

ENGINEERING

What Keeps the Power On?

Topological models use tools from graph theory to explore connections among elements of complex systems. Recently their application to electricity distribution has stoked fears, including in the U.S. Congress, that massive grids could be crippled by seemingly minor initial disruptions. Targeted attacks on nodes with low loads but high connectivity, some argued, could inflict more damage than attacks on the highest-loaded nodes. Yet such systemwide failures are dictated not only by the nodes and connectivity of the system but also by the laws of Ohm and Kirchhoff that describe the physics of electrical flow. In a systematic comparison of topological and current-flow models, Hines *et al.* show that topological models, which do not fully capture the effects of electrical flow, can lead to some misleading conclusions. Though all models showed that different types of targeted disruption would inflict more damage than would random failures, the physics-based measure of blackout size—the amount of electrical load curtailed—did not show the same susceptibility to disruption of low-traffic nodes as did the topological measures of connectivity that so alarmed Congress. Allocation of infrastructure protection resources informed by physics-based models would focus on nodes that transport the largest amounts of power. — BW

Chaos **20**, 33122 (2010).

CELL BIOLOGY

Turn Down the Noise

Many cellular signaling pathways are now sufficiently well mapped to allow more sophisticated investigation of their regulation and of how the range of physiological states that a cell can achieve is determined by the regulatory network structure. One well-studied pathway is that initiated by mating pheromone in yeast. The binding of pheromone to its receptor initiates a signaling pathway that ultimately causes changes in the transcription of genes required to reorganize the cell for mating. McCullagh *et al.* explored why this pathway contains two redundant components, Dig1 and Dig2, both proteins that bind to and inhibit the transcription factor Ste12 in cells that have been exposed to mating pheromone. Although either protein alone is sufficient to inhibit Ste12-mediated transcription, deletion of the gene that encodes Dig1 revealed several distinct functions. Dig1-deficient cells had increased the variation or “noise” in the amount of transcription of a target gene regulated by Ste12. These cells also exhibited disrupted intranuclear localization of Ste12 and increased interchromosomal interactions of

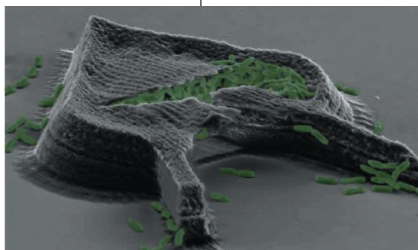
Ste12-regulated genes. These changes may be because the region of Ste12 that interacts with Dig1 is also able to interact with other proteins. Thus, in the absence of Dig1, the interactions between Ste12 and its target genes are not as well coordinated, which results in an increase in noise in the system. Such long-range interactions between genes could be important for coordinating gene expression, but these analyses indicate that such regulation comes at the cost of increased variability in signal output. — LBR

Nat. Cell. Biol. **12**, 954 (2010).

MICROBIOLOGY

Microbe Trapping

Bacteria often exhibit distinct behaviors when in a group. In order to better study these behaviors, Connell *et al.* manufactured tiny, 2- to 6-picoliter chambers out of bovine serum albumin covalently cross-linked by laser lithography into permeable three-dimensional structures. After trapping single bacterial cells in the chambers (bacteria, in green, shown inside trap above), clonal growth was observed. Captive *Pseudomonas* bacteria grew at rates comparable to those seen in



conventional culture and in the mouse lung, because nutrients and other small molecules could freely enter and exit the chambers. This system was applied to experiments on quorum sensing and antibiotic resistance, and coupled with new sequencing technologies could be envisaged to add an interesting dimension to experimentation probing early phases of infection and biofilm formation. — CA

mBio **1**, e00202 (2010).

IMMUNOLOGY

T Cells Cause Trouble

Multiple sclerosis (MS) results from inappropriate immune responses against antigens in the central nervous system (CNS). CD4⁺ T cells that make interleukin-17 (T_H17 cells) are a major contributor to the development and pathogenesis of MS. Two recent studies now reveal how T_H17 cells are regulated in the CNS and they how might contribute to disease. Using a mouse model of MS, Hao *et al.* show that natural killer (NK) cells residing in the CNS play a critical role in suppressing T_H17 cell responses. NK cells do not act directly on the T_H17 cells, however. Instead, they kill microglia, which present antigens and provide cytokine cues to direct T_H17 cell differentiation in the CNS.

Siffrin *et al.* focus on how T_H17 cells contribute to disease pathogenesis, also in a mouse

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model of MS. They show, through use of cell transfer experiments and intravital imaging, that T_H17 cells (but not other $CD4^+$ helper cell subsets) form long-lived contacts with neurons in the CNS of diseased mice. Neurons interacting with T_H17 cells exhibited elevated amounts of intracellular calcium, which is indicative of neuronal toxicity, and in vitro, T_H17 cells induced neuronal cell death. Together, these studies underscore the importance of T_H17 cells in MS pathology and suggest that these cells, and NK cells, may be potential targets for therapeutic intervention. — KLM

J. Exp. Med. **209**, 1907 (2010);
Immunity **33**, 424 (2010).

ASTROPHYSICS

All Quiet on the Dark Front

Astrophysical observations suggest that the mass content of the universe is dominated by dark matter that neither emits nor absorbs radiation and is thus invisible. Its as yet unobserved constituents, probably neutral Big Bang relics called weakly interactive massive particles (WIMPs for short), should be detectable on Earth because they are expected to scatter off atomic nuclei, but the prospects are daunting: Detection rates could range from one event per kilogram of matter per year to less than one event per ton of matter per year. It is thus not surprising that the analysis of the first 11.17 days of data from the Xenon100 experiment, reported by Aprile *et al.*, does not show any evidence for dark matter interactions. Xenon100 is designed to detect WIMPs scattering off 62 kg of ultrapure liquid xenon, a material selected for its high atomic mass, and hence large nucleus, associated with higher detection probability. Like other dark matter experiments, the success of Xenon100 depends on minimizing and discriminating against background events arising from radioactivity and cosmic rays. Encouragingly, the first dark matter results from Xenon100 suggest that, by design, the experiment is essentially background-free. — MJC

Phys. Rev. Lett. **105**, 131302 (2010).

APPLIED PHYSICS

A Supporting Role for Graphene

Over the past 6 years, graphene has gone on from its discovery, isolation, and characterization to become the material du jour. A freestanding sheet of carbon atoms just one

atom thick, peeled from a block of graphite with scotch tape, the material displays a wealth of exotic electronic, optical, and mechanical properties, all of which are being studied fundamentally and developed for applications as well. Nair *et al.* now show that graphene can also be used as a support for high-resolution transmission electron microscopy. Such microscopes accelerate electrons to very high energy. These electrons can be absorbed or scattered by the usual thin carbon supports, creating a large background signal that diminishes the contrast and can obscure the object under study when homing in on the smallest of molecules or features. As demonstrated with individual tobacco mosaic virus specimens without the need for staining, the mechanical strength and transparency of graphene lend themselves very well in support of high-resolution imaging applications. — ISO

Appl. Phys. Lett. **97**, 153102 (2010).

APPLIED PHYSICS

Carrier Trapping

Ideally, solar cells should have high surface areas at the molecular level, in order to maximize the proportion of sites where light absorption can produce a current carrier. Although networks of nanoparticles can optimize carrier production, they also restrict current

flow efficiency on account of scattering at all the interfaces. Nanotube architectures with well-defined flow paths would thus seem to offer the best of both worlds, yet their performance has not met expectations, instead proving little better than that of the particulate assemblies. Richter and Schmuttenmaer used ultrafast THz spectroscopy to probe

the origins of this inefficiency, and they found that in an array of titanium dioxide nanotubes (shown above), a sharp resonance at 7.5 meV identified the culprit: excitonic trapping. They propose that the traps result from a comparatively high concentration of trivalent titanium ions associated with the fabrication technique, raising hopes that improved synthetic methods could clear the path. — JSY

Nat. Nanotechnol. **5**, 10.1038/nnano.2010.196 (2010).

