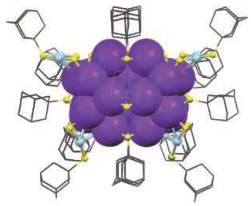
RESEARCH

Atomic packing controls exciton lifetime

Zhou et al., *p. 279*



IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

STRUCTURAL BIOLOGY

Spectrin in mammalian hearing mechanisms

Stereocilia are hair-like structures in the inner ear that transform sound vibration into a neural signal. These structures stop growing in humans early in fetal development, so their resilience is critical to lifelong hearing. Liu *et al*. used stimulated emission depletion imaging of the inner ear hair cells of mice to observe the arrangement of cytoskeletal proteins at the base of stereocilia rootlets. The elasticity of the protein spectrin may allow long-term survival of stereocilia under constant mechanical stress, analogous to the role of spectrin in red blood cell deformability. Damage to the observed ring-like structures of spectrin was associated with hearing loss in mice. —PLY and KJP

Sci. Adv. 10.1126/sciadv.aav7803 (2019).

Stereocilia within the inner ear, shown in a scanning electron micrograph

IMAGES: (TOP TO BOTTOM) ZHOU *ET AL.*; WELLCOME IMAGES/SCIENCE SOURCE

BIOTECHNOLOGY

Spotting off-targets from gene editing

Unintended genomic modifications limit the potential therapeutic use of gene-editing tools. Available methods to find off-targets generally do not work in vivo or detect single-nucleotide changes. Three papers in this issue report new methods for monitoring gene-editing tools in vivo (see the Perspective by Kempton and Qi). Wienert *et al*. followed the recruitment of a DNA repair protein to DNA breaks induced by CRISPR-Cas9, enabling unbiased detection of off-target editing in cellular and animal models. Zuo *et al*. identified off-targets without the interference of natural genetic heterogeneity by injecting base editors into one blastomere of a two-cell mouse embryo and leaving the other genetically identical blastomere unedited. Jin *et al*. performed whole-genome sequencing on individual, genome-edited rice plants to identify unintended mutations. Cytosine, but not adenine, base editors induced numerous single-nucleotide variants in both mouse and rice. —SYM

Science, this issue p. 286, p. 289, p. 292; see also p. 234

CANCER

Tissue specificity of tumor suppression

It is well known that the loss of tumor suppressor genes leads to a limited subset of cancers in specific tissues. But why just those tissues? He *et al*. found a relatively simple explanation for how this tissue selectivity works for the tumor suppressor BAP1 using a mouse model of BAP1-induced cancer. In most cells, loss of BAP1 caused cell death or apoptosis. But in the tissues that formed tumors, differences in the regulation of genes with anti-apoptotic effects allowed the cells to survive, even though BAP1 was lost. At least for this one tumor suppressor, its inactivation would normally cause a cell to die; however, this mechanism is absent in a subset of tissues, allowing the cells to proliferate and cause a tumor. —LBR

Science, this issue p. 283

PIEZOELECTRICS

Samarium supersensors

Piezoelectric materials produce electric charge in response to changes in stress and are thus good sensor materials. One challenge has been growing single-crystal piezoelectrics with

uniform properties. As of now, much of the crystal is discarded because of compositional variations. Li *et al*. synthesized single crystals of samarium-doped $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ that have uniform and extremely high piezoelectric properties (see the Perspective by Hlinka). These crystals are ideal for a variety of sensing applications and could reduce cost by eliminating waste. —BG

Science, this issue p. 264; see also p. 228

WATER STRUCTURE

Wet surface sightings in clusters

In principle, the surface structure of water (H_2O) should be discernable from the O–H vibrations. In practice, however, so many configurations rapidly interconvert that the bands are bewilderingly broad. Yang *et al*. studied a cluster of 20 H_2O surrounding a cesium ion, using isotopomers that vary in the position of one H_2O amid 19 heavy water (D_2O) molecules. Precisely assigned spectral features from contributing configurations mapped well onto a bulk surface spectrum. —JSY

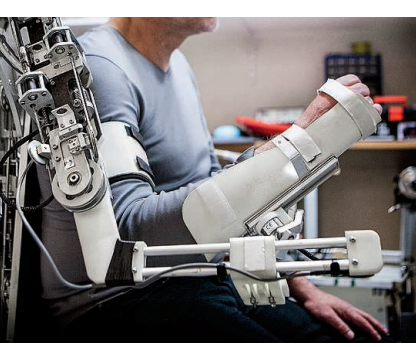
Science, this issue p. 275

ASSISTIVE ROBOTICS

Motion measurement

Clinicians and roboticists often use different metrics when assessing robot-assisted human motion. Fitzsimons *et al*. used ergodicity, a concept from information theory, to evaluate human performance with and without robotic guidance. The more similar a given motion was to the distribution of successful balancing trajectories, the more ergodic. Ergodic measures revealed effects of both training and robotic assistance, whereas other common measures failed to detect one or the other. This task-agnostic metric could be used to evaluate performance changes during training or therapy for human-machine interactions or human motion alone. —RLK

Sci. Robot. **4**, eaav6079 (2019).



A patient uses a physical therapy robot to aid in neuromotor rehabilitation.

ASTEROIDS

Hayabusa2 at the asteroid Ryugu

Asteroids fall to Earth in the form of meteorites, but these provide little information about their origins. The Japanese mission Hayabusa2 is designed to collect samples directly from the surface of an asteroid and return them to Earth for laboratory analysis. Three papers in this issue describe the Hayabusa2 team's study of the near-Earth carbonaceous asteroid 162173 Ryugu, at which the spacecraft arrived in June 2018 (see the Perspective by Wurm). Watanabe *et al*. measured the asteroid's mass, shape, and density, showing that it is a "rubble pile" of loose rocks, formed into a spinning-top shape during a prior period of rapid spin. They also identified suitable landing sites for sample collection. Kitazato *et al*. used near-infrared spectroscopy to find ubiquitous hydrated minerals on the surface and compared Ryugu with known types of carbonaceous meteorite. Sugita *et al*. describe Ryugu's geological features and surface colors and combined results from all three papers to constrain the asteroid's formation process. Ryugu probably formed by reaccumulation of rubble ejected by impact from a larger asteroid. These results provide necessary context to understand the samples collected by Hayabusa2, which are expected to arrive on Earth in December 2020. —KTS

Science, this issue p. 268, p. 272, p. 252; see also p. 230

IN OTHER JOURNALS

Edited by **Caroline Ash** *and* **Jesse Smith**

EDUCATION

Getting to the core of biology success

The "Vision and Change" report details a nationally agreed upon framework of core concepts designed to prepare students for the biology-related challenges of the 21st century. Couch *et al*. describe the development of General Biology–Measuring Achievement and Progression in Science (GenBio-MAPS), an instrument designed to measure student understanding of the core concepts at key time points during an undergraduate biology program, allowing for assessment at both 2- and 4-year institutions. Data were collected from more than 5000 students at 20 institutions, resulting in the first programmatic assessment for general biology programs that align with the core concepts. Implementing GenBio-MAPS will allow departments to identify areas of proficiency and deficiency throughout their programs and guide curricular changes to address problem areas and support the teaching of core concepts. —MMc

CBE Life Sci. Educ. **18**, ar1 (2019).

NANOMATERIALS

Putting polymer micelles in their place

Block-copolymer micelles generally have been used in solution, for applications such as drug delivery. Surface assembly methods that work with other nanosized objects that use electric or magnetic fields or shear tend to be inefficient with these materials. Gould *et al*. show that optical tweezers can be used to position cylindrical block copolymer micelles on a glass substrate. The micelles have a polyferrocenylsilane core with a high refractive index that enables optical manipulation. Total internal reflection fluorescence spectroscopy of a dye trapped in the poly(dimethylsiloxane) corona enabled positioning and orientation of the micelles on the surface. Arrays consisting of

PHOTOS: (LEFT TO RIGHT) BSIP/NEWSCOM; MARK SISSON/MINDEN PICTURES

ALSO IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

CHEMISTRY

Flame retardants require care

Many consumer products contain flame retardants to reduce the risk of fire. However, halogenated flame retardants have been detected in the environment, including in fish and marine mammals, and there are concerns about human health impacts. Although efforts are under way to regulate their use, banned products are often replaced with other comounds that also turn out to be harmful. In a Perspective, de Boer and Stapleton call for the replacement of common halogenated flame retardants with safer alternatives and for a critical evaluation of where flame retardants are needed. —JFU

Science, this issue p. 231

NEUROSCIENCE

Neuron activity across the brain

How is it that groups of neurons dispersed through the brain interact to generate complex behaviors? Three papers in this issue present brain-scale studies of neuronal activity and dynamics (see the Perspective by Huk and Hart). Allen *et al*. found that in thirsty mice, there is widespread neural activity related to stimuli that elicit licking and drinking. Individual neurons encoded task-specific responses, but every brain area contained neurons with different types of response. Optogenetic stimulation of thirst-sensing neurons in one area of the brain reinstated drinking and neuronal activity across the brain that previously signaled thirst. Gründemann *et al*. investigated the activity of mouse basal amygdala neurons in relation to behavior during different tasks. Two ensembles of neurons showed orthogonal activity during exploratory and nonexploratory behaviors, possibly reflecting different levels of anxiety experienced in these areas. Stringer *et al*. analyzed spontaneous neuronal firing, finding that neurons in the primary visual cortex encoded both visual information and motor activity related to facial movements. The variability of neuronal responses to visual stimuli in the primary visual area is mainly related to arousal and reflects the encoding of latent behavioral states. —PRS

Science, this issue p. 253, p. 254, p. 255; see also p. 236

QUANTUM SIMULATION

A logarithmic signature

Some one-dimensional disordered interacting quantum systems have been theoretically predicted to display a property termed many-body localization (MBL), where the system retains the memory of its initial state and fails to thermalize. However, proving experimentally that something does not occur is tricky. Instead, physicists have proposed monitoring the entanglement entropy of the system, which should grow logarithmically with evolution time in an MBL system. Lukin *et al*. observed this characteristic logarithmic trend in a disordered chain of interacting atoms of rubidium-87. This method should be generalizable to other experimental platforms and higher dimensions. —JS

Science, this issue p. 256

QUANTUM ENTANGLEMENT

An entropic look into entanglement

Quantum systems are predicted to be better at information processing than their classical counterparts, and quantum entanglement is key to this superior performance. But how does one gauge the degree of entanglement in a system? Brydges *et al*. monitored the build-up of the so-called Rényi entropy in a chain of up to 10 trapped calcium ions, each of which encoded a qubit. As the system evolved, interactions caused entanglement between the chain and the rest of the system to grow, which was reflected in the growth of the Rényi entropy. —JS

Science, this issue p. 260

NANOMATERIALS

Atomic packing controls exciton lifetime

Like semiconductors, small metallic clusters can absorb light and create excitons (electron-hole pairs). In ligand-capped gold clusters of 30 to 40 atoms (Au_{30} to Au_{40}) that adopt the usual face-centered cubic packing, the lifetime of these excitons is ~100 nanoseconds. Zhou *et al*. found that atomic packing and molecular orbital overlap can greatly affect carrier lifetimes. Despite having similar bandgaps to those of face-centered cubic clusters, a hexagonal close-packed Au_{30} cluster had a much shorter lifetime (~1 nanosecond), and a body-centered cubic Au_{38} cluster had a lifetime of ~5 microseconds, which is comparable to bulk silicon. —PDS

Science, this issue p. 279

AUTOIMMUNITY

AIRE and autoreactivity

Autoimmune polyendocrinopathy-candidiasis-ectodermal dystrophy is a condition caused by mutations in the gene encoding the autoimmune regulator (AIRE) and is associated with central T cell tolerance defects and circulating autoantibodies. Sng *et al*. observed that the altered development of T cells seen in AIRE deficiency is associated with a greater frequency of autoreactive B cells in the periphery. This defect in B cell tolerance to self-antigens is linked to reduced numbers of certain regulatory T cells. This T cell defect may allow the selection and expansion of B cells that are autoreactive to peripheral self-antigens, thus leading to autoantibody production. —CNF

Sci. Immunol. **4**, eaav6778 (2019).

PHYSIOLOGY

A stressful balancing act for the heart

Stress increases the risk of dying from cardiometabolic disease. In humans, stress triggers the release of cortisol, which activates the glucocorticoid receptor (GR) and the structurally related mineralocorticoid receptor (MR). Oakley *et al*. found that mice with a cardiomyocyte-specific deficiency in MR or both receptors did not develop the heart failure seen in GR-deficient mice (see the Focus by Chapman). Reexpression of MR in mice deficient in both GR and MR induced the development of heart failure, suggesting that MR antagonists are cardioprotective because they promote GR signaling. —WW

Sci. Signal. **12**, eaau9685, eaaw8715 (2019).