalamic neurons expressing the leptin receptor or neuropeptide Y, two proteins known to be involved in the regulation of feeding, receive inputs from a number of different brain areas, including the amygdala, cortex, and other regions of the hypothalamus.

Neighborhood Conflicts

Development and conservation are often competing goals. Balmford *et al.* (p. 2616; see the news story by Vogel) have looked at this competition in detail. They show that scattered reports of a link between human settlement and areas of high conservation value are supported for an entire continent (Africa); across 1° grid squares, species richness in four vertebrate groups is positively correlated with human density. This relation is intimately associated with primary productivity. The scope to avoid conservation conflicts is therefore limited because many high-density grid squares contain species that are found nowhere else. Hence, the pervasive conflicts between conservation and development are unlikely to be easily side-stepped.

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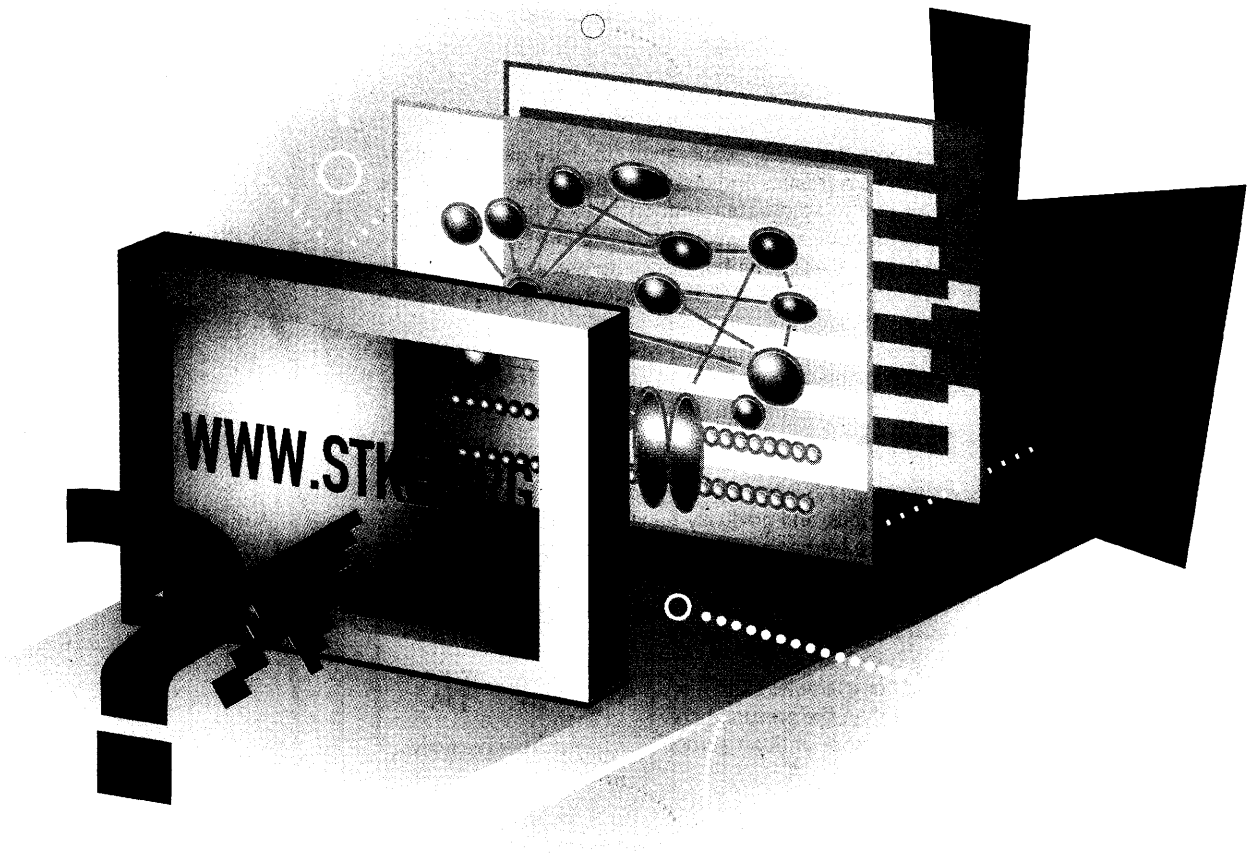

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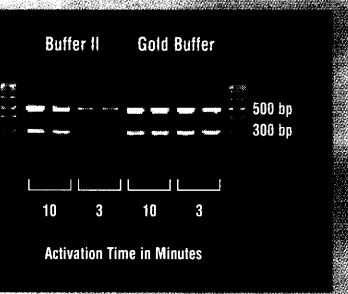

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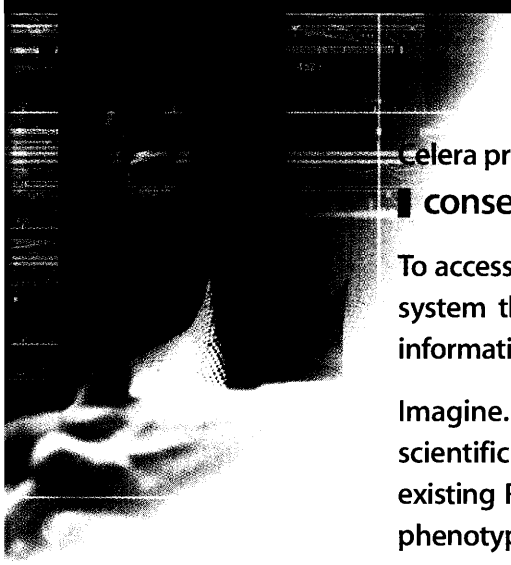

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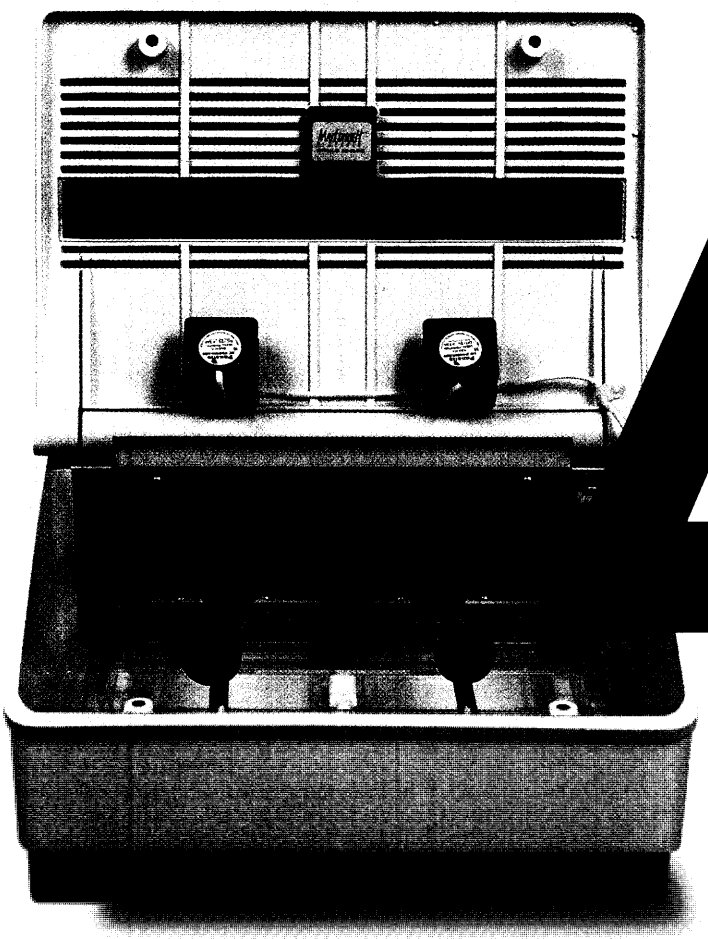

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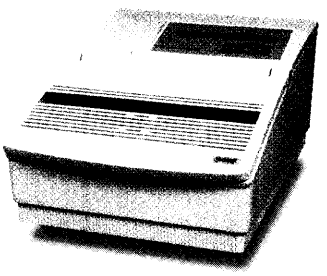

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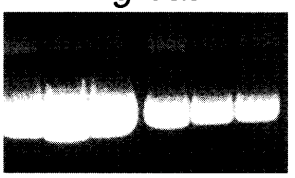

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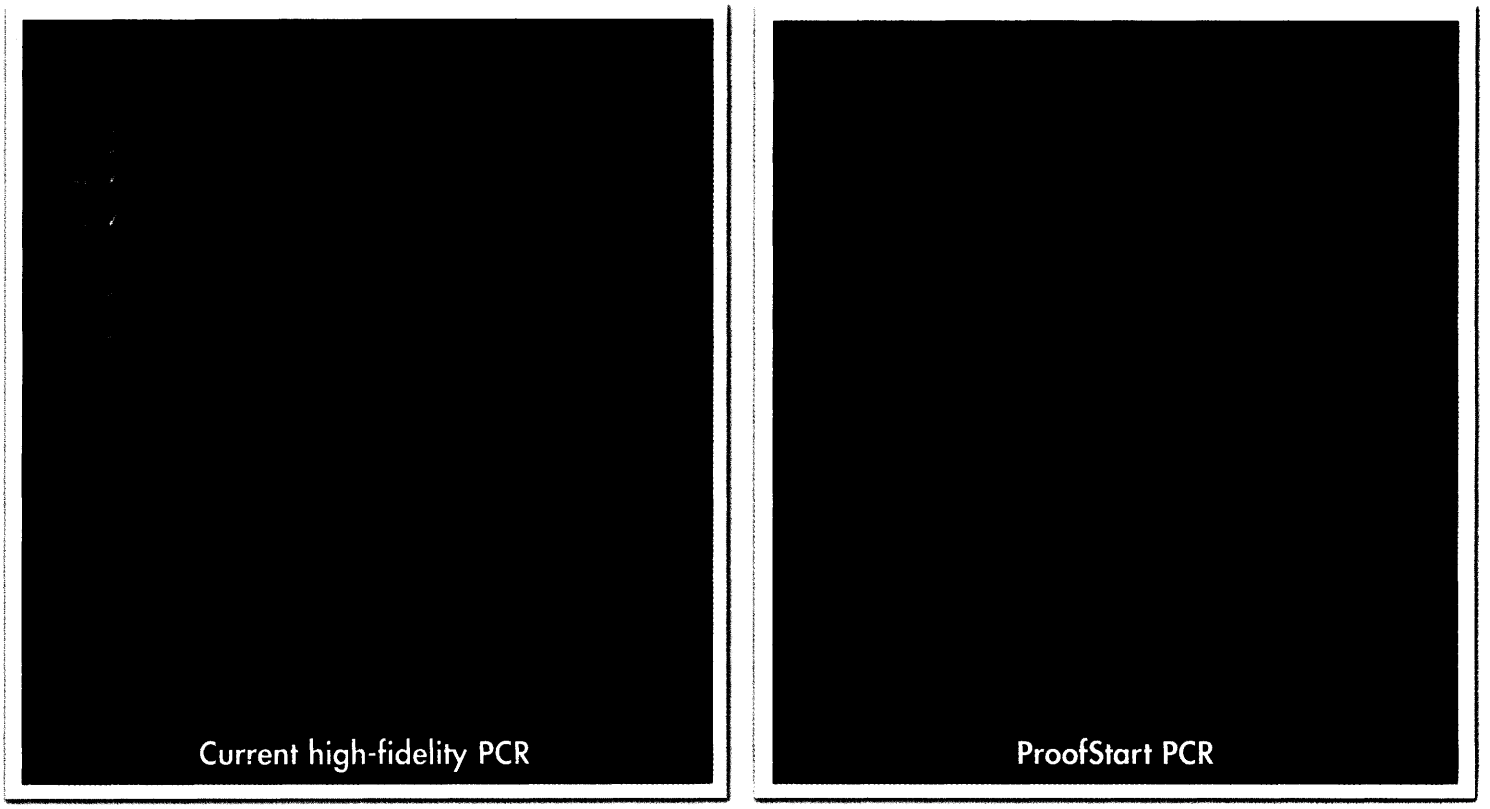

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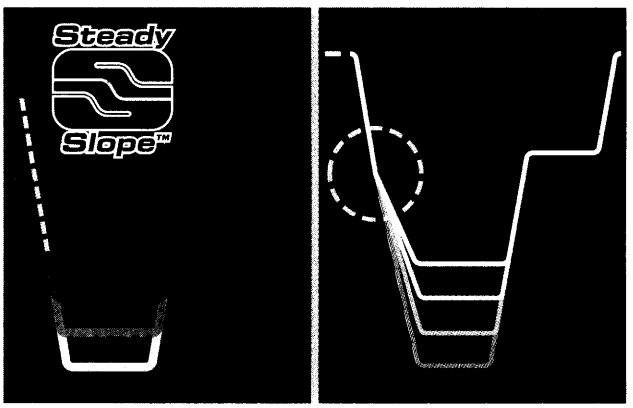

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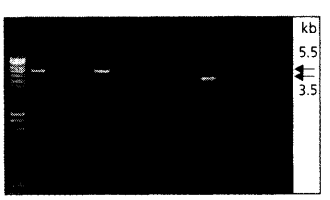
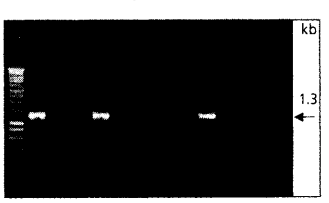


Parallel screen using the 5' vector-derived primer and a gene-specific reverse primer to determine extent of 5'- end sequence.



Alternate screen using the 3' vector-derived primer and a gene-specific forward primer to determine extent of 3' sequence

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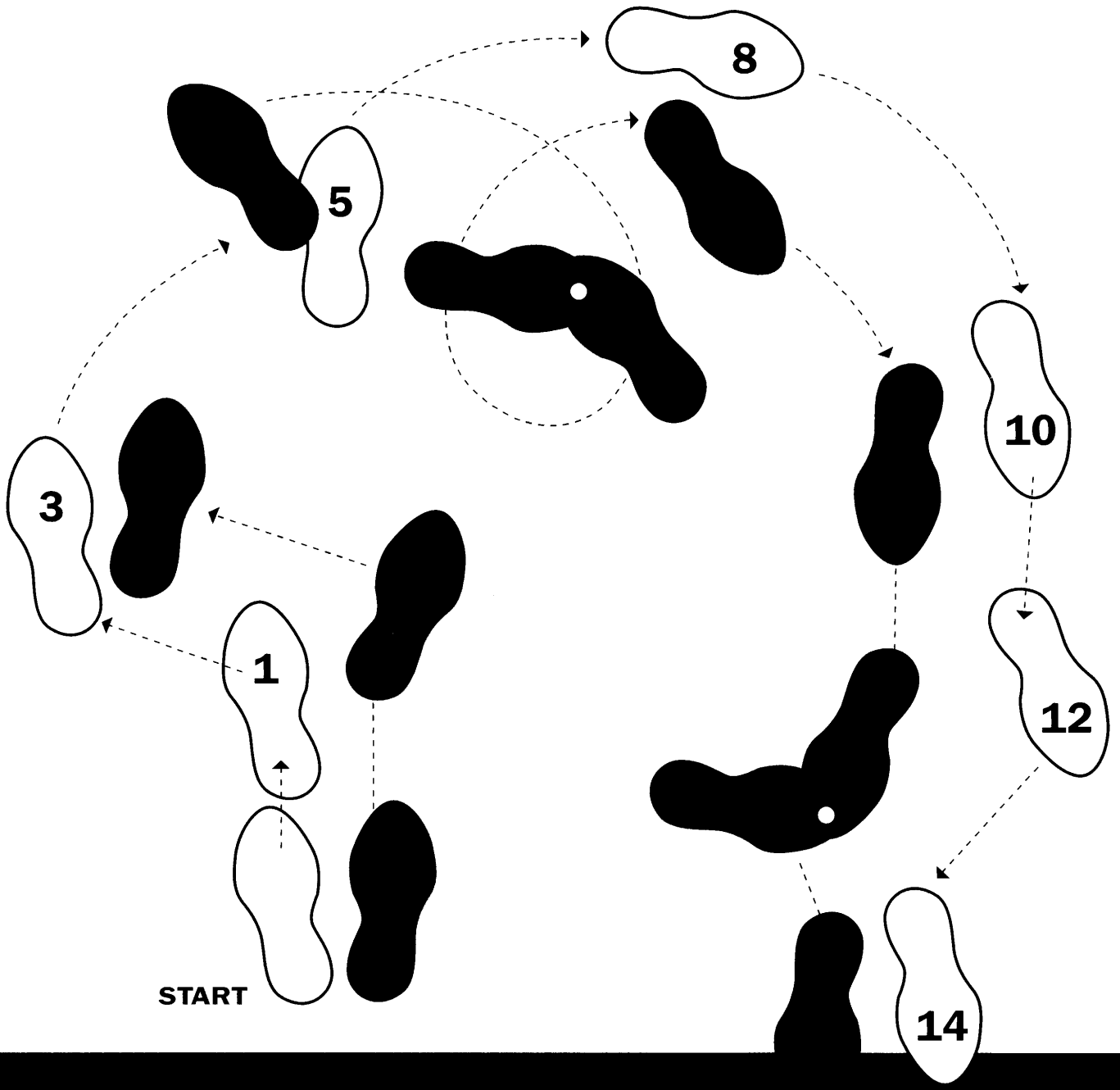

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Nuclear magnetic resonance (NMR) spectroscopy is a powerful tool for determining the three-dimensional (3D) structures of biological macromolecules. Recent successes in genomics, together with technical advances in structural biology, have allowed for significant advances in the field of structural genomics. In the rapid screening of folded material, for example, NMR plays a major role in both the structure determination of difficult to crystallize targets and the ratification of sequence homology models. Recent developments in NMR spectroscopy are amenable to rapid analysis by advanced computer software, making it a method of choice for high-throughput screening and therapeutic design.

The first step in the NMR 3D structure determination is the assignment of all the chemical shifts of the macromolecule of interest. For this, even an experienced researcher requires a versatile software package that permits simultaneous analysis of several multidimensional heteronuclear spectra. FELIX is a software product containing built-in data processing macros and import filters, which process data acquired from any major NMR spectrometer. The package incorporates several options for baseline correction and solvent suppression, and it contains a powerful macro language that enables flexibility in processing data and ready implementation of NMR methodological advances.

FELIX can provide numerous views of NMR spectra. Contour plots of planes and 1D vector extraction from any 2D, 3D, or 4D spectra are also available. Peaks can be picked automatically, pruned interactively, and transferred between datasets. Although the software provides semi-automatic assignment of chemical shifts, it also has a fully automatic option for NMR spectral assignments relative to biological macromolecules. These include spin-system detection and identification. A broad range of NMR spectra could be analyzed this way, homonuclear 2D to heteronuclear 3D spectra for example, but substantial manual input is necessary to ensure a reliable result. Identification, tabulation, and interpretation of the nuclear Overhauser effect (NOE) by the software provides distance measurements essential for the final structure determination.

The approach used by FELIX is well refined and highly appropriate for a productive biological NMR laboratory. The program is expensive, particularly for an academic environment, but the software provides a comprehensive solution for the NMR structural biologists, from the processing of raw NMR data to chemical shift assignment and structure calculation. Although FELIX provides a practicable approach, good quality and less costly alternatives do exist.

—Stephen Matthews

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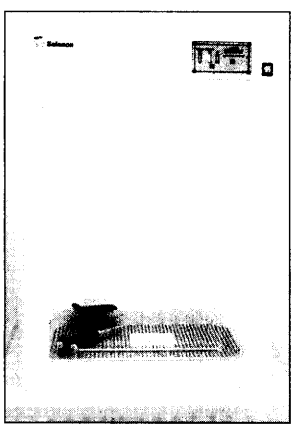
The Gene Spec III spectrophotometer allows for greater sensitivity and precision than conventional spectrophotometers, while analyzing samples as small as one microliter within 8 s. The instrument scans and quantifies DNA/RNA and protein samples. It has specialized software for DNA/RNA measurement that measures absorbance, 260/280 nm ratio, concentration, and purity. Other capabilities include wavelength scanning, time scans, and quantitation. In as little as 8 s, it measures and displays samples and their results in a complete spectrum from 190 nm to 1100 nm. The 1024-element photodiode array technology allows for greater sensitivity, precision, and faster scanning than most spectrophotometers. Operations are controlled through a personal computer, allowing upgrades of the accompanying software and secondary processing of spectra.

Astec Microflow

For more information call 800-DUCTLESS or **circle 141** on the Reader Service Card
www.ductless.com

PCR WORKSTATION

The AirScience economy polymerase chain reaction (PCR) sterile-air unit offers all polypropylene construction, electronic airflow monitoring, and a reinforced glass sliding sash. It has dual electronically controlled ultraviolet lights with automatic shutoff in addition to twin fluorescent lights. The compact 23.5-inch by 23.5-inch footprint saves valuable bench space. Two integrated decontamination shelves and a stainless or polypropylene work surface complete the interior. The compact workstation offers Class 100 laminar flow high-efficiency particulate air filtration to 99.999%. It doubles as a vertical laminar flow workstation and can be used for metals analysis.



CLONTECH

For more information call 800-662-2566 or **circle 142** on the Reader Service Card
www.clontech.com

AUTOMATED DNA PURIFICATION

The TECAN Genesis RSP Robot is a fully automated purification system that can process 96 samples in just 75 min. Once the purification procedure is started, no manual interaction is required. The robot is equipped with an eight-channel liquid-handling device, a vacuum filtration unit, and an arm tool that reassembles the vacuum manifold during purification. The basic purification process can be integrated with additional devices such as a plate reader or thermocycler, making the robot suitable for automating applications such as polymerase chain reaction.

Pierce Chemical

For more information call 800-874-3723 or **circle 143** on the Reader Service Card
www.piercenet.com

PEROXIDASE SUBSTRATE

FluoroBlot Peroxidase Substrate is a nonphotobleaching, chemifluorescent substrate for the detection of peroxidase in blotting applications that is more stable than typical alkaline phosphatase chemifluorescent substrates. Like enhanced chemiluminescence, it allows for sensitive, subfemtogram detection. FluoroBlot gives high signal-to-noise ratios and allows for a broad, 5-log dynamic detection range of peroxidase activity. It can detect less than 1 pg of horseradish peroxidase in a dot blot and

has been shown to detect subfemtogram levels of a target protein in a protein immunoblot. Similarly strong results have also been obtained with Northern and Southern blotting applications.

Nanonics Imaging
For more information call
+972-2-678-9573 or
circle 144
on the Reader Service Card
www.nanonics.co.il

LIQUID CELL FOR CONFOCAL MICROSCOPE

A new liquid cell, when used with the Nanonics NSOM/AFM 100 Confocal Microscope, allows high power objectives to be placed above and below the aperture in the center of the microscope system. The liquid cell consists of a bath, in which the sample sits, and a tip mount, which is suitable for either Nanonics cantilevered optical fibers or standard atomic force microscopy silicon cantilevers. It has a clear optical axis. It permits all forms of AFM, including contact, noncontact, and intermittent contact in a liquid environment. The ability to keep the optical axis free from the top and the bottom of the liquid cell comes from patented cantilevered near-field optical elements and the optics of the NSOM/AFM 100 Confocal System.

Epicentre
For more information call
800-284-8474 or
circle 145
on the Reader Service Card
www.epicentre.com

MICROBIAL GENETIC ANALYSIS

The EZ::TN Transposome Kits are a fast, easy, and reliable method to create gene "knockouts" in microorganisms and to facilitate microbial genetic analysis. The Transposome can be electroporated into a living cell, where it randomly inserts its transposon into the host's genomic DNA to create gene "knockouts" and phenotype changes. Then, it is possible to sequence up to 1000 bases surrounding the transposon insertion site, without cloning, using primers provided in the kits that are homologous to the ends of the inserted transposon.

Columbus Instruments
For more information call
614-276-0861 or
circle 146
on the Reader Service Card
www.colinst.com

METABOLIC CAGES

New Metabolic Cages enable measurement of urine excretion, food and liquid consumption, animal activity, and VO_2/VCO_2. To allow animal exercise, an optional exercise wheel can be installed. Cages are available in sizes for rats and mice. Urine is collected through a special channel that directs the urine droplets to a container on a precision scale. Food consumption is measured through special feeders that feature a narrow tunnel that minimizes food spillage. The food cup rests on a precision scale that communicates with the computer. Animal activity is measured by a system of infrared beams. Oxygen consumption and carbon dioxide production are measured by an Oxymax metabolic computer, which periodically samples the air from the animal cages. Up to 16 cages can be combined into a Comprehensive Lab Monitoring System, with all data collected by a Pentium computer.

Promega
For more information call
800-356-9526 or
circle 147
on the Reader Service Card
www.promega.com

IN VITRO TRANSLATION LABELING SYSTEM

The FluoroTect Green$_{Lys}$ in vitro translation labeling system allows for the fluorescent labeling and detection of proteins synthesized in vitro. The system is based on a lysine-charged tRNA that is labeled at the epsilon position of the lysine with a fluorophore.

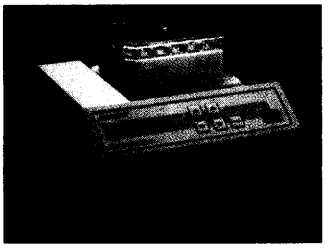
CONTINUED ON PAGE 2622

Fluorescent lysine residues are incorporated into synthesized proteins during in vitro translations reaction, eliminating the need for radioactivity. There is no requirement to transfer, fix, or dry gels.

Eppendorf
For more information call (040) 5 38 01-239 or **circle 148** on the Reader Service Card
www.eppendorf.com

BENCHTOP THERMOSTAT

The ThermoStat plus provides temperature control of all commonly used lab tubes. This compact, benchtop thermostat with Peltier technology can precisely maintain temperature levels up to 99°C, with a cooling facility for temperatures as low as −5°C. The autoclavable, exchangeable thermoblocks for 24 × 0.2-ml, 0.5-ml, 1.5-ml, or 2.0-ml tubes as well as for microtiter plates and deep-well plates provide a high degree of flexibility. A thermoblock is available for vials and beakers as tall as 60 mm. Up to four temperature levels and four time phases can be run through automatically in immediate succession.



InnoGenex
For more information call 925-543-1400 or **circle 149** on the Reader Service Card
www.innogenex.com

KITS FOR IMMUNOFLUORESCENT STAINING

New ready-to-use immunofluorescence kits offer efficient and sensitive fluorescence detection of antibodies for immunohistochemical staining of cells and tissues. Through the use of enhanced biotin-streptavidin detection technology that delivers high signal-to-noise results, the new kits provide high-resolution fluorescence staining of paraffin sections, cryostat sections, cell monolayers, and whole mounts. A choice of four streptavidin-conjugated fluorescent dyes is available: phycoerythrin (absorption 475 to 575 nm, emission peak 580 nm); FluorBlue (absorption 350 nm, emission peak 442 nm); FluorGreen (absorption 488 nm, emission peak 524 nm); and FluorRed (absorption 519 nm, emission peak 617 to 630 nm). A wide selection of biotinylated secondary antibodies is also offered, permitting the use of mouse, rabbit, rat, or goat primary antibodies.

Physitemp
For more information call 800-452-8510 or **circle 150** on the Reader Service Card
www.physitemp.com

LITERATURE

Physitemp: Precision Temperature Specialists is a 36-page catalog detailing a complete line of high-quality electronic thermometers, microprobes, and related accessories. A temperature measurement system using Physitemp thermocouple monitors and probes includes the advantages of adaptability to most situations, accuracy traceable to National Institute of Standards and Technology standards, tiny probes when required, fast response, high stability, interchangeability, and wide temperature range.

Newly offered instrumentation, apparatus, and laboratory materials of interest to researchers in all disciplines in academic, industrial, and government organizations are featured in this space. Emphasis is given to purpose, chief characteristics, and availability of products and materials. Endorsement by *Science* or AAAS of any products or materials mentioned is not implied. Additional information may be obtained from the manufacturers or suppliers named by circling the appropriate number on the Reader Service Card and placing it in a mailbox. U.S. postage is free.