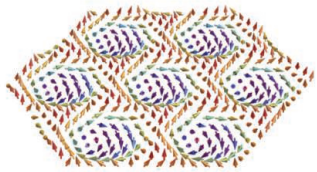
RESEARCH

Skyrmion lattice in a centrosymmetric magnet

Kurumaji et al., *p. 914*



IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

Fields and managed forests, such as these in Eifel, Germany, are common agricultural land uses.

ARCHAEOLOGY

A synthetic history of human land use

Humans began to leave lasting impacts on Earth's surface starting 10,000 to 8000 years ago. Through a synthetic collaboration with archaeologists around the globe, Stephens *et al*. compiled a comprehensive picture of the trajectory of human land use worldwide during the Holocene (see the Perspective by Roberts). Hunter-gatherers, farmers, and pastoralists transformed the face of Earth earlier and to a greater extent than has been widely appreciated, a transformation that was essentially global by 3000 years before the present. —AMS

Science, this issue p. 897; see also p. 865

COMPUTER SCIENCE

AI now masters six-player poker

Computer programs have shown superiority over humans in two-player games such as chess, Go, and heads-up, no-limit Texas hold'em poker. However, poker games usually include six players—a much trickier challenge for artificial intelligence than the two-player variant. Brown and Sandholm developed a program, dubbed Pluribus, that learned how to play six-player no-limit Texas hold'em by playing against five copies of itself (see the Perspective by Blair and Saffidine). When pitted against five elite professional poker players, or with five copies of Pluribus playing against one professional, the computer performed significantly better than humans over the course of 10,000 hands of poker. —JS

Science, this issue p. 885; see also p. 864

ORGANIC CHEMISTRY

Displacing OH groups catalytically

The Mitsunobu reaction is widely used to invert the configuration of alcohols. However, its major drawback is the need to activate the alcohol with a full equivalent of phosphine, thereby generating a phosphine oxide co-product. Beddoe *et al*. report a phosphine oxide compound that achieves the same result catalytically (see the Perspective by Longwitz and Werner). The key is a phenol substituent that can reversibly bond through its oxygen to phosphorus, forming a ring that the alcohol opens. The phosphorus thus remains in the +5 oxidation state throughout the reaction, and water is the only by-product. —JSY

Science, this issue p. 910; see also p. 866

MANTLE CHEMISTRY

Deep divide in fate of iron

A large component of Earth's atmosphere comes from the interior, where the gas species are dictated by the redox state of the mantle. After formation of Earth's iron core, the mantle became several orders of magnitude more oxidized. Armstrong *et al*. conducted a set of experiments looking at the redox state of silicate melt representative of Earth's early magma oceans. They found that at some depth, iron oxide disproportionates into iron(III) oxide and metallic iron. The reduced iron sinks to the core, leaving an oxidized rocky mantle that emits carbon dioxide and water instead of more reduced species. —BG

Science, this issue p. 903

ASTROCHRONOLOGY

Filling a dating hole

The periodic nature of Earth's orbit around the Sun produces cycles of insolation reflected in climate records. Conversely, these climate records can be used to infer changes in the dynamics of the Solar System, which is inherently chaotic and not always similarly periodic. A particular obstacle is the lack of well-defined planetary orbital constraints between 50 and 60 million years ago. Zeebe and Lourens found an astronomical

Published by AAAS

solution for that interval showing that the Solar System experienced a specific resonance transition pattern. These data provide a measure of the duration of the Paleocene-Eocene Thermal Maximum. —HJS

Science, this issue p. 926

PLANT SCIENCE

Microbial tRNA pieces regulate nodulation

To fix nitrogen, leguminous plants enter into a symbiotic relationship with nodulating bacteria. Ren *et al*. now reveal the bacteria as active regulators in this process (see the Perspective by Baldrich and Meyers). Small fragments cleaved from rhizobial tRNA molecules tap into the hosts' RNA interference machinery to silence key host genes. Thus, both host and microbe shape the symbiotic environment. —PJH

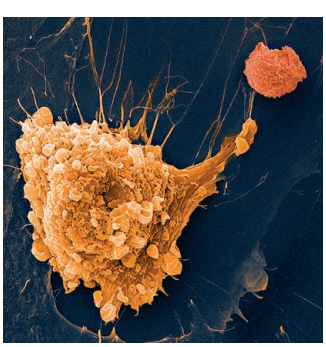
Science, this issue p. 919; see also p. 868

IMMUNOLOGY

Empowering NK cells against cancer

Tumors release factors, such as the cytokine transforming growth factor–β (TGF-β), that block antitumor immunity mediated by natural killer (NK) immune cells by promoting their differentiation into a less suppressive cell type. Rautela *et al.* found that activin-A, another member of the TGF-β family, had similar effects on both mouse and human NK cells but through a pathway independent of TGF-β. Inhibition of activin-A reduced skin cancer growth in a mouse melanoma model, suggesting that targeting this pathway could enhance NK cell function and antitumor immunity. —JFF

Sci. Signal. **12**, eaat7527 (2019).



Natural killer cell (top) and melanoma cell in a scanning electron micrograph

PHOTOS: (LEFT TO RIGHT) FERNANDO S. F. GUIMARAES/WEHI; CAROLINA C. CAMARGO/UFPR AND SIMON TAPLIN/WEHI; DPA PICTURE ALLIANCE/ALAMY STOCK PHOTO

SYNTHETIC BIOLOGY

Programmable genome engineering

The model bacterium *Escherichia coli* has a single circular chromosome. Wang *et al*. created a method to fragment the *E. coli* genome into independent chromosomes that can be modified, rearranged, and recombined. The efficient fission of the unmodified *E. coli* genome into two defined, stable pairs of synthetic chromosomes provides common intermediates for large-scale genome manipulations such as inversion and translocation. Fusion of synthetic chromosomes from distinct cells generated a single genome in a target cell. Precise, rapid, large-scale genome engineering operations are useful tools for creating diverse synthetic genomes. —SYM

Science, this issue p. 922

MICROBIOTA

Superantigens spur IgA secretion

Mucosal immunoglobulin A (IgA) is abundant and interacts with the gut microbiome. To examine microbial induction of IgA in humans, Bunker *et al.* screened microbiota from infants against mouse and human IgA. A subset of samples bound IgA in a way that indicated the presence of superantigens, which bind T cell receptors or B cell receptors outside of the typical antigen-binding region, leading to nonspecific activation. Putative superantigens in commensal members of Lachnospiraceae activated human VH3-positive B cells and induced IgA production in mice. The authors suggest that commensal superantigens may be dominant forces behind IgA production in humans. —LP

Sci. Transl. Med. **11**, eaau9356 (2019).

IN OTHER JOURNALS

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

The ubiquitous protist parasite *Toxoplasma gondii* infects many species but only develops sexually in cats.

PARASITES

Breaking the species barrier

The protozoan parasite *Toxoplasma gondii* is found in most mammals and is spread by ingestion of contaminated food and water. It is a health risk to humans because it can form brain cysts and cause life-changing complications during pregnancy. Despite this parasite's ability to infect many mammals, it can only complete its life cycle in felids, including domestic cats. Martorelli di Genova *et al.* sought to understand the basis for the specificity of the sexual stages for the gut epithelium of cats. Using cat gut organoids, they found that the parasite's sexual stages are stimulated to develop by the plant fat linoleic acid. Cats uniquely lack the enzyme needed for linoleic acid digestion, delta-6-desaturase. To test whether intact linoleic acid acts as a parasite signal, mice were given a chemical treatment to inhibit their desaturase, then fed linoleic acid and infected. *T. gondii* promptly initiated sexual development and the mice shed infectious oocysts in their feces 6 days later. —CA

PLOS Biol. **17**, e3000364 (2019).

PHYSICS

Twisted multilayer graphene

Since the recent discovery of superconductivity in twisted bilayer graphene, physicists have been exploring other twisted heterostructures, including those in which two bilayers of graphene are twisted with respect to each other. These experiments have shown signatures of exotic states, inspiring theorists to try to understand their properties. Liu *et al.* undertook a theoretical study of the general case of two graphene multilayers, each of which could contain an arbitrary number of graphene monolayers, twisted with respect to each other. They found that such heterostructures retained the approximately flat bands characteristic of twisted bilayer graphene at the same "magic" twist angle. Additionally, twisted

ALSO IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

NEURODEVELOPMENT

Neurons negotiating boundaries

Barriers around the brain and spinal cord separate central from peripheral nervous systems, yet the two systems are interlinked. Suter and Jaworski review what is known about how cells, axons, and signals negotiate the boundary zone. Understanding what goes wrong in boundary transgressions reveals the inner workings of multiple, partially redundant mechanisms built during development that separate the two compartments in adulthood. —PJH

Science, this issue p. 881

HUMAN GENETICS

The genetics of sexual orientation

Twin studies and other analyses of inheritance of sexual orientation in humans has indicated that same-sex sexual behavior has a genetic component. Previous searches for the specific genes involved have been underpowered and thus unable to detect genetic signals. Ganna *et al*. perform a genome-wide association study on 493,001 participants from the United States, the United Kingdom, and Sweden to study genes associated with sexual orientation (see the Perspective by Mills). They find multiple loci implicated in same-sex sexual behavior indicating that, like other behavioral traits, nonheterosexual behavior is polygenic. —LMZ

Science, this issue p. 882; see also p. 869

IMMUNOLOGY

Thirteen is the charm in anaphylaxis

Immunoglobulin E (IgE) is a type of antibody associated with allergies and response to parasites such as worms. When high-affinity, allergen-specific IgE binds its target, it can cross-link receptors on mast cells that induce anaphylaxis. It remains unclear, however, how B cells are instructed to generate high-affinity IgE. Gowthaman *et al*. discovered a subset of T follicular helper cells ($T_{FH}13$) that direct B cells to do just that. $T_{FH}13$ cells are induced by allergens but not during parasite infection. Transgenic mice lacking these cells show impaired production of high-affinity, anaphylactic IgE. $T_{FH}13$ cells, which are elevated in patients with food and aeroallergies, may be targeted in future antianaphylaxis therapies. —STS

Science, this issue p. 883

MALARIA

Targeting parasite's protein kinase

Malaria elimination goals are constantly eroded by the challenge of emerging drug and insecticide resistance. Alam *et al*. have taken established drug targets—CLK protein kinases involved in regulation of RNA splicing—and investigated how inhibition of the parasite's enzymes blocks completion of its complex life cycle. They identified an inhibitor of the parasite's CLK protein kinase that was 100-fold less active against the most closely related human protein kinase and effective at clearing rodent malaria parasites. Not only does this compound halt the development of sexual stages but it also limits transmission to the mosquito vector of the parasite, a key requirement for malaria drugs. —CA

Science, this issue p. 884

SUPERCONDUCTIVITY

Pervasive fluctuations

Among the many intertwined phases in the cuprate superconductor phase diagram is the charge density wave (CDW) order, which has been detected in all major cuprate families. It is thought that CDW competes with superconductivity, but whether it has bearing on the mechanism of superconductivity remains unclear. Arpaia *et al*. undertook a comprehensive study of charge density fluctuations in a cuprate family, varying doping and temperature. They found that short-range dynamic charge fluctuations were present in a large portion of the phase diagram, at temperatures considerably higher than those at which the CDW order disappears. —JS

Science, this issue p. 906

SIGNAL TRANSDUCTION

A dynamic signaling scaffold

In neurons, many cellular processes are regulated by receptor tyrosine kinases (RTKs), cell surface receptors whose activation can depend on other signaling pathways. Zhou *et al*. used super-resolution imaging to visualize colocalization of signaling proteins on the membrane-associated periodic skeleton (MPS) that is formed by actin, spectrin, and related molecules in the axons and dendrites of neurons. The colocalization of signaling proteins in different pathways leads to transactivation of RTK, which initiates intracellular signaling. In a negative feedback loop, the downstream signaling in turn leads to degradation of the MPS. Thus, the MPS is a dynamically regulated platform that coordinates signal transduction in neurons. —VV

Science, this issue p. 929

IMMUNOLOGY

Distinct immunology of the placenta

The placenta is formed when specialized cells from an embryo invade the maternal uterus. The effectiveness of this process can determine whether complications in pregnancy, such as preeclampsia, arise. In a Perspective, Colucci discusses the emerging role of immune cells in the formation of the placenta. Homeostatic immune cell activities facilitate placental implantation without inducing an immune response to foreign antigens expressed on fetal-derived tissues. Understanding this process more fully could help to prevent or treat placenta-associated complications of pregnancy. —GKA

Science, this issue p. 862

SKIN INFLAMMATION

Resurrecting sentinels in the skin

Langerhans cells are resident innate immune cells in the skin that play essential roles in promoting local immune responses and maintaining skin homeostasis. Langerhans cells arise from fetal progenitors that seed the skin early in development. In a mouse hematopoietic stem cell transplant model, Ferrer *et al*. found that monocytes from the blood infiltrate the skin and eventually replenish the Langerhans cell network. These observations are in agreement with previous studies looking at other sites, but the process by which monocytes give rise to Langerhans cells is inefficient, limiting the extent to which they can be renewed in the skin. —AB

Sci. Immunol. **4**, eaax8704 (2019).

ARCHAEOLOGY

The early occupation of America

The Cooper's Ferry archaeological site in western North America has provided evidence for the pattern and time course of the early peopling of the Americas. Davis *et al*. describe new evidence of human activity from this site, including stemmed projectile points. Radiocarbon dating and Bayesian analysis indicate an age between 16,560

and 15,280 years before present. Humans therefore arrived in the Americas before an inland ice-free corridor had opened, so a Pacific coastal route was the probable entry route. The stemmed projectile points closely resemble those found in Upper Paleolithic Japan, also supporting the hypothesis of a coastal route. —AMS

Science, this issue p. 891

MAGNETISM

Skyrmions in a frustrated magnet

Skyrmions—tiny, topologically protected whirlpools of spin—have been investigated as potential information carriers in spintronic devices. Usually, skyrmions appear in noncentrosymmetric materials or at interfaces between materials. In contrast to this rule of thumb, Kurumaji *et al*. observed a skyrmion lattice phase in the centrosymmetric material Gd_2PdSi_3. The magnetic frustration present in this material helped stabilize the skyrmion phase, which was detected through transport measurements in magnetic field. —JS

Science, this issue p. 914