Condensin II and Transvection >>

Distant regions of the genome in eukaryotic chromosomes are able to interact with each other, allowing long-range regulatory communication both in cis, between regions on the same chromosome, and in trans, between chromosomes. For example, in transvection, alleles of the same gene on chromosome homologs can cross-regulate each other. Hartl et al. (p. 1384) study the extreme case of trans association seen in polytene chromosomes in Drosophila, which each consist of many copies of an individual chromosome associated in perfect register. Condensin II subunits are involved in polytene chromosome disassembly, and these same subunits also interfere with instances of transvection in the fruit fly, suggesting that the condensin II complex may antagonize homology-dependent chromosomal interactions.

Images of Extra-Solar Planets

More than 300 planets have been found outside the solar system, most of them discovered indirectly through their influence on their parent star. Now two groups have obtained images of planets orbiting neighboring stars that resemble the Sun (see the Perspective by Marley, published online 13 November). Kalas et al. (p. 1345, published online 13 November; see the cover) present optical images of a planet with a mass no greater than three times that of Jupiter that orbits the star Fomalhaut 25 light-years from Earth. Marois et al. (p. 1348, published online 13 November; see the cover) present near-infrared images of three giant planets orbiting a star 128 light-years from Earth. This planetary system is reminiscent of the outer part of our solar system.

Dynamic Instability Revisited

Microtubules are intracellular polymers of the protein tubulin essential for the intracellular organization, polarization, and cell division of every eukaryotic cell. Microtubules display “dynamic instability”—alternating between tubulin polymerization and depolymerization phases separated by catastrophe and rescue events. The textbook model to explain this behavior proposes a small protective GTP-bound conformational cap at the microtubule’s polymerizing extremity, the loss of which could be responsible for catastrophe transitions. However, this model does not propose any mechanistic basis for the observed rescue transitions and has not been validated in vivo. Dimitrov et al. (p. 1353, published online 16 October) generated a conformational antibody that specifically recognizes tubulin in a GTP-bound conformation and confirmed the presence of a GTP cap at the extremity of cellular microtubules. In addition, unexpected GTP-tubulin remnants inside the polymer were revealed, which may be responsible for the observed rescue events.

Cation Capture

Crown ethers and cryptands—cagelike molecules in which several oxygen and/or nitrogen atoms create an inner environment hospitable to charged guests—can sequester hard metal cations, such as Mg$^{2+}$ and Ca$^{2+}$, in solution. Rupar et al. (p. 1360; see the Perspective by Lambert) now show that a cryptand can also encapsulate a free germanium dication. This more polarizable element, sometimes termed a metalloid-like boron and silicon, has previously required tightly bound ligands to stabilize a +2 oxidation state. Examination of the cryptand-bound ion using x-ray crystallography suggests that a range of soft cations could similarly be isolated in solution environments.

“Nothing” Affects Electronic Circuits

A vacuum is not empty, but is a seething sea of virtual particles being constantly created and annihilated. When a quantum system is coupled to a vacuum, you would expect the vacuum to have an affect on your system. For atomic systems, like hydrogen, this coupling manifests itself as a small shift, the Lamb shift, in the energy levels of the hydrogen atom. Now, Fragner et al. (p. 1357) demonstrate such a Lamb shift for a more complex, many-body solid-state system—an electrical circuit. When a superconducting two-level quantum system (qubit) was placed in a cavity, a shift in energy-level transitions of the qubit were observed consistent with those predicted from theory, which may prove important in designing future quantum electronic devices.

Melt in Mantle

Some regions of Earth’s mantle and deep crust have anomalously high electrical conductivities, which have usually been interpreted as indicating the presence of partial melt of mantle silicate minerals, distributed water, or high proportions of graphite. Gaillard et al. (p. 1363; see the Perspective by Evans) now show that the electrical conductivity of molten carbonate minerals is extremely high—orders of magnitude more than that of silicate phases. Thus, the previous anomalous observations could indicate small amounts of carbonate melt in the mantle.

Coating the Nuclear Pore

The Nuclear Pore Complex (NPC) is a 40- to 60-megadalton protein assembly that facilitates the exchange of macromolecules across the nuclear envelope. Low-resolution views of the structure and computer modeling have given general
insight into its organization. Brohawn et al. (p. 1369, published online 30 October) now add to the picture by providing a crystal structure of Nup85•Seh1, a module in the Nup84 complex that probably comprises the two peripheral rings of the NPC. Nup85, along with several other nucleoporins, has structural similarity to intracellular vesicle coat proteins. This similarity and mutagenesis experiments were used to define the organization of the Nup84 complex and to suggest that the NPC structural scaffold is a lattice-like coat.

Acid Baths
Ocean acidification contributes to the erosion of calcium-based biosynthetic structures like coral reefs, but we have little evidence of the effects of acidification on highly calcium-dependent organisms in fresh waters. Jeziorski et al. (p. 1374) examined the sediment records of calcium-reinforced freshwater crustaceans living in the soft-water (low pH) lakes of the Canadian Shield. During the 1970s these lakes suffered particularly from industrial acid rain. Even though the pH of many of these lakes has recovered, populations of small daphniid crustaceans have become depleted as water calcium levels continue to decline. Daphniids are keystone prey species, thus their loss predicts consequences to freshwater food webs in eastern Canada and, for similar reasons, probably also in many other parts of the Northern Hemisphere.

The Yin Yang of Root Regulation
The root meristem is a group of stem cells at the root tip that give rise to differentiated root tissues. The root meristem exists as a balance between new cells added by proliferation, and daughter cells removed by differentiation. The plant hormone, auxin, seems to oversee meristem cell proliferation, while the plant hormone, cytokinin, oversees differentiation. Using Arabidopsis plants, mutants, and expression and chromatin analysis, Dello Ioio et al. (p. 1380) find that signaling pathways from the two hormones converge on the SHY2 gene. Cytokinin activates the SHY2 gene, the effects of which cascade toward redistributing auxin. Auxin, on the other hand, directs degradation of the SHY2 protein, thus stabilizing auxin distribution.

Hybrid Dysgenesis
In Drosophila melanogaster crosses between a strain of flies with, and a strain of flies without, a specific type of transposon in their genomes can result in infertility in the progeny—a phenomenon known as hybrid dysgenesis. However, hybrid dysgenesis is only seen in the crosses between transposon-bearing males and transposon-free females, and not the reverse cross (whose progeny are fertile), suggesting that a “protective” cytoplasmic factor is inherited through the maternal germ line. The control of mobile elements in germ cells is mediated in large part by Piwi-interacting (pi) RNAs, produced from the transposons themselves. Brennecke et al. (p. 1387) now show that piRNAs are the cytoplasmic factor in P- or I-element transposon mediated hybrid dysgenesis, transmitted through the female’s egg and providing protection against transposon activation in the germ line of the newly introduced transposon. Thus, piRNAs can act directly to convey epigenetic information to progeny.

TB Prodrug Chemistry
Drug-resistant tuberculosis (TB) has emerged as a major threat to global health with few new candidates emerging to replace the rapidly dwindling array of existing agents. Among those offering promise are the bicyclic nitroimidazoles that include two candidate molecules (PA-824 and OPC-67683) currently in human clinical trials. Singh et al. (p. 1392; see the Perspective by Nathan) recreated the cellular machinery that metabolizes these drugs. The structure of the resulting metabolites suggested that, unlike normal biological reduction of aromatic nitro compounds, the deazaflavin-dependent nitroreductase, Fnr, reduced the imidazole ring, not the nitro group, and that the resulting reduced nitroimidazole eliminated nitrous acid as a result. Nitrous acid was detected both in vitro in the enzymatic reaction, as well as in vivo inside the bacterial cell. In addition, among a series of derivatives with very different anaerobic killing effects on Mycobacterium tuberculosis (the causative agent of TB), the extent of killing was directly related to the extent of release of nitrous acid. Thus, this class of compounds appears to kill anaerobic cells by acting as intracellular nitric oxide donors.