Geometric Propulsion

The Schwarzschild geometry describes the curvature of space-time around a mass. As mass increases, a critical Schwarzschild radius is approached such that gravity becomes strong enough to keep everything from escaping—thus creating a black hole. According to a study by **Wisdom** (p. 1865; see the 28 February news story by **Seife**), a quasi-rigid body can translate in space just by changing its shape in the Schwarzschild geometry. No external forces are necessary—the amount of translation is mainly related to the amount of intrinsic curvature. Such geometric propulsion may be miniscule for the slight curvature of space-time in the universe. Nevertheless, any previously unforeseen propulsion may be accounted for with this result.

Make It a Double Blend

The mechanical properties of conducting polymers can be improved by blending them with tougher materials, but to maintain conductivity, the conducting polymer must be present in concentrations above the percolation threshold. The necessary volume fraction decreases if the particles take on an elongated shape. **Mezzenga *et al.*** (p. 1872) show that this minimum volume fraction can be further reduced through a double-blending process. The conducting polymer is first dispersed into a third polymer, and this blend is then percolated through the matrix material.

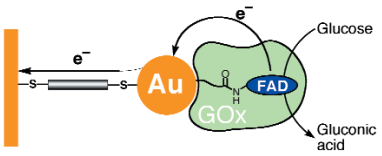
Beachfront Properties

Sand on beaches is scavenged to offshore sandbars by the large powerful waves and currents of coastal storms, and then slowly brought back by the frequent, more regular waves that normally prevail. Successfully modeling these effects is critical to understand beach evolution and aiding and focusing expensive engineering efforts aimed at saving or restoring beaches and mitigating property damage during storms. Most models have not been able to reproduce processes for more than a few days. **Hoefel and Elgar** (p. 1885; see the Perspective by **Stive and Reniers**) have now produced a model that captured sand movement for more than 45 days, a period that included several storms. Their model specifically accounts for the accelerations at the base of random waves impacting offshore sandbars.

Controlling the Behavior of a Schrödinger's Cat

Certain macroscopic objects can be treated as quantum-mechanical systems, provided they are handled properly. In addition to their uses as experimental test beds to study fundamental questions in quantum mechanics, there is a real potential to use them as processing elements (qubits) in solid-state quantum computers. Although there are now several proposals for such qubits, it is unclear which is likely to win. Adding to the list of potential candidates, **Chiorescu *et al.*** (p. 1869; see the Perspective by **Clarke**) demonstrate a magnetic-flux qubit consisting of three Josephson junctions in series on a superconducting loop. The long coherence times and relative simplicity of fabrication, manipulation, and readout make the system a strong contender for practical applications.

Connecting Metal Leads to Enzymes



1877

Enzymes that perform redox reactions usually have optimized the electron transfer pathway by creating close molecular contacts. Thus, attempts to immobilize enzymes on electrodes often lead to much slower rates because of the distance barrier for electron transfer. Recently, it has been shown that attaching cofactors such as flavin adenine dinucleotide (FAD) directly to the electrodes can recover the loss in rates. **Xiao *et al.*** (p. 1877) now show that electron transfer rates can exceed that of the natural cofactor by almost a factor of 7. Gold nanoparticles were functionalized with FAD and incorporated into a conducting film. The cofactor-free form of the flavoenzyme glucose oxidase bound to the exposed FAD cofactor, and the gold nanoparticles, acted as the electron acceptor instead of oxygen.

Very Small, Very Stable Silicon Wires

A critical issue in the creation of silicon nanostructures is the formation of surface oxides. **Ma *et al.*** (p. 1874; see the cover) fabricated silicon nanowires by reducing silicon oxide at elevated temperatures and then stabilized the nanowires by dipping them in HF solution. In agreement with theoretical predictions, quantum-confinement effects were observed in the smallest diameter wires by scanning tunneling spectroscopy. The hydrogen-coated wire ends proved to be much more stable in air than similarly treated silicon wafers.

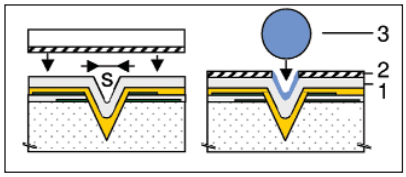
Twice by Sea to Land

Hexapods—six-legged arthropods—have been thought to be derived from a common ancestor that adapted to a terrestrial environment. **Nardi *et al.*** (p. 1887; see the Perspective by **Thomas**), in an analysis of mitochondrial genomes, provide evidence to suggest that the wingless hexapods (from the groups Collembola and Zygentoma) evolved independently from the lineage leading to insects. These results suggest that the passage from water to land occurred at least twice in the hexapods. This radical revision of arthropod phylogeny has implications for interpreting patterns of body plan evolution and of arthropod evolution as a whole.

Cut and Make

In order to manufacture transistor circuits on flexible plastic substrates, multiple layers must be aligned so that features are brought together on the submicrometer scale. Achieving this level of registry can be difficult with traditional lithography, where the fabrication of each layer requires a cycle of mask exposure and

1881



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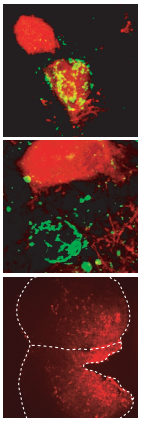
CREDITS: (TOP TO BOTTOM) XIAO *ET AL.*; STUTZMANN *ET AL.*

etching. Using an embossing technique, **Stutzmann *et al.*** (p. 1881) show they can cut through multiple layers to make thin-film organic transistors in both in-plane and vertical device alignments.

Molecules on the March 1889



The alternating left-right limb motion during walking is controlled by a neuronal network in the spinal cord, called the central pattern generator (CPG), whose molecular composition has remained a "black box." **Kullander *et al.*** (p. 1889) have now defined EphA4 receptor-expressing cells as a CPG-specific population of excitatory neurons. The abnormal, synchronous limb movements observed in genetically altered mice that lack functional EphA4 was linked to aberrant axon guidance in a localized region of the spinal cord midline, which resulted in overexcitation of the CPG. Identification of these neurons may now allow further exploration of mammalian CPG architecture and lead to therapeutic approaches to treating spinal cord damage.

RNA Mechanics

Cellular processes such as translation, mechanically deform and unfold RNA. To gain insight into the molecular response of RNA to mechanical forces, **Onoa *et al.*** (p. 1892) have determined mechanical unfolding trajectories for single molecules of the *Tetrahymena thermophila* ribozyme. RNA refolding proceeded smoothly, but unfolding was arrested temporarily at kinetic barriers until they yielded to allow sudden lengthening. The authors attribute the barriers to Mg^{2+}-dependent tertiary contacts. Secondary structures unfolded progressively as these tertiary contacts were broken.

Degrading the Opposition

Growth and development in plants are carefully regulated in response to both intrinsic and extrinsic signals, in part by the hormone gibberellic acid. **Sasaki *et al.*** (p. 1896; see the Perspective by **Harberd**) have now elucidated some of the forces that set up opposing positive and negative controls on gibberellin signaling. A newly identified protein from rice, GID2, functions as a positive regulator by pitching the opposing negative regulator, SLR1, into the hands of the proteosome, where it is promptly degraded.

Neurons That Code for Uncertainty

In the classic Pavlovian experiment, dogs associate the ringing of a bell with subsequent presentation of food. It has since been shown that dopaminergic neurons in the ventral midbrain respond (by spiking) to stimuli that predict the subsequent arrival of rewards. In trials where the reward does not appear, there is a corresponding drop in the activity of these neurons. These findings led to the proposal that the information encoded by these neurons is the prediction error, or the difference between actual and predicted rewards. **Fiorillo *et al.*** (p. 1898; see the Perspective by **Shizgal and Arvanitogiannis**) now find a new population of dopaminergic neurons that appear to encode reward uncertainty; the activity of these neurons increases as the delivery of reward becomes less certain.

The Specific Origin of Slow Inhibition in the Brain

Inhibitory processes play an important role in information processing in the cerebral cortex. The origin of a particular subtype of these processes, slow cortical synaptic events mediated by $GABA_B$ receptors, is not clear. Are they initiated by specific presynaptic cells, or can they be activated by high-frequency action potentials in most interneurons? **Tamás *et al.*** (p. 1902) show that GABA release at synapses between GABAergic neurogliaform interneurons and pyramidal cells in layer 2/3 led to the combined postsynaptic activation of $GABA_A$ and $GABA_B$ receptors. This finding indicates that slow, $GABA_B$-mediated inhibitory postsynaptic potentials arrive from unitary sources in cortical networks.

CREDIT: KULLANDER *ET AL.*

RNA Mechanics

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