Deep Impact?

On 15 February 2013, the Russian district of Chelyabinsk, with a population of more than 1 million, suffered the impact and atmospheric explosion of a 20-meter-wide asteroid—the largest impact on Earth by an asteroid since 1908. Popova et al. (p. 1069, published online 7 November; see the Perspective by Chapman) provide a comprehensive description of this event and of the body that caused it, including detailed information on the asteroid orbit and atmospheric trajectory, damage assessment, and meteorite recovery and characterization.

Lighter Hydrogenation Catalysts

Enzymes have evolved to use abundant metals such as iron, cobalt, and nickel for redox catalysis. However, synthetic catalysis has generally relied on the rarer, heavier relatives of these elements: ruthenium, rhodium, iridium, palladium, and platinum (see the Perspective by Bullock). Friedfeld et al. (p. 1076) used high-throughput screening to show that the right cobalt precursor can be activated for asymmetric hydrogenation catalysis by using the traditional ligands developed for the precious metals. Zuo et al. (p. 1080) focused on iron, demonstrating a highly effective asymmetric transfer hydrogenation catalyst that uses a ligand rationally designed after careful mechanistic study. Jagadeesh et al. (p. 1073) prepared supported iron catalysts that selectively reduce nitro substituents on aromatic rings to amines, thereby facilitating the preparation of a wide range of aniline derivatives.

Remembrance of Places Past

The hippocampus has two major roles in cognition. Place-responsive neurons form a context-sensitive cognitive map, firing more strongly when an animal traverses specific regions of its environment. Both humans and animals use the hippocampus to learn their way around novel environments. Similarly, the hippocampus is critical for our ability to remember a specific event in space and time. It has thus been suggested that the spatial and memory functions of the hippocampus reflect a common architecture. Recording from neurosurgical patients playing a virtual reality memory game, Miller et al. (p. 1111) found that the recall of events was indeed associated with reinstatement of the place-firing of neurons activated as the subjects navigated through the environment.

Foil-Forged Images

X-ray diffraction is widely used to determine molecular geometries and can often distinguish mirror image isomers (enantiomers), which generally requires well-ordered crystals. Herwig et al. (p. 1084) report an imaging technique to characterize enantiomers in the gas phase. A succession of ionization events were induced by passage through a carbon foil that culminated in a Coulomb explosion of mutually repelling nuclei. The trajectories of these nuclei precisely reflected the original molecular structure.

Cholesterol and Cancer

Obesity and high cholesterol levels are associated with an increased risk of breast cancer in postmenopausal women. Nelson et al. (p. 1094) found that a specific metabolite of cholesterol, 27-hydroxycholesterol (27HC), promoted tumor growth and metastasis in mouse models of mammary cancer by serving as a partial agonist for the estrogen receptor and the liver X receptor. The most aggressive human breast cancers were found to express the highest level of the enzyme that converts cholesterol to 27HC, suggesting that 27HC produced within tumors (in addition to circulating 27HC) may contribute to tumorigenesis.

Banding Together

It is important to understand how and where the Antarctic Ice Sheet and underlying ground are coupled, if we want to predict the glacial contribution to sea level rise. Sergienko and Hindmarsh (p. 1086, published online 7 November) used observations of ice surface velocities, ice surface elevations, and bed elevations to perform inverse calculations of basal shear stress. Areas of high basal stress were distributed in riblike patterns embedded in much larger areas of no basal shear stress, which may affect the rates at which ice is discharged into the ocean.

Deciphering Hepatitis C

Hepatitis C virus is a major cause of liver disease and cancer. Two envelope glycoproteins, E1 and E2, form a heterodimer that facilitates infection. The envelope proteins have been difficult to crystallize, hindering vaccine development. Kong et al. (p. 1090) designed an E2 core glycoprotein construct and solved the crystal structure of the glycosylated protein in complex with a broadly neutralizing antibody. The host cell receptor binding site was identified by electron microscopy and mutagenesis. The findings should help in future drug and vaccine design.

Don’t Ape Protein Variation

Changes in DNA and messenger RNA (mRNA) expression levels have been used to estimate evolutionary changes between species. However protein expression levels may better reflect selection on divergent and constrained phenotypes. Khan et al. (p. 1100, published online 17 October; see the Perspective by Vogel) measured the differences among and within species between mRNA expression and protein levels in humans, chimpanzees, and rhesus macaques, identifying protein transcripts that seem to be under lineage-specific constraint between humans and chimpanzees.

Newlywed Game?

The extent to which our “gut” feelings influence our social interactions has been a matter of debate. Social psychologists have sometimes been criticized for their reliance on short-term analyses of undergraduates as test subjects. McNulty et al. (p. 1119) measured explicit and implicit attitudes of newlywed couples toward one another twice a year for 4 years. Over time, the implicit or unaware evaluations of the relationship predicted changes of marital satisfaction, whereas the explicit or conscious evaluations did not.
Keeping Quiet

Many bacteria overcome antibiotic treatment by expressing proteins that confer antibiotic resistance, for instance, efflux pumps. But when a strain that expresses these antibiotic resistance proteins encounters an environment containing the corresponding drug, the resistance against the drug may paradoxically become silenced in many cells. In this case, a fraction of a population of genetically identical cells will grow in the presence of antibiotics while other subpopulations fail to grow at all. Deris et al. (p. 1068) show that this bistable response arises from a built-in global feedback originating in antibiotic-mediated inhibition of growth, which reduces the expression of proteins that protect against growth inhibition. The resulting populations of dormant cells can exceed 50%, among otherwise identical resistance-expressing cells. This is important for antimicrobial treatment strategies because many bacterial cells may remain vulnerable to an antibiotic even when they apparently display strong resistance to it.

Protecting Self-Replicating RNA?

The potential for self-replication makes RNA an attractive candidate as a primordial catalysis in the origin of life. Catalysis may have occurred in some kind of compartment, possibly a fatty acid vesicle. However, RNA catalysis generally requires high levels of magnesium, which are incompatible with fatty acid vesicle integrity. Adamaala and Szostak (p. 1098) screened magnesium chelators and found that several—including citrate, isocitrate, and oxalate—could maintain the membrane stability of fatty acid vesicles in the presence of Mg\textsuperscript{2+}. Citrate also allowed Mg\textsuperscript{2+}-dependent RNA synthesis within protocell-like vesicles, while at the same time protecting RNA from Mg\textsuperscript{2+}-catalyzed degradation.

Neuronal Activity and Dendrite Development

How does the developing brain establish the correct connections? Matsui et al. (p. 1114, published online 31 October) discovered an activity-dependent transcription mechanism during mouse and ferret visual cortex development that controls the direction of dendrite orientation, allowing dendrites to steer toward active axons and away from inactive axons. This mechanism enables the construction of polarized neuronal shapes for integration into neural circuits with the required fine-scale architecture to process subtle activity patterns, a property underlying complex behavior.

Complexing Photosynthesis

Photosynthesis operates through a series of protein complexes that harvest sunlight and turn it into chemical energy. The separate complexes—including photosystems I and II, phycobilisome antennae, and reaction centers—are understood for a number of photosynthetic organisms; however, the large-scale organization and interactions between them are less clear. Using protein cross-linking, Liu et al. (p. 1104) demonstrate how the individual components are organized when present as a megacomplex in the cyanobacterium *Synechocystis* PCC 6803. Time-resolved fluorescence spectroscopy indicated that the phycobilisomes transfer energy to both photosystems, which is consistent with their molecular arrangement.

It Takes a Few

Persistent maintenance of long-term potentiation (LTP) of glutamatergic synapses and long-term memory requires neuronal nuclear signaling that leads to gene transcription. It is unclear whether signaling produced at a single dendritic spine can be transmitted into the nucleus to regulate gene transcription. Using two-photon glutamate uncaging in combination with two-photon fluorescence lifetime imaging, Zhai et al. (p. 1107) show that induction of LTP in only three to seven dendritic spines in a hippocampal pyramidal neuron can trigger activation of nuclear extracellular signal-regulated kinase and downstream transcription factors cyclic adenosine monophosphate response element–binding protein and E26-like transcription factor-1. Thus, signaling initiated in each dendritic spine can be transmitted into the nucleus to regulate gene transcription. Furthermore, biochemical signaling in multiple dendritic branches was integrated to activate the nuclear signaling.