RESEARCH

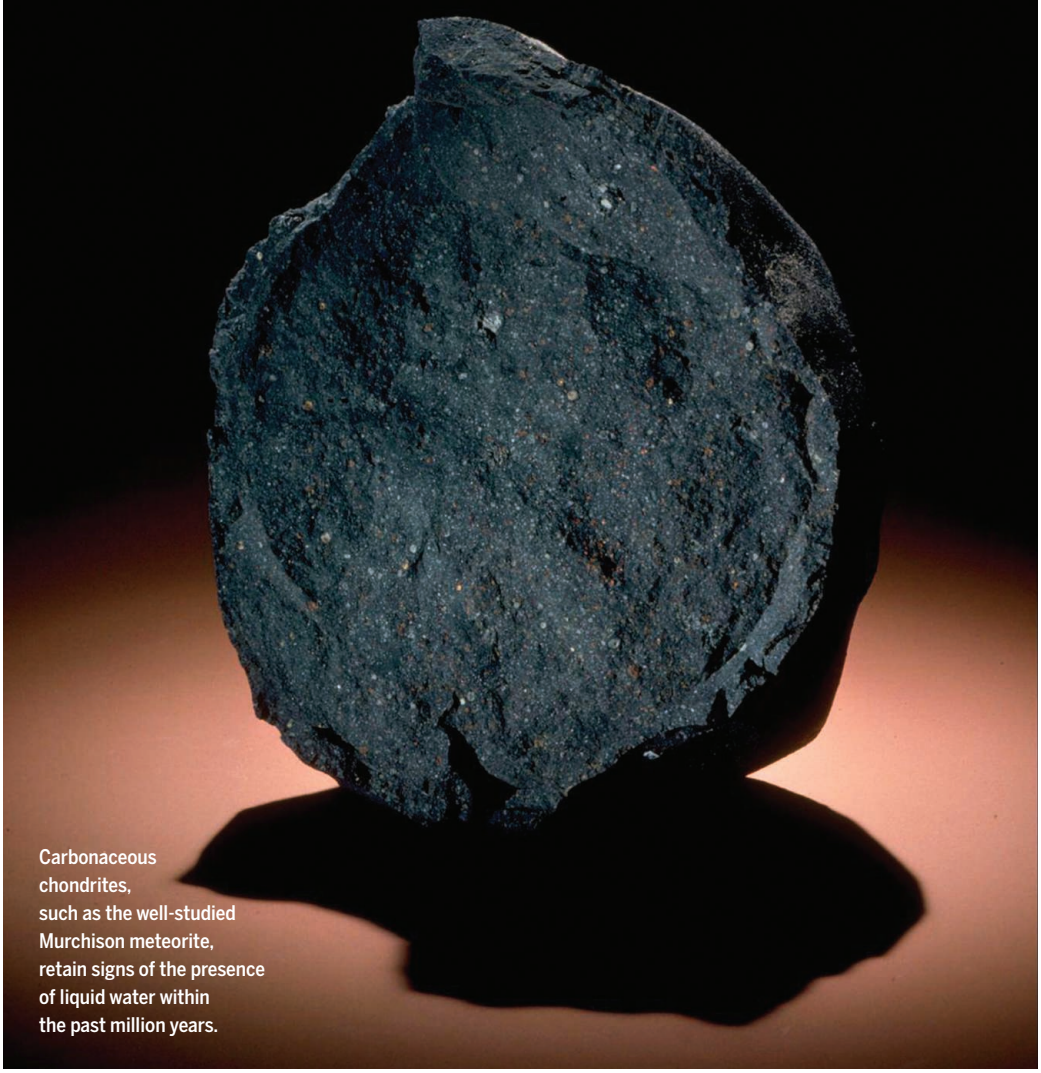
IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

METEORITES

Recent fluid flow in ancient meteorites

Carbonaceous chondritic meteorites are thought to be fragments broken off parent bodies that orbit in the outer Solar System, largely unaltered since their formation. These meteorites contain evidence of reactions with liquid water that was thought to have been lost or completely frozen billions of years ago. Turner *et al*. examined uranium and thorium isotopes in several carbonaceous chondrites, finding nonequilibrium distributions that imply that uranium ions were transported by fluid flow. Because this signature disappears after several half-lives of the radioactive isotopes, the meteorites must have been exposed to liquid within the past million years. The authors suggest that ice may have melted during the impacts that ejected the meteorites from their parent bodies. —KTS *Science*, this issue p. 164



Carbonaceous chondrites, such as the well-studied Murchison meteorite, retain signs of the presence of liquid water within the past million years.

PHOTO: SBS ECLECTIC IMAGES/ALAMY STOCK PHOTO

ECOTOXICOLOGY

Tire tread particles turn streams toxic

For coho salmon in the U.S. Pacific Northwest, returning to spawn in urban and suburban streams can be deadly. Regular acute mortality events are tied, in particular, to stormwater runoff, but the identity of the causative toxicant(s) has not been known. Starting from leachate from new and aged tire tread wear particles, Tian *et al.* followed toxic fractions through chromatography steps, eventually isolating a single molecule that could induce acute toxicity at threshold concentrations of ~1 microgram per liter. The compound, called 6PPD-quinone, is an oxidation product of an additive intended to prevent damage to tire rubber from ozone. Measurements from road runoff and immediate receiving waters show concentrations of 6PPD-quinone high enough to account for the acute toxicity events. —MAF

Science, this issue p. 185

STRUCTURAL VIROLOGY

Two antibodies against flaviviruses

Flaviviruses are a group of RNA viruses that include the human pathogens dengue virus, Zika virus, and West Nile virus. The envelope protein (E) on the virus surface has been the target of vaccine development, but problems have arisen with antibodies against E, leading to enhanced infection. Now, Modhiran *et al.* and Biering *et al.* describe two different antibodies that bind to the flavivirus NS1 protein and prevent it from disrupting epithelial cells, which is associated with severe disease. Both antibodies cross-react with multiple flavivirus NS1 proteins. The antibodies reduce viremia and increase survival in mouse models of flavivirus disease. Both papers include structures of NS1 bound to an antibody, which give insight into the protective mechanism. —VV

Science, this issue p. 190, p. 194

CANCER

To respond or not to respond

Patients with cancer are frequently treated with chemotherapy, but it does not always work and it is difficult to predict who will respond to the treatment. In addition to the direct effects of chemotherapy, antitumor immune responses can also play an important role. By examining the immune responses in patients with muscle-invasive bladder cancer, Vollmer *et al.* identified a key role for the CXCR3 chemokine system of ligands and receptors. The activity of this system before initiation of treatment was associated with subsequent response to chemotherapy in multiple independent cohorts of patients, suggesting a potential rational approach to the selection of therapies. —YN and MN

Sci. Transl. Med. **13**, eabb3735 (2021).

MULTIPLE SCLEROSIS

Precision therapy for immune tolerance

Autoimmune diseases, such as multiple sclerosis (MS), result from a breach of immunological self-tolerance and tissue damage by autoreactive T lymphocytes. Current treatments can cause systemic immune suppression and side effects such as increased risk of infections. Krienke *et al.* designed a messenger RNA vaccine strategy that lacks adjuvant activity and delivers MS autoantigens into lymphoid dendritic cells. This approach expands a distinct type of antigen-specific effector regulatory T cell that suppresses autoreactivity against targeted autoantigens and promotes bystander suppression of autoreactive T cells against other myelin-specific autoantigens. In mouse models of MS, the vaccine delayed the onset and reduced the severity of established disease without showing overt symptoms of general immune suppression. —PNK

Science, this issue p. 145

CHEMICAL PHYSICS

The nature of short hydrogen bonds

Hydrogen bonding (H-bonding) unquestionably plays an important role in chemical and biological systems and is responsible for some of their unusual properties. Strong, short H-bonds constitute a separate class that, owing to their elusive characterization, has remained a point of contention over the past several decades. Using femtosecond two-dimensional infrared spectroscopy in conjunction with quantum chemical calculations, Dereka *et al.* demonstrate a powerful way to investigate the nature of short H-bonding (see the Perspective by Bonn and Hunger). Their quantitative characterization of multiple coupled motions in the model system of bifluoride anion $[F\text{-}H\text{-}F]^-$ in aqueous solution reveals several distinctive features of a crossover from conventional to short, strong H-bonding. —YS

Science, this issue p. 160
see also p. 123

OCEAN ANOXIA

Where they can't breathe

Climate warming is causing the expansion of marine oxygen-deficient zones, which are regions in which dissolved oxygen concentrations are so low that many marine animals cannot survive. This phenomenon also might affect the global cycles of carbon, sulfur, nitrogen, and trace metals in the oceans. Raven *et al.* show how ocean anoxia affects microbial sulfur processing in sinking marine particles. They observed cryptic microbial sulfate reduction, which forms organic sulfur that is resistant to acid hydrolysis, a process that could enhance carbon preservation in sediments underlying oxygen-deficient water columns. This may help explain some of the more extreme episodes of organic carbon preservation associated with marine anoxia in Earth's history. —HJS

Science, this issue p. 178

IN OTHER JOURNALS

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

Copepods use pheromone trails and hydrodynamic signals to track down females under turbulent conditions.

IMAGE: D.P. WILSON/FLPA/SCIENCE SOURCE

SYNTHETIC BIOLOGY

A microfactory in yeast peroxisomes

Considerable synthetic biology efforts are focused on engineering yeast to produce valuable metabolites. Production in the cytosol can be challenging because of toxicity or cross-talk with cellular pathways. Dusséaux *et al.* harnessed the yeast peroxisome to produce geranyl diphosphate (GPP), a precursor to monoterpenoids, monoterpene indole alkoids, and cannabinoids. Targeting the entire pathway for GPP synthesis, along with an enzyme that converts GPP to the monoterpene limonene, to the peroxisome gives a 125-fold improvement in yield of limonene compared with production in the cytoplasm. Additional monoterpenes can be synthesized with the same platform using the appropriate monoterpene synthase. Peroxisomal production also facilitates downstream processing involving oxidation by cytochrome P450 enzymes. Peroxisome microfactories could be used for the modular assembly and optimization of other complex pathways. —VV

Proc. Natl. Acad. Sci. U.S.A. **117**, 31789 (2020).

SCIENTIFIC WORKFORCE

Keep calm and measure the gap

Academic conferences are fertile ground for data collection on gender inequities, owing to their importance in career development, networking, and increasing visibility. Corona-Sobrino *et al.* developed a tool based on performance indicators that allows for real-time monitoring and evaluation of gender roles and inequalities at academic conferences. In developing the tool, three relevant perspectives (participation, organizational structure, and attitudes) were identified, along with a specific list of performance indicators for each, allowing for both individual and combined analysis. Results are shown as a traffic light visualization, with red meaning bad and green meaning good, making

ALSO IN *SCIENCE* JOURNALS

Edited by **Michael Funk**

CORONAVIRUS

Testing as a public health tool

Tests for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection have been used for people with symptomatic infections and those at high risk of infection, as determined by contact tracing. In a Perspective, Mina and Andersen discuss how testing can go beyond diagnostics and be used as a public health tool in surveillance and screening. These applications have different requirements for the types of tests and how accurate they need to be, but they could be a key tool in preventing transmission chains to control the pandemic. —GKA

Science, this issue p. 126

NEURODEVELOPMENT

Complex diversity from shared toolkits

Neural development builds diverse circuits out of a common toolkit, with shared mechanisms, transcription factors, and cellular signaling systems. Sitko and Goodrich compare and contrast the development of visual and olfactory systems to parse the similarities in logic and the differences in sensory information processing. —PJH

Science, this issue p. 140

SPLICEOSOME

Remodeling an RNA processing machine

Splicing of precursor messenger RNA (pre-mRNA) is carried out by the spliceosome, a highly dynamic, supramolecular complex that undergoes assembly, activation, catalysis, and disassembly. These essential spliceosome remodeling events are driven by a conserved family of adenosine triphosphatase (ATPase)/helicases. In the presence of its coactivator Spp2, the ATPase/helicase Prp2 associates with the activated spliceosome and translocates the single-stranded pre-mRNA toward its 3′ end. Bai *et al.* now report the cryo–electron microscopy structures of Prp2 both before and after recruitment into the activated spliceosome. These structures and the associated biochemical analysis reveal how Prp2 remodels the activated spliceosome and how Spp2 safeguards the function of Prp2. —DJ

Science, this issue p. 141

HIV

Convergent HIV evolution across species

Human immunodeficiency virus (HIV) has a highly diverse envelope protein that it uses to target human cells, and the complexity of the viral envelope has stymied vaccine development. Roark *et al.* report that the immediate and short-term evolutionary potential of the HIV envelope is constrained because of a number of essential functions, including antibody escape. Consequently, when introduced into humans as HIV or into rhesus macaque monkeys as chimeric simian-human immunodeficiency virus, homologous envelope glycoproteins appear to exhibit conserved patterns of sequence evolution, in some cases eliciting broadly neutralizing antibodies in both hosts. Conserved patterns of envelope variation and homologous B cell responses in humans and monkeys represent examples of convergent evolution that may serve to guide HIV vaccine development. —PNK

Science, this issue p. 142

PLANT SCIENCE

Microbes modify plant root permeability

The root provides mineral nutrients and water to the plant. Diffusion barriers seal the root, preventing the loss of internal water and nutrients. Salas-González *et al.* found that microbes living on and in roots of the model plant *Arabidopsis thaliana* influence diffusion barrier formation, which affects the balance of mineral nutrients in the plant (see the Perspective by Busch and Chory). Plants with modified root diffusion barriers show altered bacterial community composition. Microbes tap into the plant's abscisic acid hormone signals to stabilize the root diffusion barrier against perturbations in environmental nutrient availability, thus enhancing plant stress tolerance. —PJH

Science, this issue p. 143; see also p. 125

CELL BIOLOGY

Glycylation regulates axonemal dyneins

Physiological functions of the microtubule cytoskeleton are expected to be regulated by a variety of posttranslational tubulin modifications. For instance, tubulin glycylation is almost exclusively found in cilia and flagella, but its role in the function of these organelles remains unclear. Gadadhar *et al.* now demonstrate in mice that glycylation, although nonessential for the formation of cilia and flagella, coordinates the beat waveform of sperm flagella. This activity is a prerequisite for progressive sperm swimming and thus for male fertility. At the ultrastructural level, lack of glycylation perturbed the distribution of axonemal dynein conformations, which may explain the observed defects in flagellar beat. —SMH

Science, this issue p. 144

NEUROSCIENCE

Social transmission of pain and relief

In mice, both pain and fear can be transferred by short social contact from one animal to a bystander. Neurons in a brain region called the anterior cingulate cortex in the bystander animal mediate these transfers. However, the specific anterior cingulate projections involved in such empathy-related behaviors are unknown. Smith *et al.* found that projections from the anterior cingulate cortex to the nucleus accumbens are necessary for the social transfer of pain in mice (see the Perspective by Klein and Gogolla). Fear, however, was mediated by projections from the anterior cingulate cortex to the basolateral amygdala. Interestingly, in animals with pain, analgesia can also be transferred socially. —PRS

Science, this issue p. 153; see also p. 122

CORONAVIRUS

Two-way transmission on mink farms

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a zoonotic virus—one that spilled over from another species to infect and transmit among humans. We know that humans can infect other animals with SARS-CoV-2, such as domestic cats and even tigers in zoos. Oude Munnink *et al.* used whole-genome sequencing to show that SARS-CoV-2 infections were rife among mink farms in the southeastern Netherlands, all of which are destined to be closed by March 2021 (see the Perspective by Zhou and Shi). Toward the end of June 2020, 68% of mink farm workers tested positive for the virus or had antibodies to SARS-CoV-2. These large clusters of infection were initiated by human COVID-19 cases with viruses that bear the D614G mutation. Sequencing has subsequently shown that mink-to-human transmission also occurred. More work must be done to understand whether there is a risk that mustelids

may become a reservoir for SARS-CoV-2. —CA

Science, this issue p. 172; see also p. 120

IMMUNOLOGY

PreTCRs use horizontal docking geometry

The T cell receptor (TCR) recognizes peptide-bound major histocompatibility complex molecules (pMHCs) and consists of an α chain in association with a β chain. Both chains have hypervariable complementarity-determining regions (CDRs) that inform whether a particular TCR can recognize a given pMHC. To successfully graduate from the thymus, aspiring αβT cells must generate a functional TCR. During one early checkpoint in this process, the β chain is first paired with a preTβ chain to form the preTCR. Li *et al.* used x-ray crystallography to visualize how preTCRs recognize pMHCs. They report that the CDR3 loop of the preTCR β chain contacts the pMHC with a distinctive lateral topography. This is in contrast to the established binding modality of mature TCRs, whereby all three CDR loops on both α and β chains bind in a vertical orientation. These complexes help solve the mystery of how only functionally rearranged β chains using competent CDR3 loops can properly engage with pMHC at the preTCR stage. —STS

Science, this issue p. 181

CANCER

A metabolic shift into kidney cancer

Deficiency in the metabolic enzyme fumarate hydratase distinguishes a particularly aggressive and lethal form of kidney cancer. Crooks *et al.* investigated the molecular basis for why this subset of kidney tumors rapidly grow and metastasize. Deficiency in fumarate hydratase led to the accumulation of the metabolite fumarate, resulting in the modification and inactivation of factors involved in mitochondrial DNA replication and proofreading. Subsequently, mitochondrial DNA mutations increased, leading to loss of mitochondria and a metabolic shift to aerobic glycolysis. —WW

Sci. Signal. **14**, eabc4436 (2021).

STELLAR ASTROPHYSICS

Potassium and lithium on a white dwarf

White dwarfs are dense stellar remnants left when a dying parent star throws off its outer layers. The high gravitational fields should cause heavy elements to rapidly sink below the white dwarf surface. Nevertheless some "polluted" white dwarfs have evidence for those materials on their surface, which is thought to be due to the recent accretion of rocky bodies from a surrounding planetary system. Kaiser *et al.* report a white dwarf with pollution by potassium and lithium. This observation provides a record of the composition of the accreted rocky bodies and of the Galactic lithium abundance when the planetary system formed, billions of years ago. —KTS

Science, this issue p. 168