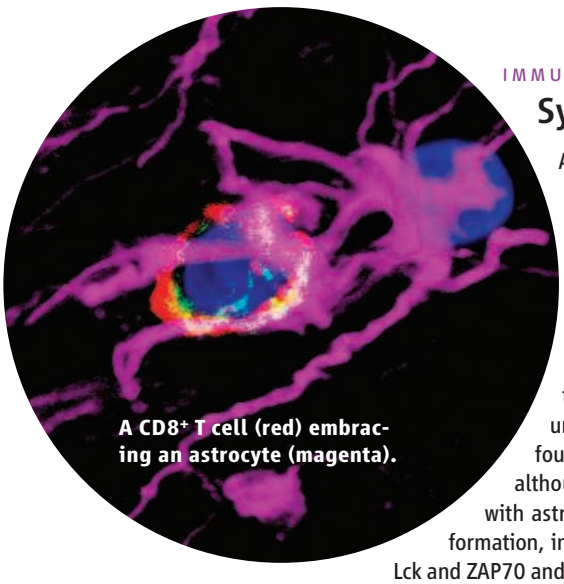


A CD8+ T cell (red) embracing an astrocyte (magenta).

IMMUNOLOGY

Synapse Formation in the Brain

A productive meeting of a T cell and an antigen-presenting cell results in the formation of an immunological synapse between the membranes of the two cells, a crucial step in promoting T cell activation. Concentrated within synapses are the adhesion protein LFA1, T cell receptors, peptide-MHC complexes, and downstream signalling components. Two concentric domains of the synapse have been characterized: peripheral and central supramolecular activation clusters (pSMACs and cSMACs). Although both domains can be observed in vitro, difficulty seeing them in vivo has prompted discussion of their importance in effective immune responses. Using a rat model with a documented immune response to virally infected astrocytes in the brain, Barcia *et al.* found that both $CD4^+$ and $CD8^+$ T cells were required for clearance of infected cells, although only $CD8^+$ cells entered the brain parenchyma to establish close contact with astrocytes. These contacts exhibited features characteristic of immune synapse formation, including recruitment and phosphorylation of the intracellular tyrosine kinases Lck and ZAP70 and a membrane reorganization into intimate three-dimensional apposition. More striking was the detection of cSMAC- and pSMAC-like regions, defined by the central and peripheral distributions of the T cell receptor and LFA1, respectively. Typical synapse structures were seen both before and during the immune-mediated clearance of infected astrocytes, suggesting their direct involvement in the antiviral response. — SJS

J. Exp. Med. **203**, 10.1084/jem.20060420 (2006).

CHEMISTRY

Bounding Biomineralization

Many organisms build skeletons or shells out of calcium carbonate, either by localizing its crystallization or by stabilizing the otherwise short-lived amorphous form. In general, control of this process has been attributed to a mix of proteins, polymers, and magnesium ions on the assumption that each plays roughly the same role in inhibiting the nucleation and growth of crystalline calcite.

DiMasi *et al.* have used in situ synchrotron x-ray reflectivity to distinguish the roles played by these different substances. Specifically, they monitored the formation of amorphous calcium carbonate films on monolayers of arachidic acid placed against a subphase of saturated aqueous calcium bicarbonate, while varying the concentration of additives, including $MgCl_2$ and the sodium salt of poly(acrylic acid)—a model of naturally occurring aspartate in proteins. The magnesium ions were found to introduce an induction period, delaying the onset of film formation, but had little influence on the subsequent growth of the film. Changing the polymer concentration also did not affect the growth rate of the films but did affect the lifetime of the metastable amorphous phase before it crystallized or redissolved into the solution. Finally, by varying the trough depth, the authors could tune the path length for the diffusion of carbon dioxide during film formation; this component of the study revealed an inverse relation between solution depth and growth rates. Overall, these results clarify the means of controlling the growth of amorphous mineral phases, of interest both in natural processes and in materials fabrication. — MSL

Phys. Rev. Lett. **97**, 45503 (2006).

PROTEOMICS

You Are What You Eat

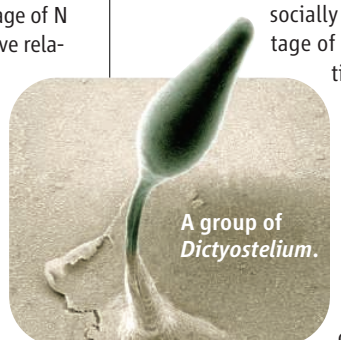
Plant biomass contains a lower percentage of N than animal biomass because plants have relatively more carbohydrate and less protein. To look more deeply at elemental aspects, Elser *et al.* compared the proteomes of nine plants and nine animals. The proteomes of plants were found to have a lower N content than those of animals; on average, animals had 7% more N atoms per amino acid. Furthermore, N content is related to overall gene expression level in such a way that, on average, plants have a lower N content in genes that are more highly expressed, whereas no discernible correlation with expression existed in the animal proteomes. These findings may reflect an eco-physiological selection away from the use of N-rich amino acids in plants, perhaps as a result of a greater sensitivity to limiting N supplies. — LMZ

Mol. Biol. Evol. **23**, 10.1093/molbev/msl068 (2006).

BIOPHYSICS

Sensory Discrimination

An attractive (or noxious) signal might come from any direction, so how can a single cell remain on the lookout in all directions? *Escherichia coli* are known to cope by interspersing periods of directional swimming with tumbling, which reorients them randomly. The single-celled slime mold *Dictyostelium* lives socially and has taken advantage of this lifestyle to apportion the community's detectors to cover all points of the compass.



A group of *Dictyostelium*.

Samadani *et al.* show that single *Dictyostelium* cells respond reproducibly (as assessed by the angular location of a cAMP-sensing component) to 10 trials of a fixed pulse of cAMP, yet this angle varies over more than 180° when measured across 40 cells. Nevertheless, the population response, summed over orientation and magnitude, yields a peak unerringly directed at the origin of the pulse. Each cell's innate inclination can be modeled as a function of (i) the overall mobilization of sensor components, (ii) the degree to which the components are distributed

CREDITS (TOP TO BOTTOM): BARCIA *ET AL.*, *J. EXP. MED.* **203**, 10.1084/JEM.20060420 (2006); DR. RICHARD KESSEL & DR. GENE SHIH

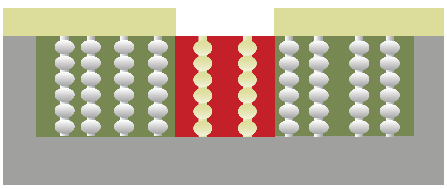
asymmetrically, and (iii) the orientation of the peak of asymmetry. Each cell's response can then be calculated as the vector sum of the intrinsic properties and the stimulus, and this captures the observed behaviors of the population, behaviors that are similar to the orientation selectivity of visual cortex neurons. This analogy leads one to wonder how the intrinsic orientations are divvied up and maintained in a *Dictyostelium* community. — GJC

Proc. Natl. Acad. Sci. U.S.A. **103**, 11549 (2006).

CHEMISTRY

Fill in the Blanks

Protease activity can be quantified in fluorescent or colorimetric assays, but such assays can require substrate modification, lengthy incubation times, and extensive workup procedures, along with relatively large sample volumes. Orosco *et al.* have fabricated a silicon-based photonic crystal device that exhibits picomolar sensitivity in analyzing microliter aliquots of pepsin and produces a rapid response visible to the eye. Furthermore, no molecular labeling is necessary.



Schematic of the photonic crystal device detecting protein fragments (yellow).

Photonic crystals block transmission of specific wavelengths of light through periodic alternation of high-refractive-index solid regions and low-refractive-index pores. The authors etched p-doped silicon to create the pores and then methylated the pore surfaces to keep out polar buffer solution. The top surface was then coated with a hydrophobic layer of zein protein. Application of pepsin caused the protein to fragment and fall into the pores, which in turn raised the refractive index in the pore region and led to a redshift in the reflected light. — PDS

Adv. Mater. **18**, 1393 (2006).

APPLIED PHYSICS

Muscling in on Optical Gratings

Optical microelectromechanical devices have found many applications as light splitters, modulators, and tunable gratings. Most such applications have relied on micromachined hard materials, which are capable of fast response but only over a limited mechanical range. Aschwanden and Stemmer show that soft materials such as electroactive polymers, or artificial muscles, can be used to extend that mechanical response because of the enormous strains (~380%) they can sustain when a voltage is applied. The authors pattern their elastomeric polymer with an initial grating period of 1 μm and append carbon black electrodes using contact printing. By sweeping the bias across these electrodes up to 4.5 kV, they can continuously vary the grating period over a range of up to 32% (to a 1.3-μm period). This change is sufficient to tune the transmission wavelength across the optical spectrum from blue to red, suggesting the possibility of display technology applications if the driving voltage can be diminished. — ISO

Opt. Lett. **31**, 2610 (2006).

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<< An Up-and Down-Regulator

The liver is a key controller of fuel utilization, and insulin acts to inhibit hepatic gluconeogenesis and activate lipogenesis, thereby preventing excessive glucose release during the fed state. Phosphatidylinositol 3-kinase (PI3K) is a mediator of insulin signaling and is a dimer of a catalytic subunit (p110) and a regulatory subunit (p85). Phosphatidylinositol (3,4,5)-trisphosphate (PIP_3), the product of PI3K, is metabolized by the lipid phosphatase PTEN. Taniguchi *et al*. created a liver-specific knockout of the p85 subunit in mice and found that, contrary to expectations, these mice showed increased liver responsiveness to insulin and had lower circulating glucose, free fatty acids, and triglyceride concentrations than wild-type littermates. Muscle and adipose glucose utilization was also increased in the knockout mice. Although the knockout mice showed decreased hepatic PI3K activity and decreased levels of the p110 subunit (p85 stabilizes p110), insulin produced a prolonged elevation in hepatic PIP_3 and a higher activation of Akt, a kinase regulated by PIP_3, as compared to wild-type mice. The increase in PIP_3 appeared to be due to decreased PTEN activity in the livers of the knockout mice, suggesting that p85 regulates not only the production of PIP_3 but also its metabolism. — NRG

Proc. Natl. Acad. Sci. U.S.A. **103**, 12093 (2006).

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