**MOLECULAR MACHINES**

**Acid fuels the motion of a threaded ring**

A central goal in the construction of molecular-scale machines is the efficient achievement of one-way motion. Erbas-Cakmak et al. developed a class of machines that transmit pH changes into the two-stage guided motion of molecular rings threaded on a linear or cyclic axle. The design relies on temporary blocking groups and landing sites along the axle that toggle between active and passive states in response to acid or base. Trichloroacetic acid initiates the first stage of motion until it is decomposed by base in the solution, spurring the second phase. —JSY

*Science*, this issue p. 340

**NANOPHOTONICS**

**Harnessing chaos for enhanced coupling**

Functional optical devices typically require the coupling of light between different components. However, conservation of momentum usually limits the bandwidth of the coupling, often to a near-resonant effect. Jiang et al. show that slightly deformed microring resonators might be able to relax those restrictions. The chaotic scattering of the light within the deformed structure can transform optical modes of different angular momenta within a few picoseconds, providing a promising route to develop advanced nanophotonic circuits and devices. —ISO

*Science*, this issue p. 344

**MICROBIOTA**

**Gut reasons to brush your teeth**

Some gut conditions, such as inflammatory bowel disease (IBD), ulcerative colitis, and Crohn’s disease (CD), are associated with imbalances in the gut microbiome community. The causes of these intractable diseases have been difficult to discern. Atarashi et al. took samples from the mouths of IBD and CD patients and inoculated the extracted bacteria into germ-free mice (see the Perspective by Cao). Some of the inoculated mice showed strong proliferation of T helper 1 cells associated with the establishment of oral *Klebsiella* species in the colon. *Klebsiella* can be resistant to multiple antibiotics and are able to replace normal colon microbes after antibiotic therapy. Now we know that they probably originate from the mouth and could potentially contribute to bowel disease. —CA

*Science*, this issue p. 359; see also p. 308

**NEUROSCIENCE**

**Memory transfer for long-term storage**

Explicit memory formation involves the transfer of rapidly encoded information from the hippocampus to long-term storage sites in the association cortex. Khodagholy et al. developed a microelectrode system for large-scale simultaneous electrophysiological monitoring of multiple sites in the rat...
neocortex. They observed discrete high-frequency neocortical oscillations called ripples only in the association cortex. These cortical ripples shared many properties with hippocampal ripples. Hippocampal ripples were coupled with cortical ripples in the posterior parietal cortex, an association cortical area linked to navigational planning. This coupling was increased during sleep after the induction of long-term hippocampal-dependent spatial memory. —PRS

Science, this issue p. 369

INFLUENZA
An antibody to battle flu B
Although it circulates globally and is prevalent enough to warrant inclusion in the seasonal influenza vaccine, influenza B is not nearly as well studied as its cousin influenza A, and therapeutics are lacking. Shen et al. generated a potent antibody that inhibits diverse strains of influenza B virus. The antibody recognizes the receptor-binding site in hemagglutinin, a region critical to viral entry, and was shown to be effective therapeutically in mice and ferrets. This antibody could be widely deployed to treat or prevent influenza B infection around the world. —LP


CANCER
Tumor angiogenesis gets nervous
The microenvironment of solid tumors hosts many intercellular conversations that can either enhance or inhibit tumor growth. Interestingly, the tumor cells need not be direct participants in these conversations. Zahalka et al. studied genetically manipulated mouse models and found that adrenergic signals from autonomic nerves in the prostate cancer microenvironment fueled tumor growth by altering the metabolism of blood vessel endothelial cells (see the Perspective by Hayakawa and Wang). These nerve-derived signals suppressed oxidative phosphorylation in the endothelial cells, activating an angiogenic switch that facilitated rapid tumor growth. This cross-talk between nerves and endothelial cells could potentially offer a target for cancer therapies. —PAK

Science, this issue p. 321; see also p. 305

MARINE BIODIVERSITY
Gradients in marine biodiversity
Marine animal biodiversity increases severalfold toward the tropics, but a general theory to explain this is lacking. Edgar et al. used extensive global surveys to address this question for fish and mobile invertebrates on rocky reefs over 100° of latitude. Regional diversity was highest near the equator, but local diversity reflected abundances that differed between fish, which peaked in the tropics, and invertebrates, which peaked at higher latitudes. These patterns correlated with temperature gradients for fish and nutrients for invertebrates. Thus, fish appear to have limited the local abundance and diversity of invertebrates in the tropics. Regionally, however, diversity depended strongly on the area of suitable reef habitat, raising alarm about the loss of biodiversity as tropical reefs decline. —JJ


IN OTHER JOURNALS

Edited by Caroline Ash and Jesse Smith

Children begin to understand the difference between institutional objects (such as money) and standard artifacts (such as hammers) at a young age.

COGNITIVE SCIENCE
A hammer is a hammer is a hammer
Hammers are designed to strike other objects, such as a nail or a rivet. A hammer’s use is independent of cultural norms or social agreements, in contrast to money, whose value and function as a medium of exchange very much relies on a common understanding, which can change when the consensus changes. Noyes et al. show that young children begin to grasp the difference between what the authors refer to as institutional (socially dependent) objects and standard artifacts, such as hammers and chairs, between the ages of 4 and 9 years. —GJC


EPILEPSY
Small groups influence large networks
How small groups of neurons can interact with large networks in the brain is a crucial question in epilepsy research. Eissa et al. analyzed multielectrode array recordings from epileptic patients and found that during seizures, local action-potential activity organized into tiny wave fronts that correlated with network activity on scales that were orders of magnitude larger. These correlations did not exist between seizures or neuronal activity outside the wave front. Computational modeling revealed an antagonistic role for feedforward inhibition. At the local level, inhibition failed, which permitted the wave front to propagate. In contrast, at a much larger scale, feedforward inhibition created the conditions for the seizure to cease after the wave front had vanished. —PRS


CELL BIOLOGY
PolyQ caught in the act?
Huntington’s disease is a neurodegenerative disorder caused by the expanded

Neurons (green) may promote increases in blood vessels (white) in prostate cancer.

Photos: Elliott Zahalka et al.; right: istock.com/Danchooalex

PolyQ protein is caught in the act (see the Perspective by Hayakawa and Wang). These nerve-derived signals suppressed oxidative phosphorylation in the endothelial cells, activating an angiogenic switch that facilitated rapid tumor growth. This cross-talk between nerves and endothelial cells could potentially offer a target for cancer therapies. —PAK

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Huntington’s disease is a neurodegenerative disorder caused by the expanded
antibodies produced by naive small intestinal plasma cells are recirculated and enriched within Peyers patches, independently of exogenous antigen and T cell help. The resulting polyreactive IgAs are released into the gut lumen and bind to microbial surface glycans, thus innately recognizing the gut microbiota. Polyreactive IgAs appear to be a product of the coevolution of host and microbiota to maintain symbiotic homeostasis. —CA

Science, this issue p. 320

ENZYMEOLOGY
Refueling an enzyme
Lipoic acid is an eight-carbon fatty acid in which sulfur groups are appended on two carbon atoms by the enzyme lipo synthase (LipA). LipA provides the sulfurs from an auxiliary [4Fe-4S] cluster. McCarthy and Booker show that in Escherichia coli, the auxiliary LipA cluster is reconstituted by the iron-sulfur cluster carrier protein NfuA (see the Perspective by Rosenzweig). This occurs fast enough that LipA can act catalytically in the final step of lipoic acid biosynthesis. —VV

Science, this issue p. 373; see also p. 307

INNATE IMMUNITY
Programmed recognition of microbiota
Increasingly, we recognize that the gut is a specialized organ for maintaining microbial symbioses alongside nutritional functions. The gut produces large quantities of immunoglobulin A (IgA), which adheres to the surface of gut microbes. Bunker et al. discovered that case: conversion of vinylidene (H2C=CH) to acetylene (HCCH). The technique probed specific states of vinylidene by ejecting electrons with varying energies from a negative ion precursor. Experimental data and accompanying theoretical simulations pinpointed a vibrational rocking mode that facilitated the migration. Replacement of hydrogen with its heavier deuterium isotope disrupted this pathway. —JSY

Science, this issue p. 336

FRAMEWORK COMPOUNDS
Tuning porosity with electric fields
Many metal-organic framework (MOF) compounds exhibit soft porosity — i.e., their lattices can undergo considerable deformation. Knebel et al. formed membrane layers of the MOF ZIF-8 and found that it was converted into a polar polymorph with a stiffer lattice in response to an applied electric field (see the Perspective by Gascon). This change reduced gas transport but, for certain gas mixtures such as propane and propene, also improved their separation factor. —PDS

Science, this issue p. 347; see also p. 303

POLYMERS
Watching growth, step by step
Polymers can grow through the stepwise addition of monomers to an active end site. One might think that this would happen in a continuous linear process. With a focus on ring-opening metathesis polymerization of norborneone catalyzed by a Grubbs catalyst, Liu et al. describe the growth of a single polymer chain. By attaching one end of a growing polymer to a bead exerting a constant force on it, they measured the extension occurring during the growth of the polymer. Oddly, the extension of the growing polymer did not increase continuously. Instead, it exhibited consecutive wait-and-jump steps, owing to conformational entanglements formed by newly incorporated monomers. —MSL

Science, this issue p. 352

2D MATERIALS
Expanding the world of 2D materials
Two-dimensional (2D) materials have a wide variety of potential applications in the electronics industry. However, certain compositions of 2D materials are difficult to obtain owing to the challenges in exfoliating thin sheets from bulk crystals. Zavabeti et al. exploited liquid metals to synthesize 2D Ga2O3, HfO2, Ga2O3, and Al2O3. The 2D sheets appear as a surface layer in gallium-based liquid metals after the Hf, Ga, or Al is dissolved into the bulk alloy. The 2D oxide that appears on the surface is the oxide with the lowest energy.

Science, this issue p. 356

CHEMICAL PHYSICS
Tracking collisions in just one beam
Much of what we know about how quantum mechanics dictates chemical dynamics comes from half a century of studying controlled collisions between crossed pairs of molecular beams. Perreault et al. now show that even finer detail emerges in a study of hydrogen-deuterium (HD) collisions with D2 in a single beam. The experimental setup lowers the collision temperature to ~1 K, allowing precise control over the rotational energy and relative alignment of the colliding partners. Scattering events in which HD loses rotational energy occurred three times as readily if the HD was aligned perpendicular rather than parallel to the beam-propagation axis. —JSY

Science, this issue p. 356

CATALYSIS
A MOF sets the stage to make amines
Reductive amination is a common method that chemists use to make carbon-nitrogen bonds. The reaction, which often requires precious metal catalysts, couples ammonia or other amines with carbonyl compounds and then with hydrogen. Jagadeesh et al. report a class of nonprecious cobalt nanoparticles that catalyze this reaction across a very broad range of substrates, including complex molecules of pharmaceutical interest (see the Perspective by Chen and Xu). The cobalt was first embedded in a metal-organic framework (MOF), which, upon heating, transformed into a graphic shell. The catalyst could be conveniently separated from products and recycled up to six times. —JSY

Science, this issue p. 326; see also p. 304

OPTICS
Slow light on the nanoscale
When light passes through an optical material, its speed is reduced by the refractive index of that material. Under exceptional circumstances, light can be slowed to a walking pace or even stopped momentarily. Exploring approaches for practical applications, Tsakmakidis et al. review how the speed of light can be controlled using designed materials and fabricated structures. They show how the combination of slow light and nanotechnology gives rise to a number of effects of interest in signal processing and optoelectronic communication. —ISO

Science, this issue p. 319

CHEMICAL PHYSICS
The quantum mechanics of a hydrogen hop
Hydrogen migration between adjacent carbons is widespread in the reaction mechanisms of organic chemistry. DeVine et al. used photoelectron spectroscopy to discern the quantum mechanical underpinnings of this 1,2 shift in a prototypical

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suggesting that it should be possible to make other 2D oxides by using the same process. —BG

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**EVO-DEVO**

Fans enable water strider adaptation

Genomes of closely related organisms are similar but contain variations that enable different phenotypes and lifestyles. The origin of evolutionary innovations, such as insect wings and bird feathers, poses a challenge to evolutionary biology because the de novo emergence of complex traits cannot easily be explained by natural selection. Water-walking *Rhagovelia* insects evolved a propelling fan on the middle leg that is associated with life on fast-flowing streams. Santos et al. discovered that the geisha and mother-of-geisha genes underlie fan development and evolution and that this evolutionary innovation is essential to the adaptation of *Rhagovelia* to its environment. Thus, the evolution of taxon-restricted genes can contribute directly to taxon-restricted novelties that allow access to unexploited ecological niches. —BAP

**CELL BIOLOGY**

Learning the smell of danger

If avoiding infection is not possible, being prepared is the next-best option for preventing pathogen-induced cellular damage. Ooi and Prahlad found that previous experience of the odor of a pathogenic bacterium in the nematode *Caenorhabditis elegans* enhanced heat shock factor 1 (HSF-1) target gene expression, which increased survival during subsequent encounters. Exposure to the pathogen odor alone caused HSF-1 to accumulate at genomic loci where RNA polymerase II is enriched. Thus, activation of the chaperone HSF-1 is not just an autonomous reaction of cells to protein damage but can be initiated in anticipation of proteotoxic stress. —AV

**IMMUNOLOGICAL MEMORY**

Selecting memory T cells

Recruitment of immune cells to infected tissues relies on interactions between receptors on immune cells and adhesion molecules expressed by vascular endothelial cells, including E- and P-selectins. Osborn et al. compared the trafficking of effector and central memory T (TCM) cells and found that the ability to enter tissues is largely restricted to TCM cells. Interleukin-15–driven transcriptional programming of TCM cells promoted glycosylation of selectin ligands, which allowed these cells to bind E- and P-selectins and enter inflamed tissues. Thus, distinct subsets of memory T cells contribute to immunological recall responses. —AB

**DEVELOPMENT**

Structure of human mTORC1 components

The mTORC1 (mechanistic target of rapamycin complex 1) complex garners much attention as a signaling hub that coordinates input from growth-factor receptors and nutrient availability with metabolism and cell growth and proliferation. de Araujo et al. report the crystal structure of the LAMTOR (or “Ragulator”) complex that helps assemble mTORC1 at the lysosomal membrane for activation. The structure and functional studies reveal how LAMTOR1 wraps around the other subunits to hold them in place and interacts with the Rag guanosine triphosphatases in the complex. —LBR

**STRUCTURAL BIOLOGY**

A strategy for drug discovery

Dopamine receptors are G protein–coupled receptors implicated in many neurological disorders. Different families of dopamine receptors are involved in different signaling pathways, so specificity is a key goal of therapeutics. Wang et al. present high-resolution crystal structures of the DRD4 dopamine receptor bound to the antipsychotic drug nemonapride. The high resolution of the structures facilitated ligand docking, and a DRD4–selective agonist was identified by computational screening of a large library, experimental testing of compounds with the best docking scores, and iterative cycles of docking and testing analogs of those compounds. The identified agonist had a high affinity for DRD4 and no measurable affinity for DRD2 or DRD3. —VV

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