



ECOLOGY

## Third-Party Parasitism

For more than 50 million years, Agaonidae wasps have laid their eggs in the ovules of the enclosed flowers, or syconia, of fig trees. The grubs stimulate the formation of a small gall and feed on the plant's tissue. The payoff for the loss of reproductive power to the fig tree occurs when the young wasps emerge and carry their host's pollen to other trees. Fortunately for the trees, wasps don't lay eggs in every ovule in a syconium, even though in evolutionary terms this might seem a good strategy for the wasp; rather than being deterred by the tree itself, the fig wasps are in fact preyed on by another wasp. The parasitoid's ovipositor is just long enough to penetrate the wall of the fig and reaches only the outermost ovules. Dunn *et al.* show that thanks to the packing architecture of the ovules within the syconium, the fig wasps predominantly use inner ovules that are out of range of the parasitoid, allowing the other ovules to mature into fig seeds and thereby stabilizing this mutualism. — CA

*PLoS Biol.* 6, e59 (2008).

### CLIMATE SCIENCE

## Catching a Cold

Earth has wandered in and out of periods of extensive glaciation for hundreds of millions of years. The oxygen isotopic record of seawater indicates that the current Antarctic ice sheet began to form about 34 million years ago, across the Eocene-Oligocene transition. In contrast, extensive permanent ice sheets are thought not to have appeared in the Northern Hemisphere for another 25 million years. However, oxygen isotope ratios are affected by temperature as well as the isotopic composition of the water itself (which in turn is controlled mostly by the amount of ice that exists in the environment), so the cooling inferred from that record was not unequivocally established. Earlier work to construct a pure temperature record by measuring Mg/Ca ratios in foraminifera actually seemed to show that there was no appreciable ocean cooling 34 million years ago, implying that the drop in temperature believed to have occurred then was instead due to an earlier appearance of ice in the Northern Hemisphere. Now, Lear *et al.* report results from Mg/Ca measurements of exceptionally well-preserved samples that show a 2.5°C tropical sea



surface temperature drop across the Eocene-Oligocene boundary. This finding at last provides direct evidence of the cooling that had previously been so difficult to demonstrate. — HJS

*Geology* 36, 251 (2008).

### EVOLUTION

## Crop Rotation

Humans, attine ants, termites, and bark beetles have one thing in common—they all practice agriculture. The attine ants are found in the neotropics in South America; they grow and harvest fungal cultivars; and they co-opt a filamentous bacterium, which produces an antibiotic, to help control a parasitic fungal "crop disease." Schultz and Brady have calculated a fossil-calibrated molecular phylogeny of the attine ants and suggest that agriculture arose only once, as it did in termites, and unlike in humans or bark beetles, where it evolved independently several times. From this single emergence, five distinct agricultural systems developed, with the most primitive appearing roughly 50 million years ago. A radically dif-

ferent fungal cultivar, coral fungus, was adopted later by some ant species, and in a third offshoot, the normally filamentous *Leucocoprineae* fungi, common to most of the attines, were instead grown as nodules of single-celled yeast by select species. Further evidence for adaptive domestication of their fungal crop is seen in the ant species (including the leaf-cutter ants) that carry out higher agriculture: These fungal cultivars cannot survive independently of the ants, unlike those cultivated under the other systems, and these fungi produce gongylidia—swollen nutritious hyphal tips harvested by their caretakers. — GR

*Proc. Natl. Acad. Sci. U.S.A.* 105, 10.1073/pnas.0711024105 (2008).

### PHYSICS

## Downsizing Synchrotrons

Particle accelerators and synchrotron light sources qualify as big science, not just in the questions they strive to answer but also in their sheer physical size. At the same time, focusing petawatt laser pulses into gas samples can produce a plasma capable of generating and accelerating ions and electrons up to energies of several hundred MeV. Whereas such electrons might traditionally be directed down an undulator—a linear chicane of alternating magnetic fields—to produce synchrotron radiation, Knierp *et al.* show that the self-

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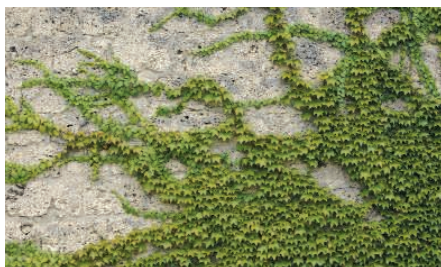
generated magnetic and electric fields present in the plasma channel can themselves be used as a miniature undulator. X-rays with energies up to 50 keV can thereby be produced, offering the possibility of reducing large-scale, national facility apparatus to instruments of more modest size. — ISO

*Phys. Rev. Lett.* **100**, 105006 (2008).

## MATERIALS SCIENCE

## Inching up the Wall

The sight of ivy clinging to a wall may evoke serene contemplation, but for the plant, wending up there takes some work. How do the slender stems scale a sheer surface without slipping back down to the ground? More than 100 years ago, Darwin noted a yellow secretion accompanying the climbing process. Zhang *et al.* have now taken a closer look and observed a multitude of nanoparticles emanating from disks that the ivy stems pressed against silicon or mica substrates as they grew. After pulling away the branches, the authors used atomic force microscopy to characterize the fairly uniform distribution of ~70-nm-diameter parti-



cles. Chemical analysis by extraction into organic solvent and subsequent high-performance liquid chromatography revealed a complex composition,

of which the 19 most prominent components were characterized by mass spectrometry. These compounds ranged in molecular weight from ~300 to ~700, comprising 18 to 38 carbons together with hydrogen, nitrogen, oxygen, and sulfur. The precise adhesion mechanism remains unclear, but the authors highlight the high surface area of contact fostered by nanoparticle secretion. — JSY

*Nano Lett.* **8**, 10.1021/nl0725704 (2008).

## BIOCHEMISTRY

## Distinctive Individualism

Single-molecule studies have shown that enzyme activities can differ substantially from the average measured in ensemble experiments and that rates of a single enzyme can vary because of conformational fluctuations. Most experiments, however, have not looked at a large enough number of molecules to characterize the stochastic nature of enzyme kinetics. Rissin *et al.* use an array of 50,000 40-fl reaction chambers in which most chambers were empty but approximately 5% contained a single molecule of  $\beta$ -galactosidase. Hydrolysis of a nonfluorescent substrate to a fluorescent product was monitored simultaneously for about 200 enzyme molecules. Averaged single-molecule turnover velocities agreed well with bulk measures, but there was a wide distribution in activities, confirming the heterogeneity within enzyme populations observed previously. The variability in rate was independent of substrate concentration, suggesting that it arises from variability in  $k_{cat}$ . The effect of enzyme activity distribution on metabolic pathways remains to be determined. — VV

*J. Am. Chem. Soc.* **130**, 10.1021/ja711414f (2008).

## Science Signaling



## &lt;&lt; An Inside Job?

Toll-like receptor (TLR) 4, which recognizes bacterial cell wall components, interacts with the TIRAP-MyD88 pair of adaptor proteins to stimulate the production of inflammatory cytokines, and also with the TRAM-TRIF pair to stimulate the production of type I interferons. Curious about how TLR4 coordinates activation of these two signaling pathways, Kagan *et al.* analyzed TLR4 location in macrophages and found that it was present both at the plasma membrane and in early endosomes. Inhibition of dynamin-dependent endocytosis prevented lipopolysaccharide (LPS)-induced internalization of endogenous TLR4 and blocked TRAM-TRIF-dependent phosphorylation of the transcription factor IRF3 (and the expression of target genes) whereas TIRAP-MyD88-dependent phosphorylation of p38 mitogen-activated protein kinase and I $\kappa$ B $\alpha$  degradation were unaffected. Although TIRAP localized to the plasma membrane, TRAM was present at both the plasma membrane and in early endosomes. Analyses of LPS-induced cytokine production by TRAM localization mutants indicated that TLR4 signaling through TRAM-TRIF took place in endosomes. Noting that no known TLRs stimulate type I interferon production from the plasma membrane (TLR4 had been thought to be the lone exception), the authors propose that TLR4 stimulates TIRAP-MyD88 signaling from the cell surface and initiates TRAM-TRIF signaling only after internalization. — EMA

*Nat. Immunol.* **9**, 361 (2008).