Internal dynamics of femtosecond soliton molecules

**NONLINEAR OPTICS**

Probing the interaction of solitons

As a pulse of light propagates through a medium, scattering and dispersion processes usually result in the pulse diffusing. However, under certain circumstances, the dispersion processes can be balanced by nonlinearities to produce localized structures known as solitons or optical bullets. Herink et al. used spectral interferometry to image and track the formation of soliton complexes as they propagated in a laser cavity. Real-time access to the formation processes and complex interaction dynamics could help in modeling other nonlinear systems. —ISO

Science, this issue p. 50

**CELIAC DISEASE**

Viruses compound dietary pathology

Reoviruses commonly infect humans and mice asymptptomatically. Bouziat et al. found that immune responses to two gut-infecting reoviruses take different paths in mice (see the Perspective by Verdu and Caminero). Both reoviruses invoked protective immune responses, but for one reovirus, when infection happened in the presence of a dietary antigen (such as gluten or ovalbumin), tolerance to the dietary antigen was lost. This was because this strain prevented the formation of tolerogenic T cells. Instead, it promoted T helper 1 immnity to the dietary antigen through interferon regulatory factor 1 signaling. Celiac disease patients also exhibited elevated levels of antibodies against reovirus. —CA and KLM

Science, this issue p. 44; see also p. 29

**SOLAR CELLS**

Seeing hot carriers break the limit

If charge carriers in solar cells can be harvested before they cool on their way to equilibrium, then the Shockley-Queisser limit of 33% for solar cell efficiency can potentially be beaten. Long carrier lifetimes (~100 ps) have been reported for hybrid organic-inorganic metal halide perovskites. Guo et al. imaged charge transport in CH$_3$NH$_3$PbI$_3$ thin films with transient absorption microscopy. Hot carriers could travel up to 600 nm, which suggests that devices that harvest hot carriers may be feasible. —PDS

Science, this issue p. 73

**MEMORY RESEARCH**

The network of memory consolidation

Memories are thought to be formed in the hippocampus and later moved to the neocortex for long-term storage. However, little is known about the mechanisms that underlie the formation and maturation of neocortical memories and their interaction with the hippocampal network. Kitamura et al. discovered that at the onset of learning, neurons for contextual fear memory are quickly produced in the prefrontal cortex. This process depends on the activity of afferents from both the hippocampus and the amygdala.

Over time, the prefrontal neurons consolidate their role in memory expression. In contrast, the hippocampal neurons slowly lose this function. —PRS

Science, this issue p. 50

**POLYMERS**

Processable cross-linked polymers

Thermoplastics can be made stiffer and more durable by cross-linking them, but this makes it more difficult to reprocess and recycle them. Röttger et al. show that the transesterification of boronic esters grafted onto common polymers such as polyethylene and polystyrene improves their shape stability and chemical resistance. However, unlike traditionally cross-linked materials, their polymers can still be extruded or injection-molded. This is because the covalent cross-links can undergo rapid

Tabletop apparatus dissects an electrocyclic reaction

*Attar et al., p. 54*
exchange reactions, which allows the material to flow at high temperatures while still retaining a cross-linked structure. —MSL

**RESEARCH ECONOMICS**

**Patents from papers both basic and applied**

Public funding for research depends on the idea that the resulting knowledge translates into socially valuable outcomes, such as medicines. Such linkages are easier to assert than to prove. Li et al. studied 27 years of grant-level funding by the U.S. National Institutes of Health. About 10% of grants are directly cited by patents, suggesting some technological application, and 30% of grants are cited in research articles that are then cited in patents. Five percent of grants result in papers cited by patents for successfully approved drugs, compared with less than 1% that are cited directly by such patents. These patterns hold regardless of whether the research is more basic or applied. —BW

Science, this issue p. 78

**EMERGING INFECTIONS**

**Fighting filoviruses with antibody therapy**

Ravn and Marburg viruses cause hemorrhagic fever with high morbidity rates in humans. Mire et al. tested the ability of previously identified human monoclonal antibodies to protect guinea pigs from lethal infection. One candidate antibody was administered 5 days after otherwise lethal Marburg or Ravn infection in nonhuman primates and was able to reduce clinical symptoms and confer almost uniform protection. This antibody is a promising therapeutic that could be helpful in future filovirus outbreaks. —LP


**VIRAL GENOMICS**

**The evolution of giant virus genomes**

Some giant viruses encode a genome larger than that of some bacteria, but their evolutionary history is a mystery. Examining the genomes within a sample from a wastewater treatment plant in Austria, Schulz et al. assembled a previously undiscovered giant virus genome, which they used to mine genetic databases for related viruses. The authors thus identified a group of giant viruses with more genes encoding components of the protein translation machinery, including aminoacyl transfer RNA synthetases, than in other giant viruses. Phylogenetic analyses suggest that the genes were acquired in an evolutionarily recent time frame, likely from, and as an adaptation to, their hosts. —LMZ

Science, this issue p. 82

**BIOMEDICAL ENGINEERING**

**Nanoparticles for drug delivery in lungs**

Engineering drug-delivery nanoparticles for adhesion to mucus can increase their residence times in lungs. Schneider et al. alternatively developed mucus-penetrating nanoparticles that exhibit greater retention in the lung and enhanced drug-delivery capability. Retention was related to the size of the particles; those smaller than the average mesh spacing of airway mucus were able to penetrate it, thus defeating physiologic mucus clearance. The result was a more effective and uniform distribution of the particles within the mucus and greater efficacy in a mouse model of acute lung inflammation. —PLY


**NEUROSCIENCE**

**Where to keep information about others?**

Because humans are social animals, it is important for us to store information about others, such as how they look and sound, who they are, and our general impressions. Little is known about how and where in the brain this kind of information is stored. Wang et al. invited subjects to learn biographical facts about a number of imaginary individuals and later scanned their brains during a memory test. They found that portions of a brain region called the anterior temporal lobe represented knowledge about other people in an abstract form. Different content areas of this knowledge—social status, personality traits,
CRISPR BIOLOGY
Variation in prokaryote adaptive immunity
To repel infection by phage and mobile genetic elements, prokaryotes have a form of adaptive immune response and memory invested in clustered regularly interspaced short palindromic repeats and associated proteins (CRISPR-Cas). This molecular machinery can recognize and remember foreign nucleic acids by capturing and retaining small nucleotide sequences. On subsequent encounters, the cognate CRISPR-Cas marshals enzymatic defenses to destroy infecting elements that contain the same sequences. Jackson et al. review the molecular mechanisms by which diverse CRISPR-Cas systems adapt and anticipate novel threats and evade countermeasures from mobile genetic elements. —CA

Science, this issue p. 40

EPIGENETICS
DNA sequence and inherited gene silencing
Cell fate decisions require a gene’s transcriptional status, whether on or off, to be stably and heritably maintained over multiple cell generations. For silenced genes, heterochromatin domains are associated with specific histone post-translational modifications, and these histone marks are maintained during DNA replication and chromosome duplication (see the Perspective by De and Kassis). Laprell et al. show that parental methylated histone H3 lysine 27 (H3K27) nucleosomes in Drosophila are inherited in daughter cells after replication and can repress transcription, but that they are not sufficient to propagate the mark. Tri-methylation of newly incorporated nucleosomes requires recruitment of the methyltransferase Polycomb repressive complex 2 (PRC2) to neighboring cis-regulatory DNA elements. Coleman and Struhl demonstrate that H3K27 trimethylated nucleosomes play a causal role in transmitting epigenetic memory at a Drosophila HOX gene memory anchoring site. Wang and Moazed examine fission yeast and show that both sequence-dependent and chromodomain sequence-independent mechanisms are required for stable epigenetic inheritance of histone modifications and the epigenetic maintenance of silencing. These studies highlight the crucial role of DNA binding for heritable gene silencing during growth and development. —BAP
Science, this issue p. 85, p. 41, p. 88; see also p. 28

DEVICE TECHNOLOGY
Printing nanosheet-network transistors
Two-dimensional (2D) materials such as graphene and metal chalcogenides such as tungsten diselenide (WSe2) are attractive for use in low-cost thin-film transistors (TFTs) because they have high charge-carrier mobility. Kelly et al. printed TFTs from networks of exfoliated dispersions of 2D materials with graphene contacts, WSe2, as the semiconductor, and a boron nitride separator. Electrolytic gating with ionic liquids enabled higher operating currents than achieved with comparable organic TFTs. —PDS
Science, this issue p. 69

NEUROSCIENCE
A tailored look at behavioral pharmacology
It is important to understand how animal behavior is mediated by molecular, cellular, and circuit components of the brain. However, it has been difficult to link the activity of specific molecules in defined cells to behavioral roles. Shields et al. developed an approach to deconstruct behavioral neuropharmacology with cellular specificity. The technique, termed DART (drugs acutely restricted by tethering), uses enzymatic capture to restrict standard drugs to the surface of genetically specified cells without prior modification of the native pharmacological target. The method provides cell-type specificity, endogenous-protein specificity, acute onset, and utility in behaving animals. This enables the activity of specific molecules in defined circuit elements to be causally linked to behavior. —SMH
Science, this issue p. 42

ORGANIC CHEMISTRY
Picking structures out of a lineup
Pharmaceutical research relies critically on determining the correct structures of complex molecules. When well-ordered crystals are not available for x-ray analysis, nuclear magnetic resonance (NMR) spectroscopy is the most common structure-elucidation method. However, sometimes it is hard to distinguish isomers with similar spectra. Liu et al. show a protocol that combines computer modeling with anisotropic NMR data acquired using gel-aligned samples. Because of its uniform sensitivity to relative bond orientations across the whole molecular framework, the method overcomes common pitfalls that can lead to invalid structure assignments. —JSY
Science, this issue p. 54; see also p. 31

CHEMICAL PHYSICS
X-ray vision catches Woodward-Hoffmann
The celebrated Woodward-Hoffmann (W-H) rules rationalize a variety of rapid bond rearrangements in organic molecules. The key insight involved symmetry conservation in the electronic journey from reactant to product. Attar et al. now report femtosecond X-ray absorption spectra and accompanying simulation studies that track shifts in carbon electronic states during one such reaction: the photochemical ring opening of cyclohexadiene to hexatriene (see the Perspective by Sensen). The smooth evolution that occurs in the vicinity of the pericyclic minimum provides direct affirmation of the W-H framework. Moreover, the use of a convenient tabletop apparatus bodes well for future x-ray studies of ultrafast electronic dynamics. —JSY

SCIENCE
pieced together like a jigsaw puzzle. This has resulted in the need for funds and additional data to fill in gaps in order to fully assemble the many chromosomes that make up a eukaryotic genome. Dudchenko et al. used the Hi-C method, which measures the distance between contact points within and between chromosomes for scaffold validation, together with correction and ordering to more completely determine the arrangement of short sequencing reads for genome mapping. They validated their approach through the de novo generation of a complete human genome. A comparative analysis of mosquito genomes was made possible by improving the Culex quinquefasciatus genome assembly and generating the genome of Aedes aegypti, the vector of Zika virus. —LMZ

**PHYSIOLOGY**

**An astrocyte call to arms after brain injury**

Brain injury stimulates the infiltration of peripheral immune cells that may cause persistent secondary tissue damage, impairing patient recovery. Using a mouse model of inflammatory brain injury, Dickens et al. found that astrocytes at the site of inflammation released vesicles into the circulation. When these vesicles reached the liver, they stimulated the secretion of cytokines that mobilized peripheral immune cells to infiltrate the brain. Inhibiting this communication between the brain and liver might accelerate and improve recovery from brain injuries.

—LKF


**HYPOTHESIS**

**From learning to instinct**

The molecular and cellular processes that govern animal learning are relatively well understood, but it is much less clear how animals acquire instincts. In a Perspective, Robinson and Barron argue that instincts evolve from learning and that the underlying processes are the same. Support for this idea comes, for example, from laboratory studies showing that when mice learn to fear an odor, their offspring learn to fear this odor faster than do their parents. Furthermore, in bees and flies, the same neural circuits govern instinctive and learned olfactory responses. Epigenetic changes that affect gene expression without changing the DNA sequence itself may be key to translating a learned response into an instinct that requires no external stimulus. —JFU


**AUTOIMMUNITY**

**Regulating the regulators**

Inhibitory receptors on T cells, including LAG3 (encoded by lymphocyte-activation gene 3), limit immune-mediated damage to the host. LAG3 is expressed by exhausted conventional T cells in the tumor microenvironment. The role of LAG3 in regulatory T cells (Treg) has remained unclear. Zhang et al. studied a mouse model of autoimmune diabetes. Treg-specific deletion of LAG3 led to enhanced Treg proliferation and reduced the incidence of type 1 diabetes. The findings highlight the cell-type dependence and context specificity of LAG3 and call for a more holistic assessment of the functions of inhibitory receptors that are emerging as targets for tumor immunotherapies. —AB