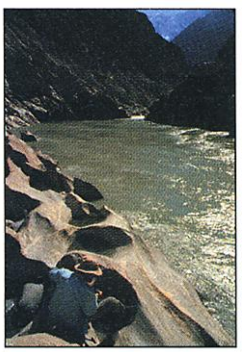
EDITORS' CHOICE

edited by Gilbert Chin

GEOLOGY

A River Runs Over It

Many waterfalls are located where a river runs over hard rocks, and large-scale geologic features such as faults influence the courses of many rivers. But how important are small-scale features in the bedrock in controlling how erosion occurs?



Potholes in Indus bedrock

Whipple *et al.* examined this question, which is central in understanding how landscapes evolve, in a variety of river settings. Where there were many cracks in the bedrock, erosion occurred mostly by movement of the bedload: small clasts and pebbles became lodged in cracks and were then jostled or knocked, plucking out joint blocks from the bed. In massive rocks, erosion was produced mostly by abrasion from sand suspended in the flow, not by particles bouncing or sliding along the river bed. A surprising suggestion is that cavitation, the formation and collapse of bubbles in the flow, may contribute by loosening grains in rocks and by initiating the formation of potholes in massive rocks. — BH

Geol. Soc. Am. Bull. **112**, 490 (2000).

PHYSICS

Engineered Quantum Entanglement

Entanglement of two or more quantum objects is a process whereby the quantum mechanical wavefunctions describing these individual objects are manipulated to create a new, interwoven state comprising a superposition of the individual wavefunctions. In this entangled system, all of the objects are correlated, and measuring the state of just one of them gives information on all of the others. Such a property is useful both for probing fundamental questions in quantum mechanics and for developing quantum computers. As the number of objects entangled increases, the superposed state becomes more complex, but exponentially more powerful.

Although entangled pairs and triplets have been demonstrated previously, the entanglement of larger systems has remained elusive. Sackett *et al.* have implemented a technique that, in principle, allows the controlled entanglement of many objects, and demonstrate four-particle entanglement—what, in essence, is a four-quantum-bit logic gate. Laser-cooling and optical pumping are used to position four beryllium ions in a line with all of them initially in the same spin-down state (the ground state). With illumination from a single laser pulse, the frequency and duration of which is selected carefully to minimize occupation of the intermediate states of mixed spin, all four ions are converted coherently to the spin-up state (the entangled state). Because there is a finite probability that the intermediate states are occupied and because of decoherence in the system when the spin information is lost, the scaling of this approach presently is limited to four particles, but these results illustrate the power of a technique that in the future may deliver many-body entanglement on demand. — ISO

Nature **404**, 256 (2000).

PHYSIOLOGY

It's a Bird, It's a Plane, It's Trouble

The remarkable ability of birds to navigate accurately over thousands of kilometers demands both a sense of location (map sense) and of direction (compass sense). The primary contributors to directional flight are sun and magnetic compasses. From an analysis of four homing pigeon races in the eastern United States and western Europe, Hagstrum resurrects an earlier proposal that atmospheric infrasound (low-frequency sound waves) may provide map cues. In all four cases, an unfortunate juxtaposition of the Concorde's shock wave and the racecourses appears to have led to catastrophic losses of birds. He suggests that these shock waves obliterated the infrasonic cues supplied by the microseisms that are produced continuously by oceanic waves. — GJC

J. Exp. Biol. **203**, 1103 (2000).

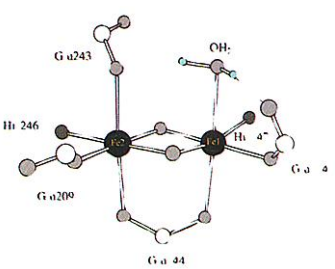
EVOLUTION

An Archaeal Signature

Genome sequencing continues to provide tantalizing new perspectives on the phylogenetic relationships between organisms. The great advantage of genome sequencing over other methods is that it removes the subjectivity of reliance on particular phenotypic characters or molecular sequences when trying to classify organisms. The disadvantage, of course, is that it is much more expensive and time-consuming, but judicious genomic sampling of the Tree of Life is beginning to provide hard data about the true differences and relationships between higher-order taxa such as kingdoms and phyla.

CHEMISTRY

Calculating Structures



Structure of Q

Methane monooxygenase hydroxylase is a dinuclear iron-containing enzyme that converts methane and dioxygen into methanol and water. The structures of the oxidized and reduced enzymes have been determined by x-ray crystallography, but detailed structural information is lacking for intermediates in the catalytic cycle. Dunietz *et al.* have performed ab initio calculations of this system using density functional theory. At 100 atoms, their model is significantly larger and more complex than previous ab initio studies of this and other transition metal-containing enzymes. On the basis of their model, the authors proceed to ascribe an unassigned electron density to a structurally important water molecule in the x-ray structure of the reduced enzyme. Their structures of the two key catalytic intermediates, H_{peroxo} and Q, differ from models previously proposed in the literature, but can be reconciled with existing experimental data. Hydrogen bonds involving water molecules are critical elements in both intermediates, and the hydrogen bonding network surrounding the active site serves to constrain the diiron and ligand geometries. More extensive calculations with a larger number of atoms may help to define the pathways between these intermediates. — JU

J. Am. Chem. Soc., in press

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SOURCE: (RIGHT) DUNIETZ *ET AL. J. AM. CHEM. SOC.* **122**, 2828–2839(2000); (LEFT) R. S. ANDERSON.

Graham *et al.* use four completed archaean genome sequences to define a genomic 'signature' for the Archaea, formerly grouped with the Bacteria as 'prokaryotes.' They identify 351 clusters of proteins, or some 15% of the total number of archaean proteins, that are unique to the Archaea. This result sets the stage for an objective assessment of the relationship of the Archaea to other groups, notably Bacteria and Eukarya, and promises much for the understanding of the evolution of genes and proteins. — AMS

Proc. Natl. Acad. Sci. U.S.A., in press.

NEUROSCIENCE

Pathogenic Tangles

One of the hallmarks of Alzheimer's disease (AD) is the accumulation of intracellular neurofibrillary tangles in the brain. These fibrils contain phosphorylated forms of tau, a protein that normally binds to microtubules but, when hyperphosphorylated, detaches and aggregates. Ahlijanian *et al.* observe pathologic argyrophilic neurons, indicative of altered tau protein, in transgenic mice expressing human p25, the soluble activator domain of a membrane-bound protein called p35. Also, the cytologic abnormalities in the amygdala of the transgenic mice and the regional profile of p25 expression correlated with diminished anxiety in behavioral tests, reflective of compromised amygdala function. Previously, Patrick *et al.* have connected high levels of p25 in brain tissue from AD patients with elevated activity of Cdk5, a cell-cycle protein kinase known to phosphorylate tau. Thus, the constitutive stimulation of Cdk5 by inappropriately generated p25 may be an important trigger in the development of AD. — PAK

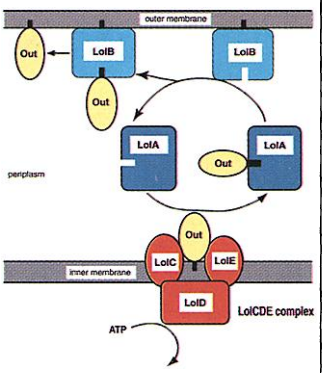
Silver-stained neurons

Proc. Natl. Acad. Sci. U.S.A. **97**, 2910 (2000); *Nature* **402**, 615 (1999).

MICROBIOLOGY

Lipoprotein ABCs

The ATP-binding cassette (ABC) proteins are a family of membrane transporters responsible for pumping drugs and other molecules across cellular membranes. Yakushi *et al.* have discovered and functionally reconstituted in proteoliposomes an ABC protein that acts in a radically different fashion—to promote the release of lipoproteins from bacterial membranes during lipoprotein transfer from the inner to the outer membrane of gram negative bacteria. The new ABC protein complex, LolCDE, is found in the *Escherichia coli* inner membrane. After translocation across the inner membrane, lipoproteins (Out) bind to LolCDE and then are transferred to the periplasmic chaperone LolA in a step that requires ATP hydrolysis. Next, LolA carries this cargo to the lipoprotein receptor LolB, and the journey ends with incorporation of the lipoprotein into the outer membrane. This specialized machinery may be particularly important in gram negative bacteria due to the large number of outer membrane lipoproteins, which do not contain any of the classical membrane targeting or anchoring signals. — SMH



Ferrying an outermembrane lipoprotein to its destination

Nature Cell Biol. **2**, 212 (2000).

Science's stke

Sensing Cold and Changing Coats

Poikilothermic organisms sense and adapt to changes in ambient temperature. The cyanobacteria *Synechocystis* responds to a decrease in membrane fluidity (indicating a drop in temperature) by expressing enzymes that increase the degree of unsaturation of membrane lipids. Suzuki *et al.* performed systematic mutagenesis of *Synechocystis* to identify the components of the signal transduction pathway linking these events; two histidine kinase genes, *hik19* and *hik33*, were identified along with a third gene, *rer1*. Based on genetic interactions and sequence analysis, the authors propose a signal transduction mechanism in which Hik33 is the cold sensor in the plasma membrane, Hik19 transduces the signal, and Rer1 is one of several targets that can regulate transcription of cold-sensitive genes. — NG

EMBO J. **19**, 1327 (2000).

CREDITS: (LEFT) AHLIJANIAN *ET AL. PNAS* **97**, 2910–2915; (RIGHT) YAKUSHI *ET AL. NATURE CELL BIOL.* **2**, 212 (2000).