EDITED BY GILBERT CHIN AND MARIA CRUZ

ENVIRONMENTAL SCIENCE

## Renewable Benefits

Few would doubt the proposition that wind and solar power provide health and environmental benefits by reducing emissions of carbon dioxide and other air pollutants, although few have considered in depth how the advantages of those renewable energy technologies might differ regionally. The variability of the advantages of renewable power is largely a function of the type of power generation that it displaces. Siler-Evans *et al.* look at how existing power generation facilities are distributed across the United States and analyze the impacts of replacing those facilities with wind or solar installations. They find uneven but significant—and in some regions, very large—social and environmental benefits resulting from the adoption of those technologies. They also discuss the value of the Production Tax Credit Subsidy for wind energy generation, how its effectiveness could be improved by regional differentiation of the policy, and how the large-scale adoption of wind or solar energy production might affect their more site-specific analysis. — HJS

*Proc. Natl. Acad. Sci. U.S.A.* **110**, 11768 (2013).

EVOLUTION

## Open to Change

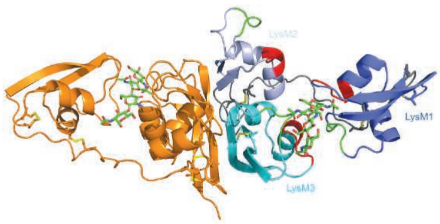
Changes in the regulation of gene expression can result in changes in organismal phenotypes. Nakagawa *et al.* have used phylogenetic analysis and biochemical measurement to study DNA binding specificity changes in the forkhead box (Fox) family of transcription factors. This family is present in a wide range of species and is one of the largest classes of transcription factors in humans. They used phylogenetic inference methods to examine the relationship of Fox domain sequences spanning 623 genes from 65 species, and they characterized binding specificity in vitro for 21 Fox proteins and combined this with published binding data for 9 proteins. They found that changes in specificity from canonical forkhead primary (FkhP) and forkhead secondary (FkhS) motifs to alternative DNA sequences have occurred separately in three different Fox subfamily lineages. In fungal Fox3 proteins, two specificities have arisen, FHL-3 and FVH, but only FVH binding involves the mutation of residues involved in DNA recognition. In the metazoan FoxM subfamily, proteins retain specificity for FkhP and FkhS but are also able to bind an FHL motif, whereas in the holozoan FoxN subfamily, some proteins exhibit a similar bispecificity, yet others have lost the ability to bind the canonical sites and only bind FHL-N. Fox domains that display bispecific binding are probably able to switch between two conformations with distinct DNA binding specificities. Such bispecificity may be central in the evolution of transcriptional regulatory networks. — VV

*Proc. Natl. Acad. Sci. U.S.A.* **110**, 10.1073/pnas.1310430110 (2013).

MICROBIOLOGY

## Hide and Seek

Plants and their fungal pathogens are at war. Plant surface receptors, which contain lysin motifs (LysMs), sense fungal chitin oligomers, which are basic components of fungal cell walls, and




thereby trigger immune defenses against the fungus. The fungi, in turn, have evolved molecular countermeasures. Sanchez-Vallet *et al.* report structural studies of a fungal effector protein, Ecp6, which is secreted by the leaf mold *Cladosporium fulvum* and provides a means for the pathogen to hide from the host. Ecp6 also contains LysM, but unlike the plant's receptors, the fungal motifs dimerize in the presence of its own chitin to form a deeply buried groove that binds chitin with high affinity and keeps it out of sight of the plant's immune responses. LysM seems to be ubiquitous among fungi and may represent a common mechanism by which such pathogens can evade host defenses. It is interesting that two evolutionarily distant organisms have converged on the ability to recognize the same molecule via the same motif that resides in divergent proteins and with antagonistic effect. — CA

*eLife* **2**, e00790 (2013).

PLANT SCIENCE

## Location and Timing

In plants, the circadian network coordinates physiological processes with the daily rhythms of light and dark. The protein GIGANTEA (GI) is found in both nuclear and cytoplasmic compartments of the plant cell and regulates different partners in the two locations. Using *Arabidopsis*, Kim *et al.* constructed plants with disrupted subcellular localizations of GI. Their modeling analyses of the

CREDITS (TOP TO BOTTOM): THINKSTOCK; SANCHEZ-VALLET *ET AL., ELIFE2* (2013)



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mutant plants show that GI in the nucleus acts as a positive regulator of the core oscillator gene *LATE ELONGTED HYPOCOTYL (LHY)*, whereas GI in the cytoplasm acts as a negative regulator. This regulatory cycle supports a peak of *LHY* in the morning and a shift to the control of flowering genes by GI in the evening. The spatial segregation and opposition of function make the circadian system more robust in the face of stochastic noise; the models suggest that using one component in opposing ways generates a more stable system than does using two separate components. — PJH

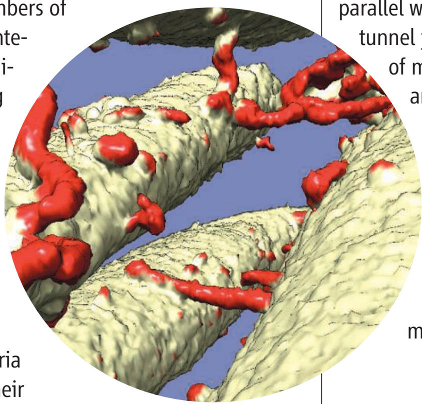
*Dev. Cell* **26**, 1016/j.devcell.2013.06.006 (2013).

MICROBIOLOGY

## The Social Life of Small Spaces

Bacteria have traditionally been considered as swarms of independent cells, but the notion of bacteria as members of populous and integrated communities is becoming more prevalent. For instance, the existence of diffusible signals that contribute to quorum sensing among groups of bacteria to coordinate their responses to the environment is now well established. Remis *et al.* have looked at how *Myxococcus xanthus*, a social bacterium present in soil, can communicate via direct contact mechanisms. Artifact-free preservation and electron microscopic 3D mimaging of cell structures revealed the fine structure of individual bacteria and their membrane appendages, as well as cellular 3D biofilm organization. Lipid-based vesicle chains and membrane tubes were observed that increased in number in biofilms and could facilitate direct communication between linked bacteria. The idea that bacteria in a biofilm can intimately connect at the level of the periplasm suggests that biofilm communities can be viewed as a ''superorganism'' that transfers membrane proteins and other molecules between cells in order to coordinate group behavior. — SMH

*Environ. Microbiol.* **15**, 10.1111/1462-2920.12187 (2013).



CREDIT: REMIS *ET AL.*, *ENVIRON. MICROBIOL.* **15** (2013)

PHYSICS

## The Higher Andreev State

In superconductors, materials capable of perfect conduction of electricity, the associated supercurrent is carried by pairs of electrons known as Cooper pairs. If a superconductor is placed in contact with a nonsuperconducting material, a single electron impinging on the interface from the nonsuperconducting side is reflected as a hole and forms a Cooper pair on the superconductor side—a process known as Andreev reflection. For a nonsuperconducting material sandwiched between two superconductors (as is the case in devices such as tunnel Josephson junctions), the reflections on the two interfaces will cause the formation of standing waves—Andreev bound states (ABSs)—which are responsible for carrying the supercurrent across the weak link. The ABSs have a discrete spectrum, but usually only the lowest energy state is accessed in experiments. Bretheau *et al.* directly detected an excited ABS in a less common form of a Josephson junction, where the weak link is an atomic contact. Their apparatus consisted of an atomic contact junction in parallel with a tunnel junction, and with another tunnel junction acting as a source and detector of microwaves. By measuring the current and voltage dependence of the latter, and by varying the phase difference across the atomic contact, they were able to precisely map out the energy needed to excite the ground ABS. It is expected that the existence of two ABSs can be used as a basis for a quantum bit or as a stage for exploring fundamental mesoscopic phenomena. — JS

*Nature* **499**, 312 (2013).

PHYSICS

## Solid-State Optical Storage

Photons are ideal carriers of information. They are fast and coherent, and because they don't interact much with each other they can have very long lifetimes. However, stopping, processing, and manipulating the photons requires them to be stored in a memory, where doing so can damage their fragile quantum properties, which leads to a loss of coherence. Although photons have been coherently stored in and retrieved from ensembles of atom gases, both warm and cold atom clouds, for practical applications a solid-state memory would be desired. Heinze *et al.* have developed a method to enhance the storage time of photons in a rare-earth–ion—doped crystal. They use a series of laser pulses to initialize the crystal for photon storage and then load it with their "information photons." By iteratively optimizing the experimental parameters, they show that they can store light pulses and even entire images in the crystal and then retrieve them up to a minute later with their coherent properties intact. The results present an important step toward building a viable quantum network. — ISO

*Phys. Rev. Lett.* **111**, 033601(2013).