EDITED BY GILBERT CHIN AND JAKE YESTON

GEOLOGY

Very Slow Growth

Gypsum [$Ca(SO_4)\cdot 2H_2O$] forms some of the largest natural single crystals on Earth (aside from the speculative iron crystals in the inner core), in some cases reaching 10 m in length. The growth of such sizable crystals requires precise maintenance of specific environmental conditions.

García-Ruiz *et al.* have investigated the giant gypsum crystals in deep caves of the Naica mine in Mexico, which has been the source of several museum specimens. Analyses of fluid inclusions, trapped sequentially in the crystals as they grew in caverns nearly 300 m below the surface, show that the temperature in the large fluid-filled caves was maintained near 54°C for thousands of years at least—the mineralization in the mine began about 25 million years ago—and the deep water there is still close to this temperature today. This temperature is just below the maximal solubility point for gypsum in low-salinity water and also slightly below the thermodynamic stability range of anhydrite (a polymorph of gypsum), which had formed previously. Thus, the dissolution of anhydrite maintained a slight supersaturation of gypsum in the fluid, and a temperature close to the equilibrium allowed the formation of only a few crystal nuclei in the deep large cavities. Shallower, cooler cavities have produced multiple smaller crystals. — BH

Geology **35**, 327 (2007).

Gypsum megacrystals.

APPLIED PHYSICS

A Peek Inside

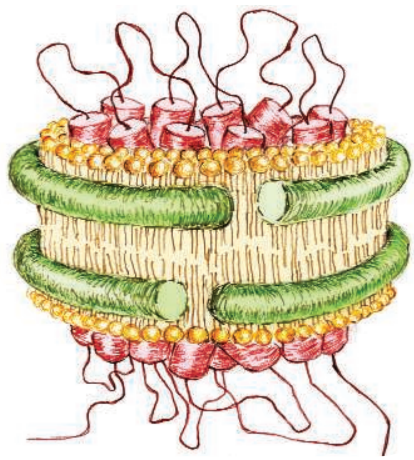
The semiconductor industry routinely fabricates device structures with feature sizes smaller than 100 nm. With millions of components crowded onto each chip and complex circuitry arrayed in three dimensions, methods to test the structures for defects— preferably nondestructively and with high throughput—become challenging. Techniques for imaging the subsurface structures tend to face a tradeoff between resolution and contrast. The probe light must have a relatively long wavelength (usually in the infrared) in order to penetrate through several millimeters of silicon in the wafer and be absorbed by the active layers of the device; however, this wavelength requirement has generally restricted lateral resolution. Ramsay *et al.* combine immersion lens imaging with two-photon absorption microscopy to improve both the lateral resolution and the absorption contrast, thereby providing a technique for the high-resolution three-dimensional imaging of the subsurface structures in silicon chip circuitry. — ISO

Appl. Phys. Lett. **90**, 131101 (2007).

BIOCHEMISTRY

A Nanomembrane

The technical difficulties of working with membrane proteins, which sport extensive hydrophobic and hydrophilic surfaces (not to mention a heterogeneous collection of attached sugars), are matched only by the ease with which cells manage to handle them. In bacteria, the trimeric complex SecYEG accepts substrate proteins made in the cytoplasm and either passes them through the inner membrane to the periplasmic space or ejects them laterally straight into the inner membrane itself (how outer membrane proteins are dealt with is a whole other story). Some of the substrates are delivered by the cytosolic motor protein SecA, but the amphiphilic character of the protein translocation machinery has made it hard to probe the structural state of functional SecA-SecYEG interactions. Alami *et al.* have reconstituted SecYEG monomers into a membrane-like lipid/protein construct, referred to as a nanodisc; adding dimeric SecA to these nanodiscs results in dissociation of the dimers and binding of monomeric SecA to SecYEG and the consequent stimulation of SecA ATPase activity. — GJC



SecY (red) in a lipid (yellow)/protein (red) matrix.

EMBO J. **26**, 10.1038/sj.emboj.7601661 (2007).

MATERIALS SCIENCE

Approaching the Ideal

Frenkel predicted 80 years ago that the ideal strength of a metal should be 1/5 of its shear modulus, but in most metals the actual strength ratio is closer to 1/1000 because of the motion of dislocations at much lower stresses. Li *et al.* use computational methods in an effort to understand the behavior of a family of body-centered cubic (bcc) Ti-Nb–based alloys known as Gum Metals. These alloys have the unusual property of sustaining very large elastic deformations before yielding, as well as substantial plastic deformation before failing. The authors argue that for this behavior to occur, the ideal strength must be below a stress at which the material would deform by ordinary dislocations, and that the material must always fail by shear rather than cleavage fracture. Using ab initio calculations to determine the elastic properties of related Ti-V alloys, they find that at a ratio of valence electrons to atoms close to the Gum Metal value, the bcc lattice becomes unstable; thus, the Gum Metals intrinsically have a low ideal strength and

CREDITS (TOP TO BOTTOM): JAVIER TRUEBA/MADRID SCIENTIFIC FILMS; ALAMI *ET AL.*, *EMBO J.* **26**, 10.1038/SJ.EMBOJ.7601661 (2007)

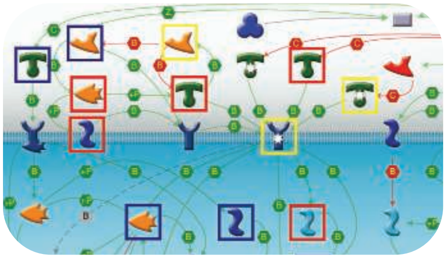
tend to fail in shear even when pulled in tension. Further, at values close to this transition, it is possible to introduce sufficient obstacles for dislocation motion through the addition of extra alloy elements without complete loss of ideal strength. The authors believe that similar computations could identify useful alloys that exist close to this edge of bcc stability. — MSL

Phys. Rev. Lett. **98**, 105503 (2007).

BIOMEDICINE

Looking for Cancer Stem Cells

The intense interest in stem cell research has helped to revive the cancer stem cell hypothesis, which postulates that tumor cell growth is driven by a small population of malignant cells that have the ability to self-renew and to differentiate—a capacity that is shared with normal tissue stem cells. The idea is attractive because it suggests that drugs could be designed to target cancer stem cells selectively, if and when these cells are identified. Although the stem cell origin of leukemias is now widely acknowledged, the role of stem cells in solid tumors has been more contentious. Shipitsin *et al*. performed a comprehensive molecular characterization of two classes of cells purified from human breast cancer: one class



A network of genes up-regulated in normal (blue) or cancer (red) CD44⁺ cells.

expressed a cell surface marker (CD44) previously associated with high tumorigenicity and stem cell–like properties, and the second class expressed a marker (CD24) previously associated with low tumorigenicity and a more differentiated state. The $CD44^+$ breast cancer cells were found to express many genes in common with progenitor cells in normal breast tissue, and the abundance of these cells in the tumor appeared to correlate with decreased patient survival. However, the $CD44^+$ and $CD24^+$ cells within individual breast tumors showed genetic differences, a finding that does not fit neatly with the simplest version of the cancer stem cell hypothesis. An alternative model is that many cancer cells retain the capacity to adapt to changing conditions, whether this means reverting to a more primitive, stemlike state or evolving into a more differentiated state. — PAK

Cancer Cell **11**, 259 (2007).

CREDIT: SHIPITSIN *ET AL., CANCER CELL* **11**, 259 (2007)

MICROBIOLOGY

A High-Fiber Diet

In the race to replace fossil fuels with biofuels, microbial fermentation may become a key technology. However, microbes can do only so much and balk when their food contains too much lignin. This is not uncommon because the fibrous tangle of lignin and cellulose, called lignocellulose but better known as wood, is ubiquitous. To add to the problem, the enzymatic breakdown of cellulose is not as rapid as the enzymatic breakdown of starches. Jeffries *et al.* present the genome sequence of the yeast *Pichia stipitis* Pignal, which can digest lignocellulose and can transform xylose, a component of lignocellulose, into ethanol. The yeast sequenced was isolated from insect larvae and is related to yeasts found in the gut of beetles that frequent rotting wood. The 15.4-Mb genome is divided into eight chromosomes and includes 5841 predicted genes, including a group of cellulases and xylanases and a number of genes encoding putative xylose transporters. Further analysis showed which genes in which metabolic pathways respond to changes in xylose, glucose, or oxygen. Unlike *Saccharomyces cerevisiae*, which regulates fermentation according to glucose availability, *P. stipitis* regulates fermentation according to oxygen levels, which is reflected in how the genes respond to oxygen. — PJH

Nat. Biotechnol. **25**, 319 (2007).

GENETICS

Networking with Your Peers

Phenotypes embody genotypes, but identifying the steps from coding region to phenotypic variant is not always straightforward because it can often involve complex or multiple protein interactions, or both. These interactions can be decomposed into the direct regulation of genes through protein-protein, protein-DNA, and DNA modifications such as methylation and an indirect regulation that includes genetic interactions between regulator genes. By creating strains of yeast carrying single or double mutations in five transcription factors known to affect filamentous growth and examining their phenotypes and gene expression profiles, Carter *et al.* employed a systematic strategy for generating a model that could be used to estimate phenotypic variation resulting from the mutation of a gene within a network. As a result of accounting for both direct and indirect genetic effects, the authors were able to predict the expression levels of the double mutants on the basis of the single mutants, and to infer functional cross-influences between previously unidentified interactions. — LMZ

Mol. Syst. Biol. **3**, 10.1038/msb4100137 (2007).

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