

GENETICS

Understanding Recombination

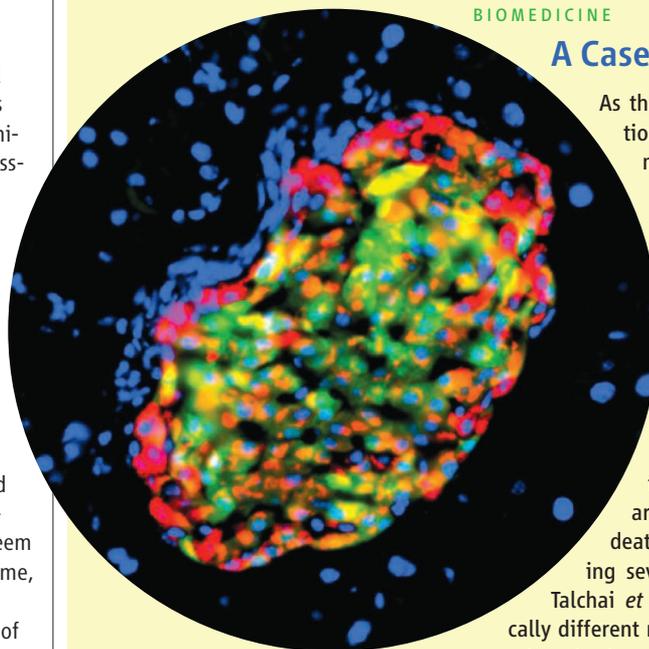
Recombination, the process of chromosomal exchanges to foster genetic variation, occurs variably along the genomes of plants and animals, with certain regions showing more crossovers than others. One feature that controls crossovers is the presence or absence of methylation on the DNA sequences, where densely methylated regions show low rates of crossover events. Colomé-Tatché *et al.* examined genome-wide recombination patterns in *Arabidopsis* plants with parents of differing methylation status: one heavily methylated and the other hypomethylated. Among the offspring, regions of high and low methylation were traced and genome-wide recombination events were inferred. Although methylation patterns did seem to affect crossover rates in parts of the genome, crossovers were suppressed near the centromere, even in individuals with low amounts of methylation in this area. These results suggest that recombination events in this region are insensitive to natural DNA sequence variation and methylation state and help to provide a framework to delineate the epigenetic basis of complex traits in *Arabidopsis*. — LMZ

Proc. Natl. Acad. Sci. U.S.A. **109**, 10.1073/pnas.1212955109 (2012).

MATERIALS SCIENCE

Ising Ice

Spin ice, a group of exotic magnetic materials that have molecular arrangements akin to that of water ice, can be artificially engineered out of nanomagnets arranged in patterns that resemble real crystal lattices, but with fully tunable properties. Normally, these nanomagnets orient themselves within the plane that they occupy; Zhang *et al.* created an artificial spin ice in which the magnetic moments point perpendicular to the plane—a realization of the canonical Ising spin model. Magnetic force microscopy confirmed that, after initialization, the magnets pointed either up or down. The frustrated kagome lattice, with perpendicular magnetization, showed similar spatial correlation properties to those of the honeycomb lattice, with in-plane moments, implying that the behavior is dominated by the nearest-neighbor interactions, which are matched between the two; the similarity was maintained through a range of interactions. The realization of perpendicular magnetization is expected to lead to interesting hybrid systems with thin films, in which the properties of the adjacent films may



BIOMEDICINE

A Case of Lost Identity?

As the cells responsible for the secretion of insulin—the major hormonal regulator of blood glucose levels—pancreatic β cells are the central command center for the prevention of type 2 diabetes. When β cells cannot keep pace with metabolic demands (which occurs with obesity, during pregnancy, and as people age), insulin secretion drops and blood glucose levels rise. The prevailing model is that β cells fail because they are lost through programmed cell death and are not replaced. Studying several mouse models of diabetes, Talchai *et al.* present evidence for a radically different mechanism of β cell failure: They propose that the loss of β cells occurs because under conditions of physiological stress, the cells change their identity through de-differentiation to a more progenitor-like state and are then converted to other pancreatic cell types that do not secrete insulin, such as α cells. The transcription factor FoxO1 plays an essential role in keeping β cells in their differentiated state. If these observations apply to humans, they would suggest that therapies for type 2 diabetes should focus on reversing the β cell de-differentiation process rather than promoting β cell replication. — PAK

Cell **150**, 1223 (2012).

be controllable by the perpendicular magnetic moments. — JS

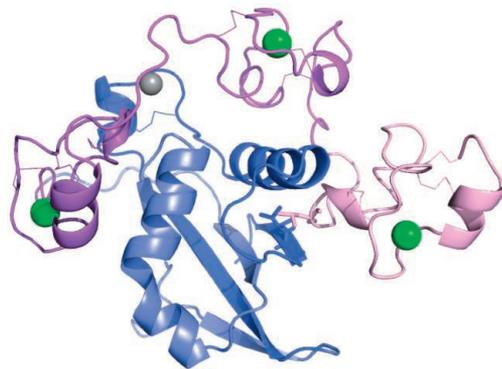
Phys. Rev. Lett. **109**, 087201 (2012).

BIOCHEMISTRY

A Forced Opening

Notch proteins are transmembrane receptors that have major roles in the regulation of cell proliferation and development, and mutations in the Notch signaling pathway contribute to human diseases and cancer. When Notch proteins are bound by their ligands, which are themselves transmembrane proteins found on adjacent cells, endocytosis of the Notch extracellular domain into the ligand-bearing cell occurs, during which the Notch protein is cleaved, allowing the intracellular domain to be translocated to the nucleus, where it activates target genes. Stephenson and Avis used atomic force microscopy (AFM) to physically stretch a portion of the receptor called the Notch negative regulatory region, which contains the masked site of proteolysis. They could show through AFM measurements and molecular dynamics simulations that such a mechanical stimulus unfolded

the protein to expose a site where proteolytic cleavage occurred (and actually monitored the latter as release of the AFM tip). The events and forces measured were consistent with a favored model of Notch signaling in which forces of



ligand endocytosis expose the otherwise buried cleavage site, leading to slicing of the receptor and initiation of signaling. — LBR

Proc. Natl. Acad. Sci. U.S.A. **109**, 10.1073/pnas.1205788109 (2012).

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ENVIRONMENTAL SCIENCE

A Sea of Difference

Large-scale anthropogenic impacts on the environment are often considered to be products of modern agricultural and industrial activity. It is becoming clearer, however, that humans have been agents of widespread environmental change for much longer than that. Through a combination of sedimentary, paleoenvironmental, and paleogenetic evidence, Giosan *et al.* chronicle how the biogeochemistry of the Black Sea has changed over the past 7500 years and how humans contributed to that. Surface salinity decreased and the delta of the Danube expanded over the past 2000 years, as sediments delivered by the Danube, the main tributary of the Black Sea, increased in volume because of the intensification of land use throughout its watershed. Over the past five to six centuries, greater nutrient fluxes resulting from rapid deforestation in Eastern Europe caused the proliferation of diatoms and dinoflagellates and

onation steps, which taken together with prior studies establish that the water-splitting cycle proceeds through strictly alternating extraction of electrons and protons.

Many synthetic systems focus on forming hydrogen from water-derived protons, rather than replicating the natural CO₂ functionalization cycle. Marinescu *et al.* probed the mechanism for one such catalyst that relies on redox-active cobalt. Using nuclear magnetic resonance spectroscopy, they tracked the rate of disappearance of a Co(III)-H intermediate, uncovering a bimolecular decay inhibited by increasing proton (acid) concentration. Analysis of these results together with cyclic voltammetry data and numerical simulations showed that the dominant mechanism involved a one-electron reduction of the intermediate by unprotonated Co(I) before H₂ formation, with a slower concurrent direct reaction involving two Co(III)-H complexes. — JSY

Proc. Natl. Acad. Sci. U.S.A. **109**, 10.1073/pnas.1206266109; 10.1073/pnas.1213442109 (2012).

IMMUNOLOGY

A Strategic Defense

Just as in American football, during the immune response, the location of your defenders is key. One player out of line can make the difference between a sack or a touchdown, or in the case of the immune system, a localized versus systemic infection. How the immune system orchestrates this careful defense, however, is not well understood. Kastenmüller *et al.* now demonstrate that the organization of cells within the lymph nodes of mice is critical for preventing pathogen spread during

the first few hours of an infection. Infecting bacteria drain to nearby lymph nodes, where they are immediately collected by a specially localized population of macrophages. Although these macrophages have antimicrobial activity, the immune system takes further precautions to ensure that the infection does not spread. Several types of lymphoid cells are localized near these macrophages. In response to bacteria, an inflammasome-dependent mechanism drove macrophages to produce the cytokine interleukin-18, which in turn alerted the nearby lymphoid cells to the threat. In response, the lymphoid cells produced the cytokine interferon- γ , which enhanced the antimicrobial activity of the macrophages, thus keeping the infection in check. — KLM

Cell **150**, 1235 (2010).



changed the entire food web structure of the Black Sea. Thus, long before industrialization, the Black Sea was much different from the time before humans populated its shores. — HJS

Sci. Rep. **2**, 10.1038/srep00582 (2012).

CHEMISTRY

Protons Coming and Going

Photosynthesis channels light into chemical energy by splitting water. Klauss *et al.* explored the sequence of steps whereby the manganese cluster in plants and algae extracts four protons and four electrons from two water molecules, forming O₂ in the process. By applying a photothermal beam deflection technique to probe the relative timing of electron and proton transfers, the authors uncovered two deprot-

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