Redox Dragonflies

Animals exhibit beautiful and varied color patterns that assist in species and gender recognition and avoiding detection. Sexual maturity is also signaled by color change in insects, birds, and mammals. In dragonflies of the genera Crocethemis and Sympetrum, the male displays yellow body coloration when young but is bright red when sexually mature. Futahashi et al. reveal that the redox state of epidermal ommochrome pigments confers this sex-related change. When the ratio of the reduced form to the oxidized form is higher, as in adult males, red color results. Females and immature males, which are yellow, have a lower ratio. When reductant or oxidant was added to extracted dragonfly pigments in vitro, color transitions were observed. In addition, reductant injected into immature males and mature females resulted in a change to the vivid red seen in adult males. These results extend our knowledge of the role of oxidants and reductants in regulating animal pigmentation, as previously shown in fruit flies and butterflies. — BAP


GENETICS

Genetic Transfer Sighted

In the early 1950s, Martha Chase and Alfred Hershey used radioisotope labeling of the protein and DNA of a bacteriophage to show that DNA, rather than the proteins that they expected, facilitated the transfer of genetic information for new phage replication within a bacterial cell. Van Valen et al. now report visual confirmation, in real time, of single fluorescently labeled molecules of DNA from bacteriophage lambda being ejected into live Escherichia coli cells. The authors’ method reveals properties of the DNA ejection event that differ from those measured by in vitro detection of DNA ejected from phage artificially treated with a bacterial outer membrane protein. Transfer to the live cell took several minutes—10 to 100 times longer than had been observed in vitro. Further characterization of variable timing of the transfer, pausing during transfer, and rates of transfer in relation to the amount of DNA transferred begin to shed light on fundamental aspects of the process that remain mysterious. Specifically, they increase our understanding of the relative extent to which transfer is promoted by molecular motors, by the energy of compaction of the DNA in the bacteriophage capsid, or by events within the bacterial cell. — LBR


BIOENGINEERING

Silk Replaces Refrigeration

Both vaccines and antibiotics lessen the burden of disease—one before the fact and one after. Successful treatment often requires a “cold chain,” in which the vaccine or antibiotic must be refrigerated from production to patient. Failure to sustain the cold chain results in loss of therapeutic efficacy, but maintaining it can be expensive, especially in developing countries. Zhang et al. demonstrate the use of silk to stabilize labile vaccine compounds at ambient temperatures. Silk fibroin, the protein polymer from silkworm cocoons, can be formed into more than scarves and ties. Specifically, as a film, silk contains tiny pockets that can harbor and protect sensitive molecules. The authors tested the efficacy of silk encapsulation on live measles, mumps, and rubella (MMR) vaccines, as well as the antibiotics penicillin and tetracycline. Their results suggest that such encapsulation can protect the compounds from degradation and temperature-induced denaturation. The activity of the MMR vaccine and the two antibiotics, as assessed with in vitro tests, was even protected in temperatures up to 60°C. This surprising application for silk has the potential to reduce reliance on the cold chain, a possibility that could be especially valuable where electricity and refrigeration are hard to come by. — PJH


BIOMEDICINE

RAC and Ruin in Melanoma

Despite the increased use of sunscreens, the incidence of melanoma, the most lethal form of skin cancer, remains high. Tumor genome sequencing has led to new therapies targeting BRAF, a protein kinase that is activated by mutation in about 50% of melanomas and helps drive tumor growth. Because the development of resistance to BRAF inhibitors limits their long-term efficacy, there is considerable interest in identifying additional driver mutations that might form the basis of new or combination therapies.

Toward this end, Krauthammer et al. sequenced the protein-coding regions of 147 human melanoma genomes. Notably, 9% of sun-exposed melanomas harbored a point mutation in RAC1, which encodes a small GTPase (an enzyme hydrolyzing guanosine triphosphate) that regulates cytoskeletal rearrangements. Structural and functional
analysis revealed that the mutation increases RAC1 binding to its downstream effectors, including PAK1 (p21-activated protein kinase), and induces melanocyte growth and migration. PAK kinases are therefore potentially druggable targets for melanoma treatment. In independent work, Hodis et al. found the same activating RAC1 mutation in 5% of their melanoma samples. — PAK

Nat. Genet. 10.1038/ng2359 (2012); Cell 150, 251 (2012).

CHEMISTRY

Aromatizing Ethers

Aryl ethers are common motifs in the production of commercially important organic compounds. Generally, they are prepared from precursors that already contain the aromatic ring (either by coupling a carbon center to a phenolic oxygen or coupling an alcohol to an aryl carbon). Simon et al. have developed a complementary approach that combines an alcohol with a cy-clohexenone derivative and then aromatizes the framework after carbon-oxygen bond formation. They initially used cupric chloride as a coupling agent, together with O₂ as an oxidant. Adding an organic radical source as co-catalyst and replacing the counterions with triflate together with potassium iodide reduced the necessary copper loading to 10%. The reaction tolerates a range of functional groups, including esters, alkenes (both internal and terminal), and aryl iodides poised for further elaboration by cross-coupling techniques. Control experiments preclude the intermediacy of phenol, thus implicating a mechanism in which alcohol addition to the carbonyl precedes hydrogen abstractions that produce the aromatic ring. — JSY


CLIMATE SCIENCE

Understanding Past CO₂

Overall, atmospheric CO₂ levels have decreased during the Cenozoic (the geological era that started 65 million years ago), coinciding with a broad cooling of Earth. Several prominent warm excursions, however, provide opportunities to calibrate the climate of CO₂ and offer comparisons for understanding the long-term effect of human CO₂ emissions. A requirement for such an analysis is a good understanding of past CO₂ levels. One prominent warmer excursion occurred during the Miocene, about 15 million years ago, when temperatures are thought to have warmed by about 3°C and sea level rose as, it is thought, the growth of the Antarctic Ice Sheet abated. Foster et al. analyzed two deep-sea cores and reconstructed detailed CO₂ levels across this excursion based on boron isotopes in foraminifera, a phylum of amoeboid protists commonly associated with marine plankton. The boron isotopic ratio of seawater varies with pH, which in turn is influenced by atmospheric CO₂ levels. Their data, broadly consistent with other measurements, imply that CO₂ levels during the warmest part of the Miocene excursion were about 400 ppm, comparable to the levels that we have reached recently. Broad excursions in the global ice volume during the Miocene coupled with these modest atmospheric CO₂ levels suggest that the Antarctic Ice Sheet was rather sensitive to this modest forcing at that time. — BH


APPLIED PHYSICS

Semiconductor Standards

Modern technology is dependent on components that perform as specified and often within extremely high tolerance. The specification of each component, whether it delivers a current, a voltage, or a resistance, is typically calibrated (although usually not directly) against a quantum standard that is dependent on only fundamental constants. These quantum standards are usually operated at a national laboratory. Secondary standards are then shipped out to factories where the components can be calibrated. Usually, each quantum standard is a separate device: superconductors for voltage and semiconductors for current and resistance. Hohls et al. demonstrate an integrated quantized circuit with which the so-called metrological triangle (V, I, and R) can be closed with a single semiconductor-based device. Using GaAs, they combined an integrated single-charge pump with a quantum Hall resistor to provide a quantized voltage source. Such a monolithic approach should be applicable to other materials, such as silicon or graphene, and could provide a platform for developing quantum standard devices on a single chip. — ISO

Silk Replaces Refrigeration
Pamela J. Hines

Science 337 (6095), 624.
DOI: 10.1126/science.337.6095.624-c