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Briefings

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BRIEFINGS

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WATER RESOURCES

Costs and benefits

GLOBAL WARMING is expected to increase evapotranspiration and surface drying in many regions, which could enhance drought intensity and duration. From a water resources perspective, however, it remains unclear whether mitigating warming will reduce water stress more than these mitigation activities enhance it.

Mohamad Hejazi, from the Joint Global Change Research Institute at the Pacific Northwest National Laboratory, and coworkers use assessment models of human and natural system processes to investigate the synergies and antagonisms between climate, energy and water management/policy in the United States. They find that — under the socioeconomic scenario investigated — reductions in water stress from climate change mitigation were less than the increase caused by emissions mitigation activities.

Although the findings are not predictive, they do show that successful policies to mitigate climate change that are not designed to preserve water resources could still enhance the severity, frequency and areal extent of water stresses.

—Alastair Brown, Nature Climate Change

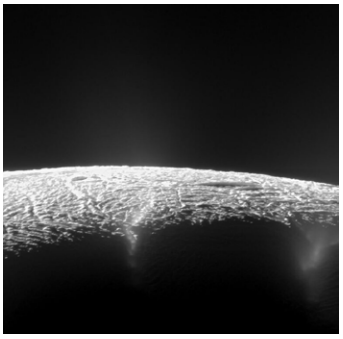
- *Proc Natl Acad Sci USA*, doi: 10.1073/pnas.1421675112 (2015)

PLANETARY SCIENCE

Global ocean on Enceladus

BENEATH AN icy crust, Saturn's moon Enceladus (pictured) has an ocean that covers its entire globe.

NASA's Cassini spacecraft measured wobbles in Enceladus's rotation over more than seven years. The data confirm that the crust is moving separately from the rocky core, meaning that there must be a widespread layer of liquid between them, says a team led by Peter Thomas of Cornell University in Ithaca, New York.



NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE

Cassini had previously spotted jets of liquid spewing from the moon's surface, and other studies have suggested that Enceladus has an underground sea only near its south pole. This latest finding further highlights how Enceladus could be one of the most likely places for extraterrestrial life.

—Alexandra Witze, Nature

- *Icarus*, doi: 10.1016/j.icarus.2015.08.037 (2015)

ZOOLOGY

How the sponge got its skeleton

SPONGES BUILD their skeletons using specialized cells that transport and assemble structural beams like construction workers — a novel way of producing a skeleton compared to other animals.

Sponge skeletons are made of rod-like silica structures called spicules that are cemented to rocks and to each other with collagen. To find out how the spicule assembly process works, Noriko Funayama at Kyoto University in Japan and her colleagues studied a freshwater

NICKFREE/ISTOCK

sponge (*Ephydatia fluviatilis*) under a microscope and discovered 'transport cells' that move spicules inside the sponge. The cells then push the spicules through the animals' outer surface to raise them up and attach them together.

This process allows sponges to adopt a huge variety of shapes and sizes, the authors say.

—Daniel Cressey, Nature

- *Curr Biol*, doi: 10.1016/j.cub.2015.08.023 (2015)

NEUROSCIENCE

Sound switches on worm cells

ULTRASOUND HAS been used to stimulate individual brain cells in a worm. If the technique works in mice, it could be a less invasive way of studying specific neurons.

Neuroscientists currently implant probes into animal brains to stimulate cells that have been engineered to become sensitive to light. Sreekanth Chalasani at the Salk Institute for Biological Studies in La Jolla, California, and his colleagues instead introduced a pressure-sensitive protein, TRP-4, into neurons in the

MARIE-ANNE FELIX, THE MONOD INSTITUTE

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ON THE COVER

Policies that don't take into account water resource preservation won't be successful in climate change mitigation. See page 2.

SOURCE: emmgunn/Thinkstock

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nematode *Caenorhabditis elegans*. They then put the worms in a Petri dish that was partially submerged in a water bath and sent a short burst of ultrasound into the dish, delivering mechanical signals to TRP-4 to activate certain neurons.

By adding the TRP-4 protein into neurons with different functions, the researchers were able to make free-crawling worms reverse direction, stop reversing or make more-frequent sharp turns in response to a brief pulse of ultrasound.

—Helen Shen, Nature

- *Nature Commun.* doi: 10.1038/ncomms9264 (2015)

NEUROSCIENCE

Electric zaps help spinal-cord rehab

ELECTRICALLY STIMULATING a damaged spinal cord as part of rehabilitation therapy may enhance improvements in movement.

Steve Perlmutter at the University of Washington in Seattle and his team bruised the spinal cords of rats to partially paralyze the animals' forelimbs. They then used a neural–computer interface connected to the limb muscles and spinal cord to direct an electrical pulse to just below the damaged spinal area whenever the device detected activity in the weakened muscles.

STOCKDEVIL/ISTOCK

Rats that received pulses for several weeks recovered their ability to reach for and grasp food pellets with their forelimbs to a greater extent than those that did not receive pulses. The stimulated rats maintained their recovery even after the stimulation was stopped, suggesting that it induced lasting changes in the spinal cord. The scientists suggest that the approach might also work in the clinic.

—Alison Abbott, Nature

- *Proc Natl Acad Sci USA.* doi: 10.1073/pnas.1505383112 (2015)

EVOLUTION

Ancient lung parts found in fish

NICOLASPRIMOLA/ISTOCK

A FISH species found in the Indian Ocean has a vestigial lung, suggesting that its ancestors had working lungs before they shifted to life in deep waters.

The coelacanth fish *Latimeria chalumnae* is descended from ancient coelacanths that lived in shallow waters. Paulo Brito at Rio de Janeiro State University in Brazil and his colleagues studied the fish at different stages of development, and found that a lung developed early in the embryo but then slowed its growth as the embryo matured. As the lung shrank in size relative to the growing embryo, a fatty organ that helps fish to control their buoyancy developed.

This is further evidence that ancestral coelacanths could breathe air in shallow waters, and that they lost the use of the lung as it was replaced by the fatty organ — an important adaptation to the deep ocean.

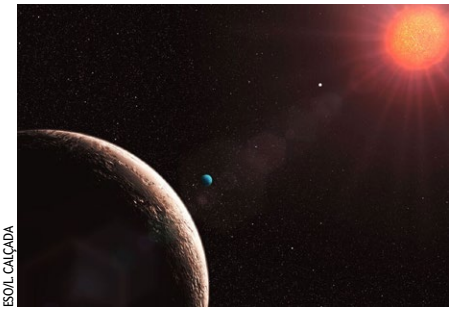
—Corie Lok, Nature

- *Nature Commun.* doi: 10.1038/ncomms9222 (2015)

PLANETARY SCIENCE

A balmy climate on exoplanets?

CERTAIN PLANETS outside our Solar System could have wind patterns that produce habitable climates.



ESO/L. CALÇADA

Ludmila Carone at the University of Leuven in Belgium and her team used climate models to investigate atmospheric temperatures and wind patterns on planets with Earth-like atmospheres. The chosen planets closely orbit red-dwarf stars and always face their stars with the same side. The team found three possible climates for planets that have orbits of less than 12 days. Two of these climates could potentially host life, because of wind jets that stop the side of the planet exposed to the star getting too hot.

The findings could help to guide the selection of exoplanets for future study, the authors say.

—Chris Cesare, Nature

- *Mon Not R Astron Soc.* doi: 10.1093/mnras/stv1752 (2015)

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PLANT ECOLOGY

Orchid shapes trick male insects

ORCHIDS HAVE adapted the shape of their flowers to attract pollinating wasps.

These flowering plants lure male insect pollinators by producing chemicals that mimic the pheromones of their female counterparts, but the effect of flower shape on pollinators has been unclear. To look at this, Marinus de Jager and Rod Peakall at the Australian National University in Canberra studied two species of *Chiloglottis* orchids that emit the same pheromone and the two species of *Neozeleboria* wasps that pollinate the flowers. They found that the wasps copulated more frequently and for longer periods of time with the orchid that they normally pollinate.

ROD PEAKALL

Two male *Neoseleboria* wasps attempt to copulate with *Chiloglottis* orchids.

The dimensions and color of the preferred orchid's callus (the central part of the flower) closely resembled the respective female wasp, and the overall shape of the flower allowed the male wasp to fit better within it.

—Emma Brown, Nature

- *Funct Ecol*, doi: 10.1111/1365-2435.12517 (2015)

AGRICULTURE

Ecological impact of crops drops

THE ENVIRONMENTAL impact of maize (corn) and cotton crops on US freshwater ecosystems has been decreasing over the past decade, mainly because of the use of genetically modified plants that require less added pesticide.

Sangwon Suh and Yi Yang at the University of California, Santa Barbara, assessed the local environmental impacts of crops, including pollution from direct runoff of fertilizers and pesticides, as well as from processing and transportation. They found that the impact of maize and cotton has decreased by about 50 percent over the past decade. However, the impact of soya-bean crops has increased threefold, owing to the spread of an invasive soya-bean pest and a consequent rise in the use of insecticides.

ROYALTY-FREE/CORBIS

The authors say that further improvements may be more difficult, because pests and weeds are beginning to develop resistance to the pesticides produced by the modified crops.

—Jeff Tollefson, Nature

- *Environ Res Lett*, doi: 10.1088/1748-9326/10/9/094016 (2015)

GENETICS

How Inuit genomes have adapted

THE GENOMES of indigenous people in Greenland show how they have adapted to thousands of years of frigid temperatures and a diet that is rich in fatty seafood.

Rasmus Nielsen at the University of California, Berkeley, and his colleagues analyzed the genomes of 191 Inuit people from Greenland and compared them with genomes from people of European or Han Chinese descent. They found that the Inuit genomes were enriched for genes that convert certain fatty acids in the diet into more biologically active forms, and that counteract the oxidative stress associated with a high-fat diet. The team also discovered a mutation in the Inuit genomes that is linked to the development of brown fat cells, which generate heat.

BRENDAN DELANY

Two Inuit women wearing Greenland national costumes.

These mutations seem to date from at least 20,000 years ago, when Inuit ancestors lived around the Bering Strait between Russia and Alaska.

—Heidi Ledford, Nature

- *Science*, doi: 10.1126/science.aab2319 (2015)

SUPERCONDUCTIVITY

The pressure to succeed

FOR 22 years, a mercury-based copper-oxide superconductor has held the highest transition-temperature record of 164 Kelvin, under pressure. We still do not understand the mechanism of superconductivity in the cuprates, or how to increase the transition temperature in these exotic superconductors. It is thus

truly exciting that A. P. Drozdov and co-workers now report 203 K superconductivity in a sulfur hydride above 90 gigapascals. Moreover, the superconductivity seems to be conventional, mediated by electron–phonon coupling as described by Bardeen–Cooper–Schrieffer (BCS) theory.

With such a small sample trapped in a diamond anvil cell, it is difficult to ascertain the exact compound of interest here. Metallic hydrogen is a tantalizing possibility, but H_3S is the more likely candidate. It is a good metal and has strong covalent bonding between H and S. Although hydrides are usually insulators, doping or gating could be a way to drive them to behave like metals at ambient pressure. As BCS superconductivity puts no upper limit on transition temperatures, who knows what the future will hold?

—May Chiao, Nature

■ *Nature*, doi: 10.1038/nature14964 (2015)

NEUROBIOLOGY OF REWARD

Predicting the unexpected

THE CALCULATION of prediction error, that is, the difference between the expected reward from a task and the actual result, is important for associative learning. It is calculated by ventral tegmental area dopaminergic (VTA DA) neurons, but the mechanism is not known. In a classical conditioning paradigm, changing the temporal expectation of a reward resulted in alterations in VTA DA neuron activity — when a cue correctly predicted a reward, VTA DA neuron activity would be suppressed (and vice versa). These activity changes, achieved by a subtraction computation, were found to be mediated by local GABAergic inputs that encode reward expectation, indicating a role for this circuit in reinforcement learning.

— Sian Lewis,
Nature Reviews Neuroscience

■ *Nature*, doi: 10.1038/nature14855 (2015)

GMAST3R/ISTOCK

BACTERIAL PATHOGENESIS

Ironing out Legionella infection

KIJLOUKU/ISTOCK

FOLLOWING INFECTION, *Legionella pneumophila* is able to hijack several cellular processes in order to establish the *Legionella*-containing vacuole (LCV), which enables bacterial replication within the host cell. However, how the bacteria acquire essential nutrients, such as iron, within the LCV is unknown. Isaac *et al.* found that the MavN protein, which is secreted by the Dot/Icm type IV secretion system (T4SS), is required for intracellular growth of *L. pneumophila*. Interestingly, MavN integrates into the host LCV membrane, and growth of a bacterial mutant lacking MavN was rescued following iron supplementation. Furthermore, the authors identified a putative iron-binding motif in MavN, and mutation of this motif recapitulated the growth defects observed for the mutant lacking MavN. Collectively, these data suggest that MavN is a bacterial protein that inserts into the LCV membrane and facilitates iron transport into the vacuole, thereby promoting bacterial virulence.

—Cláudio Nunes-Alves,
Nature Reviews Microbiology

■ *Proc Natl Acad Sci USA*, 10.1073/pnas.1511389112 (2015)

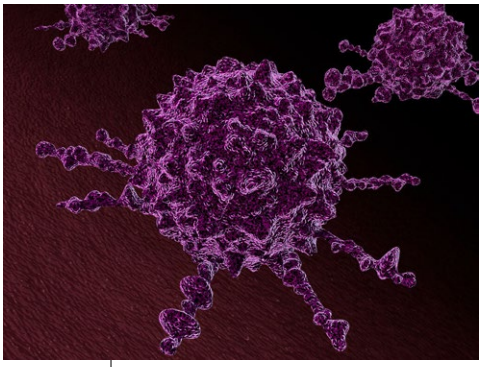
THERAPY

Conscious uncoupling

NEARLY HALF of all cancers have a dysregulated RAS–ERK signaling pathway. Dysregulation is caused by activating mutations in this kinase cascade and leads to cancer cell survival and proliferation. Unsurprisingly, this pathway has been a target for anticancer therapy development, with some success being reported. In particular, inhibition of the kinase activity of BRAF has been used to treat patients with advanced-stage melanoma. However, in most patients there are adverse effects associated with the treatment, and resistance to the drug emerges, and so further development is needed.

An alternative to kinase inhibition has been proposed that might avoid some of the usual pitfalls of these agents. ERK has been shown to dimerize in response to phosphorylation, and this dimerization is required for signaling in the extranuclear compartment of the cell. The use of molecular biology and genetic methods to prevent this dimerization has previously been shown to prevent tumor development. Therefore, pharmacological inhibition of ERK dimerization presents itself as a possible drug development area.

Now, Piero Crespo and colleagues have identified a small-molecule ERK dimerization inhibitor, DEL-22379, that has potential as an anticancer agent. It


PHOTODISC/ GETTY IMAGES

was isolated using an *in vitro* assay to detect inhibition of ERK dimerization and was further validated as binding to a cleft on the surface of the ERK protein that is known to be involved in protein dimerization. In melanoma cells and colorectal cancer cells, treatment with the inhibitor had the same effects as inhibition of ERK dimerization using a mutation in the gene, and so the researchers decided to progress to testing the agent in mice. They used both cell line and patient-derived xenograft mouse models to find the maximum tolerated dose and to test the safety and pharmacokinetic profile of DEL-22379. They were then able to show that inhibition of ERK dimerization using DEL-22379 significantly inhibited tumor growth in these mice. Using additional assays, they established that the anticancer properties of DEL-22379 were mediated by its blockade of ERK dimerization.

The pharmacokinetic profile of DEL-22379 is not suitable for direct translation into the clinic, and there is still work to be done. However, Crespo and his team have shown that the inhibition of ERK dimerization, rather than the catalytic activity of the protein, is a promising anticancer approach.

—Rebecca Kirk,
Nature Reviews Cancer

■ *Cancer Cell*. doi: 10.1016/j.ccell.2015.07.001 (2015)

CARBON CYCLE

Oceanic sink changes

THE NORTH Atlantic is one of the world's most important ocean carbon sinks, which partly mitigate climate change. However the efficiency of CO_2 uptake is expected to be reduced by changes in circulation and biological processes, although the magnitude of their effect is unclear.

Nadine Goris, from the University of Bergen, and Bjerknes Center for Climate Research, Norway, and colleagues showed that decreasing biological activity is the main reason for the warming-induced reduction in this carbon sink. They compared two model simulations from 1850 to 2099 (one with warming due to increases in atmospheric CO_2 included, and one without) to explore the biological, chemical and physical drivers of carbon uptake in the North Atlantic.


DAVID PARSONS/ISTOCK

Under warming, biological production decreased CO_2 uptake while ocean circulation had the opposite effect, but the extent to which these processes counteracted each other differed by regions. A more pronounced reduction in biological activity in the subpolar region resulted in a decrease in CO_2 uptake (about 8 petagrams of carbon) twice as large as the subtropical North Atlantic (about 4 petagrams of carbon).

To better understand the effects of climate change on the ocean carbon cycle and its implications we must improve our limited knowledge of biological production in the oceans.

—Eithne Tynan,
Nature Climate Change

■ *Glob Biogeochem Cycles*. doi: 10.1002/2015GB005109 (2015)

ARCHITECTURED MATERIALS

Snapping metamaterials

MECHANICAL METAMATERIALS are well known to be capable of nonlinear stress–strain behavior, associated with their unique architecture rather than their chemical make-up. Now, Ahmad Rafsanjani *et al.* report a design that permits a series of large serrations — or load drops — during tensile loading, caused by snapping beam buckling. Their design relies on an architecture consisting of two features, bearing and snapping segments, with the snapping segments periodically attached to the bearing segments. During tensile straining of the rubber-like material, the snapping segments behave like clamped beams, reaching a critical strain at which they snap from one


DAMIANO PASINI

A schematic of the snapping metamaterial, with two segment types that are activated under different strain conditions.

configuration to the next. The snapping segments in the multilayered structure are activated at different strains, permitting substantial periodic load-drops in the system's mechanical response. Up to 150 percent strain is demonstrated for a fully elongated structure and finite element simulations and modeling point towards how mechanical characteristics can be controlled. The authors suggest that such an architecture might be useful in deployable structures, and for vibration isolation and damping.

—John Plummer, Nature Materials

■ *Adv Mater.* doi: 10.1002/adma.201502809 (2015)

OBESITY

The supersized tumor microenvironment

THE RISK of certain types of breast cancer increases with obesity, and the density of the extracellular matrix (ECM) is also known to be a risk factor for breast cancer. Bo Ri Seo *et al.* found that obesity and ECM density are connected: they showed that the mammary fat pads of obese mice are enriched with myofibroblasts and ECM components that are associated with increased stiffness. In particular, adipose stromal cell characteristics were altered in obese mice such that they produced more myofibroblasts and generated dense and stiff ECMs. Caloric restriction reduced myofibroblast content in mice, indicating that obesity-associated fibrosis and the associated changes in tissue mechanics can be reversed.

—Gemma K. Alderton, Nature Reviews Cancer

■ *Sci Transl Med.* doi: 10.1126/scitranslmed.3010467 (2015)