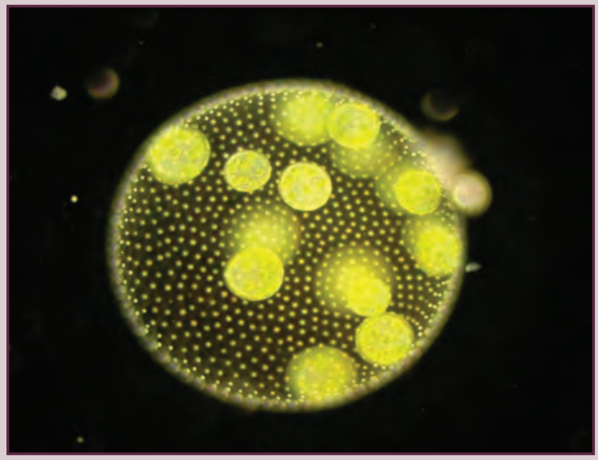
June 22, 2010 | vol. 107 | no. 25 | 11147–11650

In This Issue

PNAS
Proceedings of the National Academy of Sciences of the United States of America www.pnas.org

Moving to the light

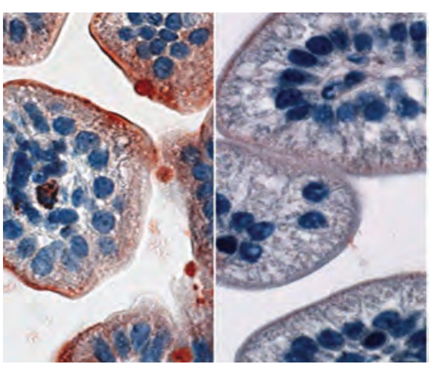


Multicellular colony *Volvox carteri*.

To optimize photosynthesis, algae such as *Volvox carteri* swim toward or away from sunlight. To execute this motion, known as phototaxis, these microorganism colonies must coordinate the beating of thousands of flagellated cells despite the organism's lack of a central nervous system. Using analytical and empirical methods, Knut Drescher et al. (pp. 11171–11176) demonstrate that *V. carteri* spins about its swimming direction at a frequency that likely coevolved with the organism's flagellar kinetics to maximize photoreactivity. To characterize the flagellar beating of the organisms, the authors measured the fluid velocities produced by the flagella and modeled the motion with hydrodynamic equations. Using the model, the authors identified a theoretical optimal spinning frequency and tested the finding experimentally by observing how well the algae swam in media with increased viscosities that inhibited the organism's ability to spin. According to the authors, the experiments demonstrated that with a decreased rotation rate the algae were unable to execute phototaxis as accurately as before, suggesting that in *V. carteri*, flagellar beating and spinning are linked adaptations. By better understanding how simple organisms coordinate multicellular processes, the findings may provide insight into key evolutionary steps that eventually led to higher organisms with central nervous systems. — T.J.

Modified probiotic may protect against cholera

Whereas low-density *Vibrio cholerae* bacterial accumulations in the hu-

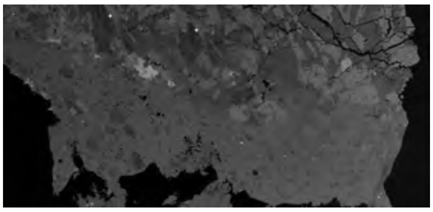


Infant mice given Nissle pretreatment (right) and no pretreatment (left).

man gut can cause harmful cholera symptoms, high-density *V. cholerae* colonies switch off virulence-expressing genes through extracellular signals such as cholera autoinducer 1 (CAI-1). Faping Duan and John March (pp. 11260–11264) modified a probiotic form of *Escherichia coli*, called Nissle, to express CAI-1, and tested the bacteria as a prophylactic against *V. cholerae* virulence in an infant mouse model. The researchers fed varying quantities of modified Nissle to 2- to 3-day–old mice at three different intervals prior to exposing the mice to *V. cholerae* bacteria. Of the mice fed the highest number of CAI-1–expressing Nissle cells 8 hours before *V. cholerae* ingestion, 92% survived. None of the mice that were fed *V. cholerae* survived without pretreatment or with nonmodified Nissle pretreatment. The authors note that the prophylactic protection was time- and dosage-dependent. Though the presence of CAI-1 secreting bacteria in the human intestine could potentially trigger a negative immune response, the authors suggest that the study may help researchers prevent and treat human diseases by using the body's own bacterial symbiotes. — J.M.

Water in early lunar magmas

Recent studies have argued that hydroxyl ions in lunar minerals indicate that the minerals crystallized from magmas that contained water, challenging the long-held theory that the moon does not have indigenous water. Francis McCubbin et al. (pp. 11223–11228) analyzed lunar specimens of the mineral apatite for hydroxyl, and report that the moon's interior may contain 100 times more water than previously estimated. Using a scanning electron microscope, the authors identified apatite grains in thin sections from two moon rocks obtained during Apollo missions and a lunar meteorite from Africa. The crystalline structure of apatite contains a bonding site that can be occupied by fluorine, chlorine, or hydroxyl, which allows researchers to analyze apatites and infer the relative amounts of fluorine, chlorine, and water in the parent magma. The authors measured hydroxyl in the lunar apatite by bombarding the grains with high-energy particles and counting the ions that were ejected. Based on the

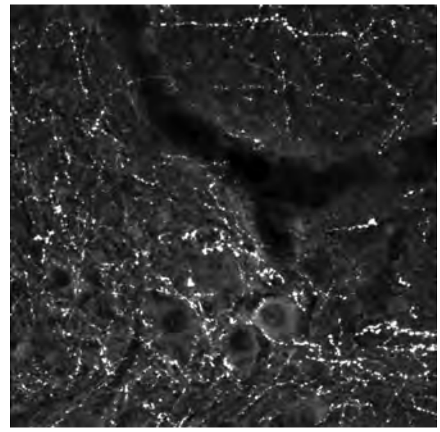


Back-scattered electron images of Apollo 15 soil grain.

hydroxyl measurements, the authors then inferred the amount of water in the lunar source magmas and extrapolated the result to estimate the moon's total water content. The study could alter current models of lunar magmatism and how the moon evolved, according to the authors. — T.J

Enzyme could enhance recovery from spinal cord injury

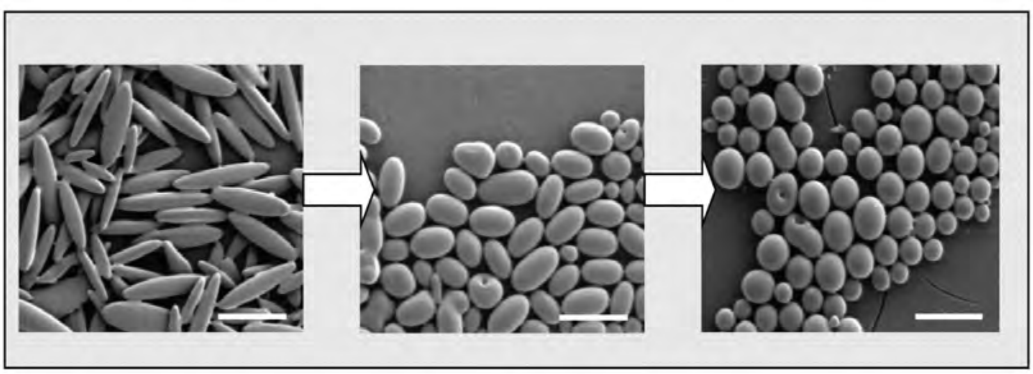
Spinal injury often results in lifelong paralysis or loss of limb function, partly because neurons fail to sprout new axons in the injured spinal cord. During injury, molecules released from the ruptured protective sheath enclosing nerve fibers latch onto receptors on the axonal membrane and block axon outgrowth, limiting recovery. One such molecule, called myelin-associated glycoprotein (MAG), curbs axonal outgrowth by binding to sialoglycans found on axons. To counter the effect of MAG, Andrea Mountney et al. (pp. 11561–11566) used engineered bacteria to produce the enzyme sialidase, which breaks down sialoglycans, and delivered the enzyme using a catheter to the site of injury in rats with injured spinal cords. The authors tested the effect of sialidase on axon sprouting, hindlimb movement, and autonomic nervous system function. Using a locomotor rating scale, the authors found that sialidase-treated rats regained significantly greater hindlimb function than control rats treated with saline. Compared to control rats, the treated rats also displayed better responsiveness in the autonomic nervous system and better axon sprouting in serotonin nerve fibers, the authors report. Because it is easy to produce, stable, and apparently nontoxic, sialidase could possibly be developed into a drug for human spinal cord injury, according to the authors. — P.N.



Serotonergic fibers in the spinal cord of a sialidase-treated rat.

Shape-shifting polymers could help improve drug delivery

Methods to manipulate the physical properties of materials have helped biomedical engineers design polymers for drug delivery, but few allow real-time control over the interaction of the polymers with body tissues.



Shape-switching of poly(lactic-co-glycolic acid) particles.

Jin-Wook Yoo and Samir Mitragotri (pp. 11205– 11210) demonstrate how a biocompatible polymer could be made to switch shape in real time in response to a range of stimuli. Particles of poly(lactide-co-glycolide) (PLGA), a polymer used in medical products, changed shape from elliptical disks to spheres when their interfacial tension with a surrounding aqueous liquid and viscosity were modulated by changes in temperature, pH, or chemical composition, the authors report. The time taken to switch shape—from minutes to days—could be controlled by altering the molecular weight and surface properties of the polymer or the size of the particles. Elongated particles tend to stay longer in circulating blood and accumulate better in target tissues than spheres but are not as easily taken up by cells. When macrophages, which phagocytose polymers administered for drug delivery, were incubated with PLGA particles in Petri dishes, they internalized the particles that changed shape to spheres but not those that remained as disks. The findings could help improve the design of polymers used for drug delivery and medical imaging, according to the authors. — P.N.