The Root of the Problem

Developmental processes can define repeated patterns of structure, such as somites in vertebrates. In plants, too, repeated structures arise during growth and development. As the above-ground shoot grows, it sends out leaves or branches at intervals guided by hormone signaling. As the below-ground root grows, it too ramifies, sending out lateral roots. Moreno-Risueno et al. (p. 1306; see the Perspective by Traas and Vernoux) explored the expression of genes underlying development of lateral roots and found that oscillations in gene expression guide the specification of lateral roots.

High-Temperature Electronic Switching

In electronic circuitry, the band gap of a semiconductor helps to provide the barrier that keeps charge carriers from flowing until a voltage is applied that switches the device. As temperatures rise, the carriers acquire enough thermal energy to overcome the band gap, causing the device to leak current even when they are turned off. The higher band gap of silicon carbide (SiC) makes it an attractive candidate for higher-temperature operations compared to conventional silicon, but several performance issues occur with SiC junction field-effect transistors. T.-H. Lee et al. (p. 1316) describe the fabrication of SiC nanoelectromechanical switches that formed inverter circuits with extremely low leakage currents and switched billions of times at 500°C.

Chlorophyll Sees Red

Among the first facts students learn about the natural world is that plants owe their green color to the pigment chlorophyll. There have actually been a handful of slightly different chlorophyll variants uncovered over the years, and Chen et al. (p. 1318, published online 19 August) have found another in bacteria from Shark Bay, Australia. The chlorophyll variant displayed a red-shifted absorption spectrum, which extended into the near-infrared region due to the insertion of a formyl group on the molecule’s periphery. The precise cellular function of the pigment awaits further study.

Cold Refreshment

Carbon nanotubes can function as chemical sensors by virtue of the shifts in resistance or capacitance induced when small molecules bind to their surfaces. Unfortunately, many molecules bind rather tightly, impairing reuse of such sensors. Salehi-Khojin et al. (p. 1327) showed that one solution to this problem was to run a strong current through the nanotubes after the detection event, which induced desorption of organic molecules. By comparison, thermal (as opposed to current-driven) desorption required heating to temperatures that irreparably degraded the sensor structure.

Charging Back and Forth

Ion binding by proteins can exert a major influence on electron transfer events in biological systems. Park et al. (p. 1324) discovered an analogous phenomenon in a simpler synthetic system. Specifically, a certain flexible molecule, known as a calix[4]pyrrole derivative, adopts a conical conformation upon binding anions, such as chloride or bromide, and this in turn leads to electron transfer to a guest acceptor that drifts into the cone. Addition of a cation that fitted more snugly into the conical cavity resulted in a reversal of the electron transfer reaction. The whole process was mapped out by spectroscopic and crystallographic characterization of the intermediates and products.

What We’re In For

What would our climate future look like if we stopped building any new infrastructure that used fossil fuels? Davis et al. (p. 1330; see the Perspective by Hoffert) made the assumption that all existing infrastructure would be used until the end of its lifetime, after which it will be replaced by infrastructure that does not produce CO₂. They then calculated the amount of additional CO₂ that will be added to the atmosphere. The outcome is that the concentration of atmospheric CO₂ would remain below 430 parts per million (ppm) (present levels are 390 ppm) and global mean temperatures would increase to 1.3°C above preindustrial values (about 0.5°C above present), well below current targets of 450 ppm and 2°C, respectively.

Biodiversity Convention

In October 2010, the Convention on Biological Diversity will meet to assess the current condition of global biodiversity and to propose and agree on priorities for its future conservation. In this context, Rands et al. (p. 1298; see the News Focus section; see the cover) review recent patterns of biodiversity conservation, highlighting successes, as well as current and future threats. They argue that biodiversity should be treated as a public good, with responsibility for its conservation integrated across sectors of society and government, rather than be confined to the business of environmental agencies, and review the conditions under which this goal might be achieved.

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Stem Cell Expansion

The ability to expand hematopoietic stem cells (HSCs) during ex-vivo culture has been an important goal for over 20 years. Using a high-throughput chemical screen, Boitano et al. (p. 1345, published online 5 August; see the Perspective by Sauvageau and Humphries) found that a purine derivative, StemRegenin1 (SR1), promoted the expansion of human HSCs. Treatment of HSCs with SR1 (which blocked the activity of the aryl hydrocarbon receptor) led to the expansion of CD34+ cells and a 12 to 17-fold increase in the number of HSCs that engraft immune deficient mice.

Transient Protein Conformations

Transient conformations are important to protein function; however, detecting and characterizing these states is technically challenging. Korzhnev et al. (p. 1312; see the Perspective by Al-Hashimi) combined recently developed methods to determine the three-dimensional atomic-resolution structure of a transient intermediate of a four-helix bundle protein domain. The intermediate formed rapidly but, owing to structural peculiarities, slowly rearranged into its native state. The methods can be applied not only to folding intermediates but also to excited states important for protein function.

UnSIRT6ain Repair

Efficient and accurate repair of double-strand DNA breaks is critical for genome stability and involves a process known as homologous recombination. During repair of the sheared ends, the DNA must be resected by trimming one of the two strands on either side of the break. For the repair to be accurate, the remaining single-stranded DNA (ssDNA) has to be bound by the ssDNA-binding protein, RPA, after which the ssDNA can then bind homologous sequences. Kaidi et al. (p. 1348) found that the mammalian deacetylase, SIRT6 (which has been implicated in maintaining genome stability), was critical for resection. At sites of DNA damage, SIRT6 deacetylated and activated CtIP (a protein important for resection), ensuring that resection occurred at the appropriate place and time.

CRISPR Processing

Many bacteria and archaea recognize invading viruses and plasmids. Foreign DNA is integrated into so-called clustered regularly interspaced short palindromic repeat (CRISPR) loci, and transcripts from these loci are processed into RNAs that can target the invading DNA or RNA for destruction. To investigate the molecular basis for this processing, Haurwitz et al. (p. 1355) screened CRISPR-associated (Cas) proteins in the opportunistic pathogen Pseudomonas aeruginosa and found they were capable of cleaving the CRISPR transcripts. The crystal structure of Cas4 with the CRISPR RNA transcript revealed how the protein specifically recognized RNA repeats, as well as the mechanism of endonucleolytic cleavage.

Connectivity Map of the Brain

The growing appreciation that clinically abnormal behaviors in children and adolescents may be influenced or perhaps even initiated by developmental miscues has stoked an interest in mapping normal human brain maturation. Several groups have documented changes in gray and white matter using structural and functional magnetic resonance imaging (fMRI) in cross-sectional and longitudinal studies. Dosenbach et al. (p. 1358) developed an index of resting-state functional connectivity (that is, how tightly neuronal activities in distinct brain regions are correlated while the subject is at rest or even asleep) from analyses of three independent data sets (each based on fMRI scans of 150 to 200 individuals from ages 6 to 35 years old). Long-range connections increased with age and short-range connections decreased, indicating that networks become sparser and sharper with brain maturation.