RESEARCH

IN SCIENCE JOURNALS

Edited by Michael Funk

ECOSYSTEM SENTINELS

Sampling seabirds

The vastness of the worlds’ oceans makes them difficult to monitor. Seabirds that forage and breed across oceans globally have been recognized as sentinels of ocean health. Sydeman et al. looked across seabird species of both the Northern and Southern Hemispheres and found varying patterns. Northern Hemisphere species exhibited greater signs of stress and reduced breeding success, indicative of low fish resources. Southern Hemisphere species showed less impact on reproductive output, suggesting that the fish populations there have thus far been less disturbed. The differences across hemispheres indicate different strategies for conservation, with active recovery needed in the north and enhanced protection in the south. —SNV Science, abf1772, this issue p. 980

IMMUNOLOGY

Ligand-patterned immune synapses

To execute virus-infected and tumor cells, natural killer (NK) cells form immune synapses with target cells through which they release cytoplasmic granules, processes that require the receptors LFA-1 and CD16. Verron et al. generated artificial immune synapses containing different patterns of ligands for LFA-1 and CD16 (see the Focus by Veillette). Their results suggested that a uniform distribution of LFA-1 and CD16 ligands promoted immune synapse stability and that degradation occurred only when both the LFA-1 and CD16 ligands were present. —AMV Sci. Signal. 14, eabe2740, eabi8525 (2021).

QUANTUM CRITICALITY

Pervasive criticality

Iron-based superconductors are believed to host a quantum critical point (QCP), a zero-temperature phase transition, beneath the “dome” delineating the superconducting phase. Elucidating the nature of this QCP is, however, tricky. Worasaran et al. set out to do just that in a prototypical iron-based superconductor, barium iron arsenide. By applying strain to their samples, the researchers found power-law behaviors that are characteristic of nematic quantum criticality. The associated quantum fluctuations were present over a large portion of the phase diagram. This method may be useful in studying quantum criticality in other material systems. —JS Science, abb9280, this issue p. 973

GENOMIC EVOLUTION

Organismal evolution of the 3D genome

The conformation of chromosomes within the nucleus can reflect a cell’s type or state. However, studies of the conservation and evolutionary history of the mechanisms regulating genome structure across species are lacking. Hoencamp et al. mapped three-dimensional (3D) genome organization in 24 eukaryote species, including animals, fungi, and plants. At interphase, species’ telomeres and centromeres either clustered across chromosomes or oriented in a polarized state maintaining individual chromosomal territories within the cell, a difference attributed to condensin II. An experimental loss of condensin II in human cells promotes the formation of centromere clusters but has no effect on loop or compartment formation. Whether the
the signaling pathways involved, the single-cell analysis approach used in this study could inform the design of future biomaterials to improve wound healing and tissue integration. —JST


BIOMATERIALS

Topography controls the T cell response

Biomaterials are regularly implanted throughout the body, and biomaterial structural properties can alter the associated tissue-healing response around the implant. To better understand this process, Hu et al. created biomaterial membranes with varied surface topography using electrospinning. When they examined the microenvironment around each membrane at the single-cell level in rodents, the T cell response occurred earlier in the most aligned scaffolds, and the T cells appeared to modulate the overall healing response. Although further assessment of these materials is needed to better understand diversity in their research-mentoring relationships. —MMc

CLIMATE CHANGE

Tusk records

Understanding how climate change may affect Arctic species is challenging given that change has been gradual. The impact of environmental transition is reflected in dietary shifts of species at upper trophic levels. Narwhals provide a unique opportunity to track wider ecological change in the Arctic because modifications in their diet can be detected using isotope analysis of the dentine deposited over their lifetimes in their elongated tusk. Dietz et al. measured isotope ratios in the tusks of 10 male narwhals collected between 1962 and 2010. The data revealed patterns consistent with dietary shifts from ice-associated (sympagic) to open-water (pelagic) food species over that time. Further,
CORONAVIRUS

Urban socioeconomics and mortality

Santiago, Chile, is a highly segregated city with distinct zones of affluence and deprivation. This setting offers a window on how social factors propel the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic in an economically vulnerable society with high levels of income inequality. Mena et al., analyzed incidence and mortality attributed to SARS-CoV-2 to understand spatial variations in disease burden. Infection fatality rates were higher in lower-income municipalities because of comorbidities and lack of access to health care. Disparities between municipalities in the quality of their health care delivery system became apparent in testing delays and capacity. These indicators explain a large part of the variation in COVID-19 underreporting and deaths and show that these inequalities disproportionately affected younger people. —CA

Science, abg5298, this issue p. 934

CORONAVIRUS

Cellular RNAs guide CRISPR-Cas9

The Cas9 nuclease widely used for genome editing is derived from natural bacterial defense systems that protect against invading viruses. Cas9 is directed by RNA guides to cut matching viral DNA. Jiao et al., discovered that RNA guides can also originate from cellular RNAs unassociated with viral defense (see the Perspective by Abudayeh and Gootenberg). They rendered this process programmable, linking the presence of virtually any RNA to cutting of matching DNA by Cas9. This capability is the basis of a new CRISPR diagnostic method developed by the authors that can detect many biomarkers at once. Named LEOPARD, this method can detect, for example, RNAs from severe acute respiratory syndrome coronavirus 2 and other viruses, thereby translating a new CRISPR discovery into a powerful diagnostic tool. —DJ

Science, abe7106, this issue p. 941; see also abh9335, p. 914

ZEOLITE CATALYSIS

Speeding catalysis through ionic strength

Brønsted acidity is introduced into microporous zeolites through the addition of framework aluminum. Prief et al., show that in the presence of water, the limited volume in the microchannels of zeolite H-MFI leads to a high concentration of hydrated hydronium ions at aluminum sites. The resulting high charge density creates a highly non-ideal solvation environment and, for cyclohexanol dehydrogenation, the charged carbenium-ion transition state was stabilized. A higher rate was maintained with lower-acidity sodium ion–exchanged zeolites that had the same high ionic strength. —PDS

Science, abh3418, this issue p. 952

EXOSKELETONS

Store energy and save energy

Many devices have been developed to harvest energy from walking or running, but their use often comes at cost to the wearer in the form of increased metabolic demand. Shepertycky et al., designed a device that can harvest mechanical energy from a natural walking gait and convert it to usable electrical energy while also reducing the metabolic energy consumption of the user (see the Perspective by Riemer et al.). The key to achieving “something from nothing” comes from designing the device to use muscle-centric control of the knee exoskeleton resistance to reduce active muscle force during the late part of the leg swing cycle. —MSL

Science, abk9947, this issue p. 957; see also abh4007, p. 909

SPIN PHYSICS

Fast spin flips for entangled atoms

The integration of pump-probe spectroscopy with scanning tunneling microscopy (STM) tools has allowed studies of spin relaxation in atoms on the nanosecond time scale. However, following the free evolution of a pair of entangled spins requires faster initial excitation than can be delivered with microwave pulses. Veldman et al., sequentially combined electron spin resonance–STM and direct current pump-probe techniques to instantaneously flip spins while preserving spin coherence. They used this method to follow free, coherent flip-flop evolution of two coupled spin-1/2 atoms (hydrogenated titanium atom dimers) on a magnesium oxide surface. —PDS

Science, abg8223, this issue p. 964

METABOLISM

Providing for protein synthesis

Compartmentalization of metabolic processes into organelles can have important consequences. Zhu et al., examined the role of the coenzyme nicotinamide adenine dinucleotide phosphate (NADP\(^+\)) and its reduced form (NADPH) in cultured human cells. They found that cells lacking NAD kinase 2, an enzyme needed to make NADPH, had decreased abundance of mitochondrial NADPH and proliferated slowly in culture medium with limited nutrients because of a lack of proline. Proline is made in the mitochondria, and thus a key function of NADPH in the mitochondria appears to be the synthesis of proline to sustain cellular protein synthesis. —LBR

Science, abd5491, this issue p. 968

CORAL REEFS

Think globally, act locally

Climate change–driven elevations in temperature over the past few decades have caused repeated coral bleaching and subsequent death. The impact is so widespread that it has been suggested that only climate change reversal can save coral reefs globally. Donovan et al., looked at the interaction between local conditions and coral reef health and found that poor conditions magnify climate impacts (see the Perspective by Knowlton). Furthermore, reefs where human stressors such as overfishing or pollution were minimized fared better. Such results suggest that caring for reefs locally may help them to persist in our warming world. —SNV

Science, abd9464, this issue p. 977; see also abj7286, p. 908

CORONAVIRUS

Community virus surveillance

Even highly effective vaccines will not save us from the need to monitor severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) activity, perhaps for years to come. Public health institutions will need early warning of any uptick in cases to prepare and deploy interventions as required. Riley et al., developed a community-wide program that was designed to detect resurgence at low prevalence and has been used to track SARS-CoV-2 virus across England. In the four rounds of sampling from May to September 2020, almost 600,000 people representative of all communities were monitored. The results revealed the greatest prevalence among 18- to 24-year-olds, with
increasing incidence among older age groups and elevated odds of infection among some communities. This testing approach offers a model for the type of real-time, country-wide population-based surveillance work that needs to be conducted to monitor SARS-CoV-2. —CA

Science, abf0874, this issue p. 990

AUTOIMMUNITY
Depleting plasmacytoid dendritic cells
Plasmacytoid dendritic cells (pDCs) are immune cells that secrete large amounts of proinflammatory molecules, an essential function that is known to promote the clearance of viral infections. However, persistent activation of pDCs is associated with autoimmune diseases, including cutaneous lupus. Karnell et al. developed and tested a monoclonal antibody, VIB7734, that depleted pDCs in both nonhuman primates and patients with autoimmune disease. Treatment reduced symptom severity in individuals with cutaneous lupus, suggesting that depleting pDCs is a feasible and effective strategy for treating patients with autoimmunity. —MM


INNATE IMMUNITY
Skin sentinels
Group 2 innate lymphoid cells (ILC2) are the predominant ILC subset in the skin and are positioned to respond to barrier disruption. Hardman et al. examined the ability of ILC2 to directly sense skin pathogens. ILC2 from in vivo–challenged skin or peripheral blood showed an increase in gene expression for two receptors involved in sensing bacterial infections, NOD2 and TLR2. ILC2 stimulated with a TLR2 agonist up-regulated interleukin (IL)-5 and IL-13 production, but stimulation with both TLR2 agonist and Staphylococcus aureus muramyl dipeptide also induced IL-6 expression. Exposure of ILC2 to heat-killed, skin-resident bacteria induced IL-6 expression, which was reduced by NOD2 pathway inhibition, and NOD2 signaling stimulated autophagy in ILC2. These findings define a role for ILC2 NOD2 in cutaneous bacterial sensing and regulation of IL-6 expression. —CNF


MEDICINE
The many talents of bispecific antibodies
Bispecific antibodies (bsAbs) bind two different molecules, and this dual specificity offers numerous approaches to therapeutic targeting. There are more than 100 bsAbs in clinical development. These are mostly for cancer, but neurodegenerative, inflammatory, autoimmune, and vascular diseases are increasingly considered as areas in which bsAbs could provide therapeutic solutions. In a Perspective, Brinkmann and Kontermann discuss the general modes of action of these biologics and clinical progress in various diseases. There are hurdles to overcome, including ensuring safety and engineering for greater efficacy. With a plethora of bsAb designs and modes of action, the focus is becoming what to target and how best to do so. —GKA

Science, abg1209, this issue p. 916

ADDITIVE MANUFACTURE
Cross-scale coordination
Laser-based additive manufacturing has the potential to revolutionize how components are designed. Gu et al. suggest moving away from a strategy that designs and builds components in a serial manner for a more wholistic method of optimization for metal parts. The authors summarize several key developments in laser powder bed fusion and directed energy deposition and outline a number of issues that still need to be overcome. A more integrated approach will help to reduce the number of steps required for fabrication and expand the types of structures available for end-use components. —BG

Science, abg1487, this issue p. 932

NEUROSCIENCE
Coding for space in the mammalian brain
Nearly all mammals navigate over large spatial scales in environments that span hundreds of meters to many kilometers. However, very little is known about the neural representations that underlie the coding of such large spaces. Eliav et al. recorded from place cells in the hippocampus of bats as they flew back and forth on an extremely long track (see the Perspective by Wood and Dudchenko). Many place cells had multiple place fields within this large environment. The place field sizes ranged from less than 1 meter up to 32 meters, and the sizes of the different place fields of an individual cell varied as much as 20-fold. Studying animals under naturalistic conditions can reveal new coding principles for the representation of their environment in the brain. —PRS

Science, abg4020, this issue p. 933; see also abg9663, p. 913