Sciences

ENZYMES

Enzymes make fertilizer with sunlight

Nitrogenase enzymes catalyze the biological production of fixed nitrogen. Because this is not enough to sustain modern agriculture, industrial fertilizers containing ammonia are produced via the energy-intensive Haber-Bosch process. Brown et al. developed a way to use nitrogenase enzymes from nitrogen-fixing bacteria to make ammonia in vitro without other biological steps or high-energy inputs. Light-activated CdS nanorods provided electrons to the FeMo nitrogenase enzyme to reduce nitrogen and produce ammonia at rates up to 64% of biological nitrogen fixation. These nanoparticle-protein complexes show the potential for solar-driven ammonia production. — NW

Science, this issue p. 448

PALEONTOLOGY

Tiny giant

Titanosaurs were the largest land vertebrates to have evolved, lacking the deposited atom (see the Perspective by Holien and Gupta). — JS

Science, this issue p. 437; see also p. 415

Medium and large ground finches diverged in beak size after a severe drought.

HYDROGEN ATOM MAKES GRAPHENE MAGNETIC

Graphene has many extraordinary mechanical and electronic properties, but it's not magnetic. To make it so, the simplest strategy is to modify its electronic structure to create unpaired electrons. Researchers can do that by, for example, removing individual carbon atoms or adsorbing hydrogen onto graphene. This has to be done in a very controlled way because of a peculiarity of the graphene’s crystal lattice, which consists of two sublattices. Gonzales-Herrero et al. deposited a single hydrogen atom on top of graphene and used scanning tunneling microscopy to detect magnetism on the sublattice lacking the deposited atom (see the Perspective by Holien and Gupta). — JS

Science, this issue p. 437; see also p. 415

Erosion overwhelmed by eruption

Volcanism and erosion can feed into long-term climate change, but determining their relative importance is challenging. Erosion is known to be a carbon sink and is thought to play an outsized role in shifting global climate. However, McKenzie et al. suggest that long-term oscillations in climate may be tied to the amount of continental arc volcanism (see the Perspective by Kump). A global compilation of arc volcano–produced zircons over the past 700 million years revealed good correlation between warm and cool epochs with the waxing and waning of volcanism. Thus, volcanism may be a more important driver and erosion a less important sink for very long-term climate changes. — BG

Science, this issue p. 444; see also p. 411

Linked loci and Galapagos finch size

Observations of parallel evolution in the finches of the Galapagos, including body and beak size, contributed to Darwin’s theories. Lamichhaney et al. carried out whole-genome sequencing of 60 Darwin’s finches. These included small, medium, and large ground finches as well as small, medium, and large tree finches. A genomic region containing the HMG2 gene correlated strongly with beak size across different species. This locus appears to have played a role in beak diversification throughout the radiation of Darwin’s finches. — LMZ

Science, this issue p. 470

EVOlUTIONARY GENETICS

LINKED LOCI AND GALAPAGOS FINCH SIZE

Science, this issue p. 470

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MAGNETISM

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Science, this issue p. 437; see also p. 415

GEology

EROSION OVERWHELMED BY ERUPTION

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Bioinorganic Chemistry

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Science, this issue p. 448

Paleontology

Tiny giant

Titanosaurs were the largest land vertebrates to have evolved,
but even they had to start small. Curry-Rogers et al. describe a baby *Rapetosaurus* only 35 cm at the hip at death. Histological and limb analysis suggest that this tiny giant had a much greater range of movement than it would have had as an adult. Furthermore, the work confirms hypotheses that these largest of dinosaurs were precocial, being able to move independently immediately after birth. This pattern differs from that seen in many contemporary dinosaur groups, such as theropods and ornithischians, for which increasing evidence suggests that parental care was important. — SNV

**INNATE IMMUNITY**

**Flu immunity shows its age**

As we age, our immune systems change in many ways not for the better. For instance, the elderly account for 90% of influenza deaths annually. Pillai et al. now report that influenza-infected human monocytes, a type of immune cell, exhibit reduced antiviral activity. In influenza-infected mice, two innate immune sensing pathways work together to promote antiviral immunity to influenza. Mice lacking antiviral immunity (similar to the situation in elderly people) had elevated bacterial burdens in their lungs and increased inflammatory responses, which both contributed to their increased susceptibility to influenza. — KLM

**PHYSIOLOGY**

**The fattening effect of ghrelin**

The peptide hormone ghrelin is thought to enhance food intake. Can targeting ghrelin or its receptor GHSR suppress appetite? Genetic ablation of the genes encoding ghrelin or GHSR does not alter food intake in mice. Chebani et al. found that cells with a truncated form of GHSR had stronger responses to ghrelin than did cells with the full-length GHSR. Rats with this mutant form of GHSR were more sensitive to injected ghrelin and gained more body weight as fat without eating more food than their normal counterparts. Thus, ghrelin promotes the expansion of adipose tissue without affecting appetite. — WW

**GEOLOGICAL SCIENCES**

**Molten rock underlies North Korean volcano**

Mt. Paektu is a volcano responsible for one of the largest eruptions in the past few thousand years. However, its location on the North Korea–China border means that little is known about its history and underlying structure. In a North Korea/United Kingdom/United States collaboration, Song et al. used distant earthquakes recorded on seismometers in North Korea to look inside the volcano. They found evidence of molten rock within the volcano that may provide a source of the magma involved in past eruptions and recent volcanic unrest. — KVH

**GENE REGULATION**

**An upstream signal for repression**

Most messenger RNAs (mRNAs) contain “untranslated” regions (UTRs) upstream (5’) and downstream (3’) of the protein-coding open reading frame (ORF). Many 5’ UTRs harbor very short upstream ORFs (uORFs), whose functions are largely unknown. Johnstone et al. show that approximately half of vertebrate mRNAs contain uORFs; however, uORFs generally do not...
**ULTRAFAST OPTICS**

**Electron pulses under control**

The ability to take snapshots of fast events can often provide insights into the dynamics of the processes involved: chemical reactions, electronic transport, structural transitions, and complex combinations involving all of these processes. Kealhofer et al. describe an ultrafast optics approach for generating bunches of electrons and compressing them by more than an order of magnitude to just femtosecond time scales (see the Perspective by Ropers). The technique opens up the possibility of imaging ultrafast phenomena with atomic-scale spatial resolution. — ISO

*Science, this issue p. 429; see also p. 410*

**ORGANIC CHEMISTRY**

**Copper adds alkyls asymmetrically**

Nitrogen-bearing rings are very common features in the molecular structures of modern drugs. Reactions that can modify these N heterocycles selectively are thus especially useful to optimize pharmaceutical properties. Jumde et al. developed a method to append alkyl groups in a single mirror-image orientation to substituted C=C double bonds dangling from N heterocycles. The copper-catalyzed reaction, which relies on Grignard reagents to introduce the alkyl groups, manifests high selectivity across a broad range of substrates, with no interference from the nitrogen. — JSY

*Science, this issue p. 433*

**QUANTUM OPTICS**

**Correlating an atomic condensate**

Parts of a quantum system can be more “correlated” than what is allowed in the everyday classical world: A measurement on one part of the system can immediately affect a spatially distant component. The strongest of such correlations, Bell correlations, have been detected in small systems containing two to a handful of particles. Schmied et al. used collective measurements to detect Bell correlations among the spins of 480 Rb atoms cooled to a condensed state. This many-body correlated state may be useful as a resource in quantum information processing. — JS

*Science, this issue p. 441*

**CELL QUIESCENCE**

**Reducing the risk of rearrangement**

As lymphocytes develop, they rearrange their antigen receptor genes and proliferate extensively, potentially putting their genomes at risk. Galloway et al. found that two RNA-binding proteins, ZFP36L1 and ZFP36L2, ensure careful entry and exit into the cell cycle. This helps developing B lymphocytes maintain their genomic integrity. Mice deficient in ZFP36L1 and ZFP36L2 exhibited a profound block in B cell development. ZFP36L1 and ZFP36L2 suppress mRNAs that help B cells progress through the cell cycle, ensuring that cells can enter quiescence and keep their genomes safe when they undergo the risky process of rearranging their antigen receptors. — KLM

*Science, this issue p. 453*

**HUMAN GENOMICS**

**Rare gene knockouts in adult humans**

On average, most people’s genomes contain approximately 100 completely nonfunctional genes. These loss-of-function (LOF) mutations tend to be rare and/or occur only as a single copy within individuals. Narasimhan et al. investigated LOF in a Pakistani population with high levels of consanguinity. Examining LOF alleles that were identical by descent, they found, as expected, an absence of homozygote LOF for certain protein-coding genes. However, they also identified many homozygote LOF alleles with no apparent deleterious phenotype, including some that were expected to confer genetic disease. Indeed, one family had lost the recombination-associated gene PRDM9. — LMZ

*Science, this issue p. 474*

**IMMUNOLOGY**

**Transcription factors define tissue T cells**

The immune system fights microbial invaders by maintaining multiple lines of defense. For instance, specialized memory T cells [resident memory T cells (T_{res})] colonize portals of pathogen entry, such as the skin, lung, and gut, to quickly halt reinfectorcr. Mackay et al. now report that in mice, T_{res} as well as other tissue-dwelling lymphocyte populations such as natural killer cells share a common transcriptional program driven by the related transcription factors Hobit and Blimp1. Tissue residency and retention of lymphocytes require expression of Hobit and Blimp1, which, among other functions, suppress genes that promote tissue exit. — KLM

*Science, this issue p. 459*

**SUSTAINABILITY**

**Reducing food loss and waste**

Globally, about one-third of all food is lost during production, harvest, storage, transport, and processing or is wasted in the retail sector, food service, and households. Food waste is widely seen as unethical and negatively affects the environment. Wasting red meat is particularly detrimental because of its large carbon and environmental footprint. Yet, as Aschemann-Witzel explains in a Perspective, the numerous interconnected factors that cause food loss and waste make it challenging to address. Efforts to reduce food loss and waste must involve many stakeholders, from individual consumers to governments, as part of a wider move toward sustainable food production. — JFU

*Science, this issue p. 408*

**PAIN**

**A gain in pain control**

The sodium channel Nav1.7 is important for the firing of peripheral pain-signaling neurons. Inherited erythromelalgia (IEM) is a painful disorder in which gain-of-function Nav1.7 mutations produce hyperresponsiveness of peripheral sensory neurons to warmth. Cao et al. created induced pluripotent stem cell (iPSC)–derived sensory neurons from IEM patients. A selective Nav1.7 sodium channel blocker normalized the phenotype of the iPSC-derived sensory neurons and blocked pain perception in human patients with IEM. Thus, selective Nav1.7 blockade may be useful in pain alleviation. — OMS

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**INNATE IMMUNITY**

**Training immune cells to remember**

Classical immunological memory, carried out by T and B lymphocytes, ensures that we feel the ill effects of many pathogens only once. Netea et al. review how cells of the innate immune system, which lack the antigen specificity, clonality, and longevity of T cell and B cells, have some capacity to remember, too. Termed “trained immunity,” the property allows macrophages, monocytes, and natural killer cells to show enhanced responsiveness when
they reencounter pathogens. Epigenetic changes largely drive trained immunity, which is shorter lived and less specific than classical memory but probably still gives us a leg up during many infections. — KLM

Science, this issue p. 427

**STRUCTURAL BIOLOGY**

**Unveiling the Zika virus**

The ongoing Zika virus epidemic is of grave concern because of its apparent links to congenital microcephaly and Guillain-Barré syndrome. Sirohi et al. present a near–atomic-resolution structure of mature Zika virus determined by cryo–electron microscopy. The structure is mainly similar to that of other flaviviruses such as dengue virus; however, there are differences in a region that may be involved in binding to host receptors. The structure provides a foundation for analysis of the antigenicity and pathogenesis of Zika virus. — VV

Science, this issue p. 467