

Sciencewatch

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Happy bumblebees

Charles Darwin believed that insects experience emotion. A new study strongly suggests he was correct, at least in the case of bees. Clint Perry of Queen Mary University in London and colleagues found dopamine-dependent positive emotion-like states in bees that were given sucrose and subjected to decision-making tests. This was not explicable simply in terms of the bees becoming more exploratory, and their apparent “good mood” was abolished by



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Unexpected rewards induce positive emotion-like state changes in bumblebees.

the dopamine-antagonist fluphenazine. The work opens up opportunities for understanding emotions in simpler organisms and for studying how emotional states affect decision-making in animals.

● **Further reading**
C Perry *et al.* 2016 *Science* **353** 1529.

Lifespan limit

The oldest well-documented human lived to the age of 122, but is there an upper limit to the human lifespan? Or could medical advances extend it indefinitely? By studying demographic literature in detail, Xiao Dong of the Albert Einstein College of Medicine in New York and colleagues have found strong evidence that there is indeed an upper limit determined by our biology, perhaps a byproduct of our fixed genetic programmes for early life events. Despite advances in medicine, the age at death of the oldest person has not increased since the 1990s.

● **Further reading**
Xiao Dong *et al.* 2016 *Nature* **538** 257.

Constraining B modes

Gravitational lensing of the cosmic microwave background (CMB) can obscure some signals, converting E-mode into B-mode polarisation and acting as a source of noise in the search for inflationary gravitational-wave signatures. Patricia Larsen of the Institute of Astronomy and the Kavli Institute for Cosmology in Cambridge and colleagues have now demonstrated delensing of Planck temperature maps using the cosmic infrared background. Using Planck maps at 545 and 857 GHz, the delensed CMB temperature anisotropies are measured at lower frequencies, with a sharpening of the acoustic peaks detected with a significance of 16 standard deviations. The technique is expected to be essential for further high-precision constraints on inflationary B-mode polarisation.

● **Further reading**
P Larsen *et al.* 2016 *Phys. Rev. Lett.* **117** 151102.

Acoustic holograms

Researchers have reported a novel technique for making holograms using sound waves instead of light. Previously, manipulating the 3D structure of acoustic waves was only possible with a conventional array of acoustic transducers. Kai Melde of the Max Planck Institute for Intelligent Systems in Stuttgart, Germany, and colleagues used just one transducer coupled to a 3D printed monolithic element (a contoured solid-plastic block), which determines the shape of the pressure wave produced. Such acoustic holograms can manipulate and direct microscale objects and also have potential for medical imaging and selective heating.



Ultrasonic waves were used to push a collection of microparticles into the shape of Picasso's peace dove. (Image credit: K Melde/MPI for Intelligent Systems.)

● **Further reading**
K Melde *et al.* 2016 *Nature* **537** 518.

Gut bugs and chemo

Microbes in the gut can dramatically boost the effectiveness of a common anticancer drug, at least in mice. That's the finding of Laurence Zitvogel of Gustave Roussy Cancer Campus in Villejuif, France, and colleagues, who looked at the anticancer antibiotic cyclophosphamide in treated mice. In those mice lacking a protein that restricts the growth of two species of gut bacteria (*Enterococcus hirae* and *Barnesiella intestinihominis*), the drug was almost twice as effective at reducing tumour size. The work suggests that gut bacteria could be used to optimise cancer therapies.

● **Further reading**
R Daillère *et al.* 2016 *Immunity* **45** 931.

Printing bone

Synthetic bone printed on a 3D printer stimulates bone regeneration when implanted into animals, according to a new study. Ramille Shah of Northwestern University and colleagues printed “hyperelastic bone” out of hydroxyapatite (a mineral similar to that in natural bone) mixed with one of two polymers already used in medicine. Implanted into mice, rats and one macaque, the samples were integrated into tissue and caused new bone to grow without negative side effects. A printed “bone” shaped like a human femur was able to withstand natural loads, and the ease with which various shapes can be printed makes the technique promising for humans.

● **Further reading**
A Jakus *et al.* 2016 *Sci. Transl. Med.* **8** 358ra127.

Factory Acceptance Testing at Buckley Systems



Mobile "Roamer" CMM used to confirm dimensions are within tolerance on a quadrupole magnet.

General

Buckley Systems manufactures sophisticated magnets, and it is certified ISO 9001:2008 for the following scope: the design and manufacture of precision electromagnets, ion-beam physics hardware, and high vacuum equipment used in the semiconductor - ion implant industry, laboratory research and particle accelerators. Nevertheless, from the customer's point of view, the manufacturing job is not complete until the Factory Acceptance Test (FAT) is successfully completed. Buckley System "FATs" are described in the Coils, and Magnets sections.

A Quality Control (QC) programme is in place to ensure that machined parts and assemblies meet dimensional tolerances (and other specified customer constraints) throughout the manufacturing process. Several high-accuracy Coordinate Measuring Machines (CMM) measure dimensions to 10 μm including a "roamer" which has "touchscan" capability meaning that its finger can be drawn along a surface rather than just touching a surface at several points. Ceramic gauge blocks measure magnet gaps to 1 μm accuracy.

Coils

Buckley Systems achieves FATs for National Laboratories that are comprehensive and stringent. All measurements within the temperature controlled test building must be within a set tolerance to achieve a pass. A sample list of typical measurements follows:

- (i) electrical resistance tests,
- (ii) inductance tests,
- (iii) pressure and flow rate tests of the cooling water,
- (iv) insulation resistance and high electric potential tests with coils immersed in salted water ($< 1,000 \Omega\text{-m}$) and leakage currents $< 50 \mu\text{A}$,
- (v) impulse-tested for turn-to-turn integrity over a range of voltages with rejection based on frequency shifts or damping rates changing as a function of voltage, or non-conformance to customer supplied waveforms,
- (vi) thermal-switch open/close testing as a function of temperature.

Magnets

Buckley Systems accommodates magnets with apertures ranging from 8 mm to 2000 mm, and has Hall probes with 3.5 m of travel at its disposal. Completed magnets must also undergo FATs and a sampling of what these entail follows:

- (i) the nominal mechanical resonant frequency orthogonal to the magnet axis,
- (ii) Magnetic measurements for dipole magnets through a range of excitation-currents include for example:
 - (a) integrated field homogeneity to one part in 10^4 over a "good field" range in the mid-plane, (b) integrated dipole field over length of yoke and including fringe field region, (c) end field maps and chamfer adjustments to minimize integrated field errors, and (d) B/I curve at the midpoint,
- (iii) Magnetic measurements for quadrupole, sextupole, and octupole magnets over a range of excitation-currents include:
 - (a) integrated field harmonics up to a maximum-pole (42-pole in some cases) at a set radius, (b) integrated field measurements over length of yoke and including fringe field region, (c) end chamfer adjustments to minimize integrated harmonic terms of the customer's choice, (d) magnetic centre measurement to better than ± 50 microns,

- (e) magnetic length, and (f) field angle,
- (iv) Leak rate tests for high vacuum and ultra high vacuum chambers with the appropriate bake-out procedures observed.

Lastly, Buckley Systems can model particle trajectories through the measured magnetic fields and compare the magnet's performance based on the measured fields to the simulated performance. This has been particularly useful in ascertaining whether magnetic spectrometer systems have achieved their design resolution or not.



Magnetic Field Measurements on a Dipole Magnet.



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