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Chemistry

12 October 2017

Rare drug made in major amounts

Total synthesis of complicated natural molecule could overcome supply problem.

A scarce but potent natural product that has shown promise as a medicine has been synthesized in the lab.

Bryostatin 1 is a candidate drug for treating HIV/AIDS, Alzheimer's disease and cancer. But it is notoriously difficult to harvest from the wild. The US National Cancer Institute had an initial stock of only 18 grams, which was extracted from 13 metric tonnes of a marine organism called *Bugula neritina*.

Paul Wender at Stanford University in California and his colleagues used convergent synthesis to produce different sections of the complicated multi-ringed structure separately, which they then assembled to create more than 2 grams of the desired molecule. The longest production sequence for a single section consisted of 19 separate reactions, as part of an overall recipe of 29 steps in total. The average yield was more than 80% per step, for an overall yield of 4.8%. The authors note that the only previously reported synthesis of bryostatin 1 had 57 steps.

Science (2017)

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More Research Highlights...

Immunology

11 October 2017

Immune cells go home to die

Neutrophil white blood cells can end up back in the bone marrow once their job is done.

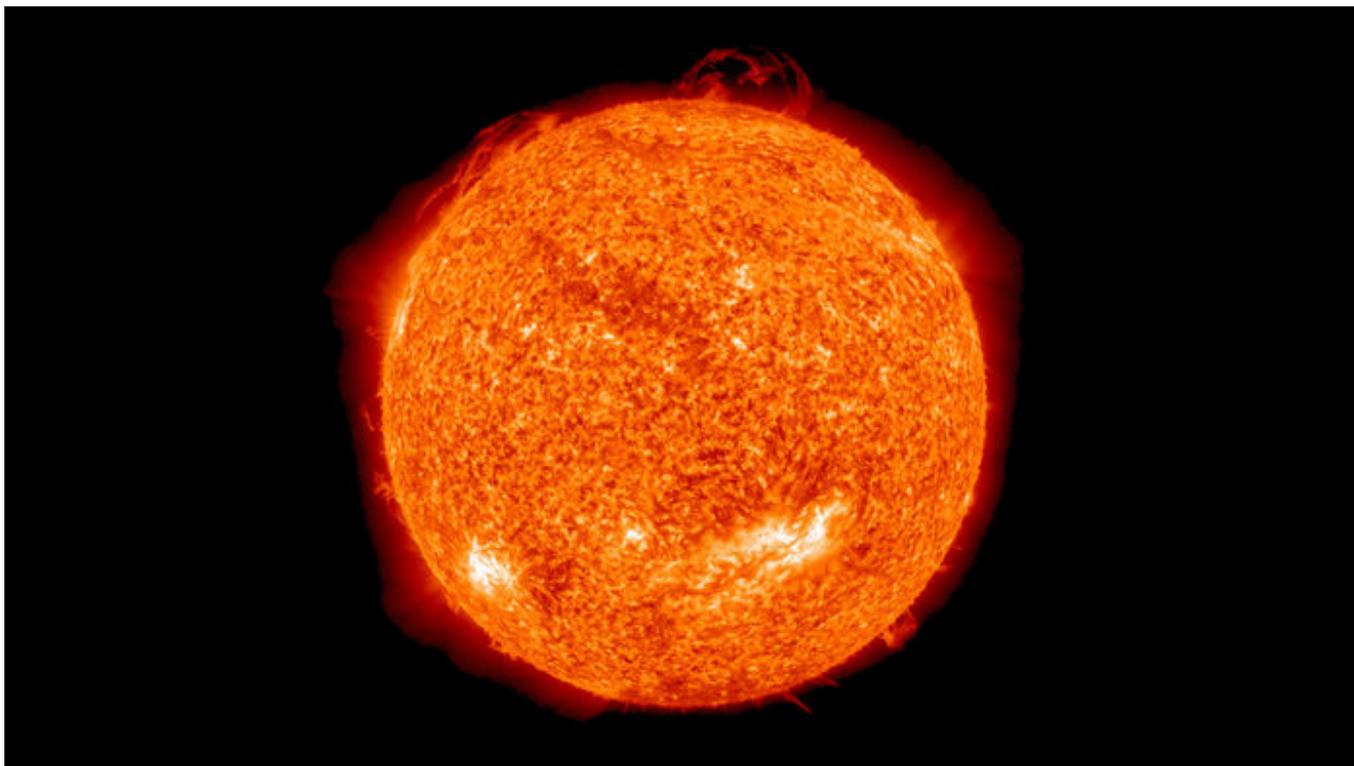
Neutrophils are white blood cells produced in the bone marrow that can fight infection and inflammation by ingesting harmful microorganisms. But some evidence has suggested that if neutrophils do not die in a wound, they might leave and cause inflammation elsewhere in the body.

Now researchers have found that the cells sometimes return to the bone marrow and self-destruct.

Paul Kubes at the University of Calgary in Canada and his colleagues used fluorescence imaging to track the activity of these cells in mice with damage to the liver. They watched as neutrophils infiltrated wounds and cleaned up DNA fragments, as expected. But 24 hours later, many of the cells had returned to the bone marrow and initiated their own deaths. This round trip could be essential for the resolution of inflammation, the authors say.

Science (2017)

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How the Sun's corona can be millions of degrees hotter than its surface has been a mystery. NASA/SDO

Astronomy and astrophysics

11 October 2017

Tiny, fleeting flares might heat Sun's corona

Short-lived 'nanoflares' could explain why the Sun's outer atmosphere can be several million degrees hotter than its surface.

Fleeting 'nanoflares' that are too small to see directly could explain why the Sun's outer atmosphere, or corona, can be millions of degrees hotter than its surface.

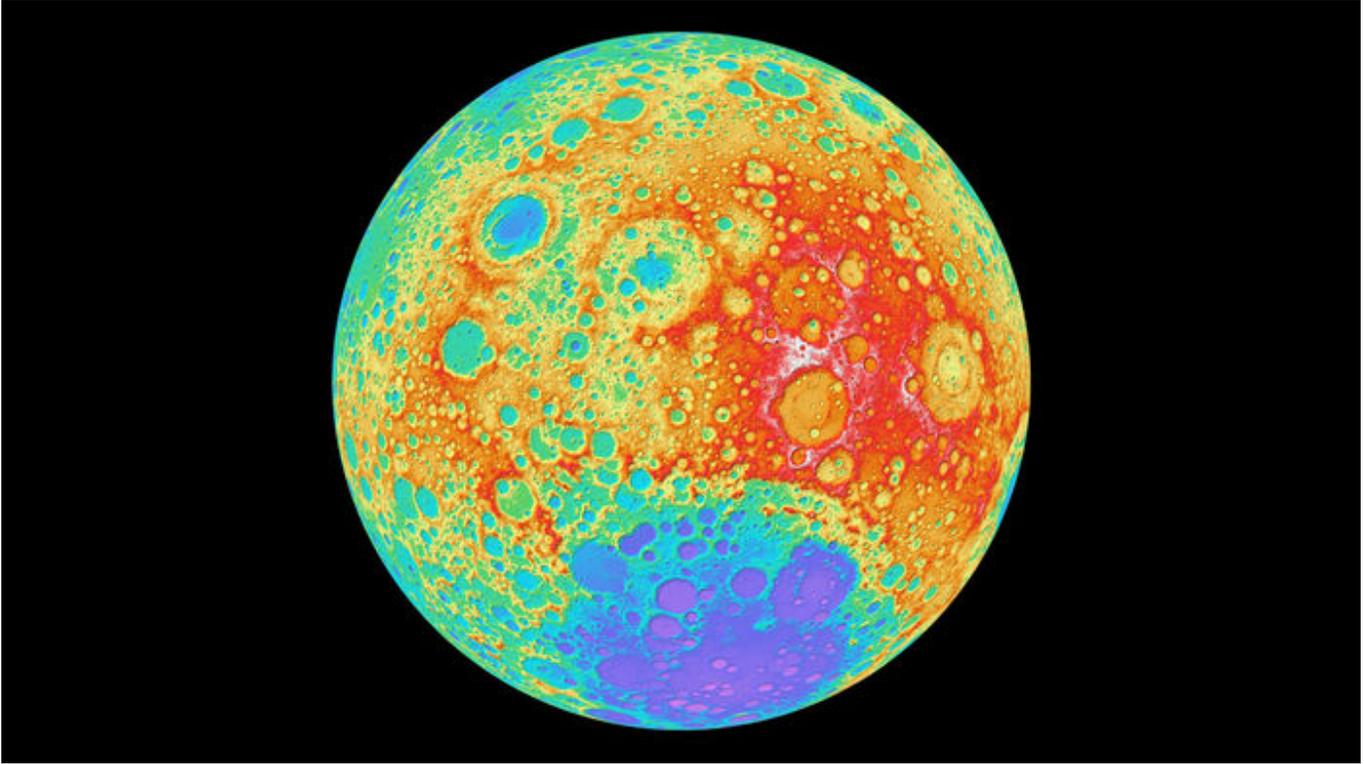
Giant eruptions of ionized gas occasionally release energy into the Sun's outer layers, but this happens too rarely to explain the zone's usual temperature of 1 million to 3 million kelvin.

Shin-nosuke Ishikawa at the Japan Aerospace Exploration Agency in Kanagawa and his colleagues looked for another potential source of heat: a plethora of small, short-lived explosions. The team compared X-ray observations of a region of the Sun made using a research rocket with data on the same area collected by the US Geostationary Operational Environmental

Satellite. Although no distinct flares were indicated by the satellite data, the X-ray maps showed a faint emission, suggestive of a small amount of plasma at an extraordinary 10 million kelvin. The presence of nanoflares could explain this finding, say the authors. They add that the results will constrain models of how these flares could be distributed.

Nature Astron. (2017)

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The huge South Pole-Aitken basin on the Moon was created by a massive impact around 4 billion years ago. NASA/GSFC/DLR/Arizona State Univ./Lunar Reconnaissance Orbiter

Planetary science

11 October 2017

Moon mantle's make-up revealed

Huge asteroid impact on far side ejected rocks from deep under the crust.

The surprising composition of the Moon's upper mantle — the layer below the crust — is revealed by ancient asteroid-impact debris.

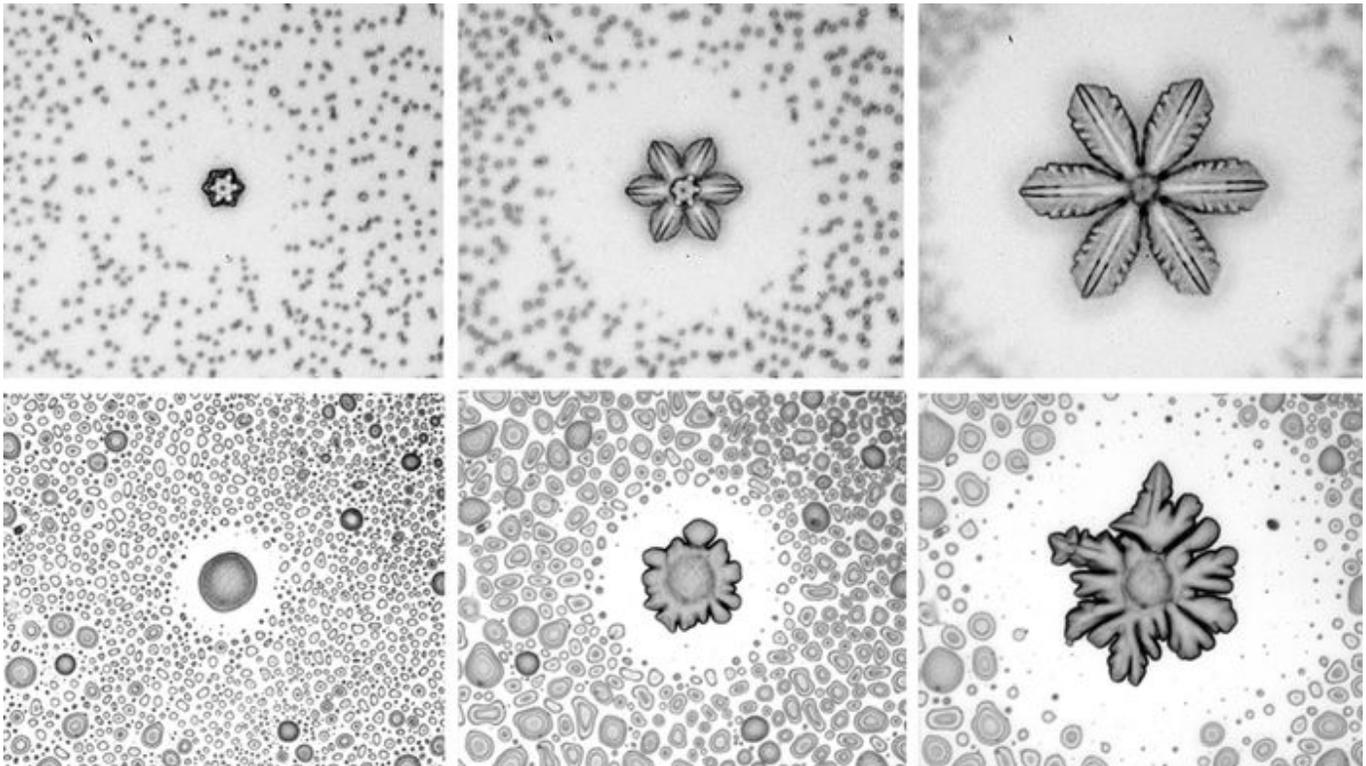
Planetary scientists have long searched for olivine on the Moon, because this mineral is commonly found in Earth's upper mantle. They thought that huge asteroid impacts would have punched through to the lunar mantle, leaving olivine scattered around the surface.

Jay Melosh at Purdue University in West Lafayette, Indiana, and his colleagues used computer simulations to show that one such impact — which created the 2,500-kilometre-wide South Pole-Aitken basin — blasted into the Moon to a depth of at least 100 kilometres. Debris from this farside impact would have scattered across the surrounding highlands, the simulations show.

But that area is covered by a different mineral: low-calcium pyroxene. So the Moon's mantle must be mostly made of low-calcium pyroxene, the team argues — not olivine, as long thought.

Geology (2017)

Share



Ice formed six-leaved-clover patterns on hydrophobic surfaces, and sunflower-like arrangements on hydrophilic ones. J. Liu et al./PNAS

Physics

11 October 2017

Watching how surface properties affect ice growth

Water-repellent surfaces trigger formation of crystals shaped like six-leaved-clover.

Ice crystals grow on solid surfaces in two distinctly different ways, depending on the degree to which the surface attracts or repels water. Jianjun Wang at the Chinese Academy of Sciences in Beijing and his colleagues triggered ice formation using silver iodide nanoparticles, and watched as crystals formed on hydrophilic and hydrophobic surfaces.

When ice formed on the former, it grew along the surface, producing sunflower-like patterns (bottom). On the latter, it minimized its contact with the substrate by growing away from the surface at an angle, and forming six-leaved-clover shapes (top).

Although the influence of factors such as temperature and humidity on ice formation has been well studied, the influence of surface properties is less well understood. The new findings could inform the design of surfaces that need to repel ice, such as windscreens.

Proc. Natl Acad. Sci. USA (2017)

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This ceramic gear is part of a pump that can move molten tin at temperatures of 1,400 °C. Christopher Moore/Georgia Tech

Materials science

11 October 2017

Ceramic pump is hot-tin proof

Machine withstands molten metal at more than 1,000 °C.

A ceramic pump can transport liquid tin heated to 1,400 °C, the highest temperature any liquid has been pumped at so far.

Molten metals offer an attractive option for transporting thermal energy, but finding materials that can contain them at extreme temperatures is tricky.

Asegun Henry at the Georgia Institute of Technology in Atlanta and his team made a mechanical pump entirely from ceramics including Shapal — a mixture of aluminium and boron nitrides. Ceramics had been considered too brittle for such use, but the team was able to pump liquid tin through the machine for three days at temperatures averaging 1,200 °C. The carefully engineered ceramics held fast under mechanical pressures and did not react with the flowing metal, even when temperatures peaked at 1,400 °C.

Ceramic pumps could be used to store and redistribute heat energy that is a waste product of many industrial activities, the

authors say.

Nature (2017)

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This artist's impression shows the ring system of Haumea that was discovered earlier this year. IAA-CSIC/UHU

Astronomy and astrophysics

11 October 2017

A ring far beyond Pluto

Dwarf planet Haumea joins select list of Solar System bodies with rings.

The dwarf planet Haumea, which orbits 1.9 billion kilometres beyond Neptune, has a ring — the first object beyond the orbit of Neptune known to have such a feature.

A team led by Jose Ortiz from the Institute of Astrophysics of Andalusia in Spain combined observations taken by multiple telescopes of changes in light intensity as Haumea passed in front of a star. Dips in the light just before and after the main bulk of Haumea obscured the distant star indicated the presence of a dense, narrow ring encircling the planet's equator. The team estimate the ring's radius at 2,287 kilometres and width at 70 kilometres. Only two other minor planets have been

observed with rings: Chariklo and Chiron, which orbit the Sun between Jupiter and Neptune.

The observations also enabled the team to calculate that Haumea is about one-third as dense as Earth and shaped like a rugby ball.

Nature (2017)

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Climate sciences

11 October 2017

Dry summers ahead for US–Mexico border region

Higher abundance of carbon dioxide in the atmosphere means less rainfall for northwest Mexico.

Summer in northwestern Mexico and the southwestern United States is expected to become palpably drier as a result of rising atmospheric carbon dioxide levels.

Abundant summer rain over parts of this region is crucial for replenishing the limited local water supply. But scientists have been uncertain how climate change might affect the seasonal monsoon rainfall, owing to the coarse resolution and inconsistency of models of atmospheric circulation.

Using an improved climate model that accounts for small-scale atmospheric processes such as convection, Salvatore Pascale of Princeton University in New Jersey and his colleagues found that summer rainfall in the region would drop by up to 40% in response to doubling CO₂ levels. The projected weakening of the North American monsoon, the authors suggest, is driven mainly by rising global sea surface temperatures, which tend to suppress rain-generating atmospheric convection. More climate-adaptation measures and better freshwater management will be needed across the region, the researchers say.

Nature Clim. Change (2017)

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Diseases

11 October 2017

Historical data chart malaria's decline

Millions of blood samples provide comprehensive picture of disease in sub-Saharan Africa.

The largest-ever data set of malaria prevalence in sub-Saharan Africa reveals a long-term decline in the debilitating and often deadly disease.

Robert Snow at the Kenya Medical Research Institute in Nairobi and his colleagues gathered data from the past 115 years on the prevalence of malaria parasite *Plasmodium falciparum*. The data set includes the results of 7.8 million blood samples collected across almost 37,000 locations. The team found that the malaria infection rate has generally declined in sub-Saharan Africa, from 40% of those examined in 1900–29 to 24% in 2010–15.

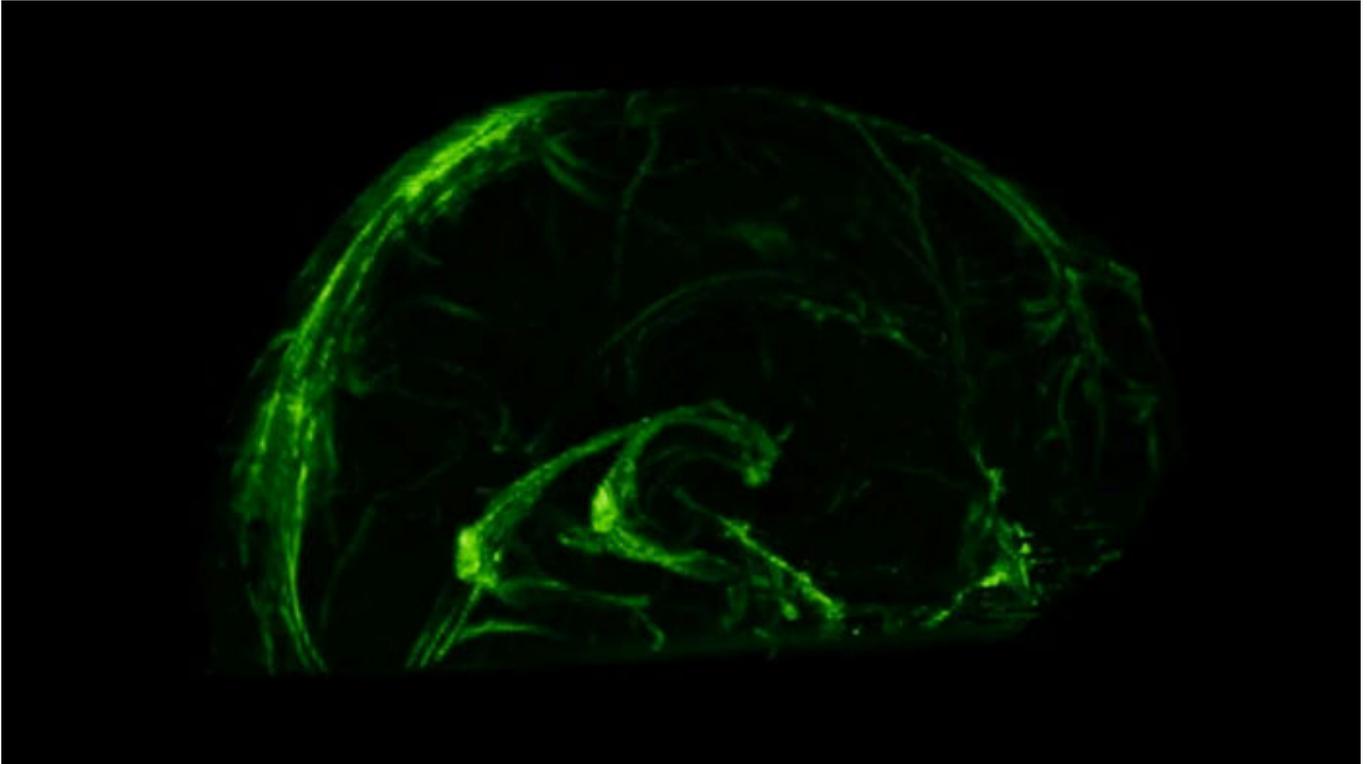
There were two periods of rapid decline in infection, coinciding with the introduction of two major anti-malarial compounds between 1945 and 1949, and the widespread introduction between 2005 and 2009 of bed nets treated with insecticides and a new combination drug treatment.

Resurgence of the disease between 1985 and 2004 can be attributed to the spread of drug resistance, unusual weather events and a lack of investment in prevention.

The team notes that large areas of West and Central Africa still experience high rates of malaria transmission, and warn against crediting the most recent decline in malaria prevalence to human intervention alone.

Nature (2017)

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When the signals from blood vessels are dimmed, lymph vessels can be seen in primate brains on magnetic resonance imaging scans. M. Absinta et al./eLife (CC0 1.0)

Neuroscience

10 October 2017

Scans light up the ‘drain pipes’ in human and monkey brains

Discovery follows previous finding of lymphatic systems in rodents.

Waste-removal ‘drain pipes’ have been observed in the brains of humans and non-human primates for the first time.

Lymphatic vessels in the brain were first hypothesized in 1816, but they were not seen until 2015, when researchers working in mice found them in the meninges — membranes that protect the brain.

Lymphatic vessels are hard to spot because they closely resemble blood vessels. Using a magnetic dye in combination with high-resolution magnetic resonance imaging (MRI), Daniel Reich of the US National Institutes of Health in Bethesda, Maryland, and his team were able to dim the signal from blood vessels while scanning the brain, thus revealing a network of

lymph vessels in humans and marmoset monkeys.

Because it used MRI, the technique has immediate application for studying how these drainage vessels affect a variety of neurological disorders, the researchers say.

eLife (2017)

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Genomics

10 October 2017

Ancient encounters of the Neanderthal kind

New genomes from ancient hominids further entangle their respective family trees.

All humans whose ancestors lived outside Africa carry pieces of Neanderthal DNA. Two ancient-genome studies now suggest that human and Neanderthal populations may have mated more often than was previously thought.

A team led by Kay Prüfer and Svante Pääbo at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, generated a high-quality genome sequence from 50,000-year-old remains of a Neanderthal female found in Vindija Cave in Croatia. Her genome, like one previously sequenced from Neanderthal remains found in a Siberian cave, contain traces of gene flow from *Homo sapiens*. But the Neanderthals who left their mark on modern humans were more closely related to the Croatian individual than to her Siberian relative.

Another team, led by Eske Willerslev at the Natural History Museum of Denmark in Copenhagen, sequenced 5 genomes from a 34,000-year-old *Homo sapiens* burial site in Russia. One individual carried more Neanderthal ancestry than do non-Africans today, possibly also reflecting additional mating episodes between humans and Neanderthals.

Science (2017) *Science* (2017)

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Despite claims of recent sightings in Tasmania, most researchers think the thylacine (*Tylacynus cynocephalus*) died out decades ago. Popperfoto/Getty

Zoology

10 October 2017

Drought drove Tasmanian tiger from Australian mainland

Genomes of extinct marsupial predator reveal ancient family history.

The last known Tasmanian tiger, or thylacine, died in 1936 on the island for which it was named. But, by then, the animal had been extinct on the Australian mainland for more than 3,000 years.

Jeremy Austin and his colleagues at the University of Adelaide in Australia collected samples from thylacine (*Tylacynus cynocephalus*) museum specimens. They sequenced DNA contained in cell structures called mitochondria for 51 animals, including 15 from mainland Australia. Mapping of the relationships between animals suggests that there were two separate mainland populations — a larger, more genetically diverse population in the west and a smaller, less-diverse population in the

east and Tasmania — that diverged about 30,000 years ago.

When Europeans settled on Tasmania in the 1800s, the thylacine population seems to have been expanding after long being kept small and genetically similar by centuries-long drought. This severe dry spell could have contributed to the species' extinction on the mainland, where it was more severe.

J. Biogeogr. (2017)

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Budgies come in two distinct colour combinations; now researchers think they have worked out why. Getty

Genetics

10 October 2017

Pinpointing pigment genes for parrot pets

Enzyme identified that makes budgies yellow and green or blue and white.

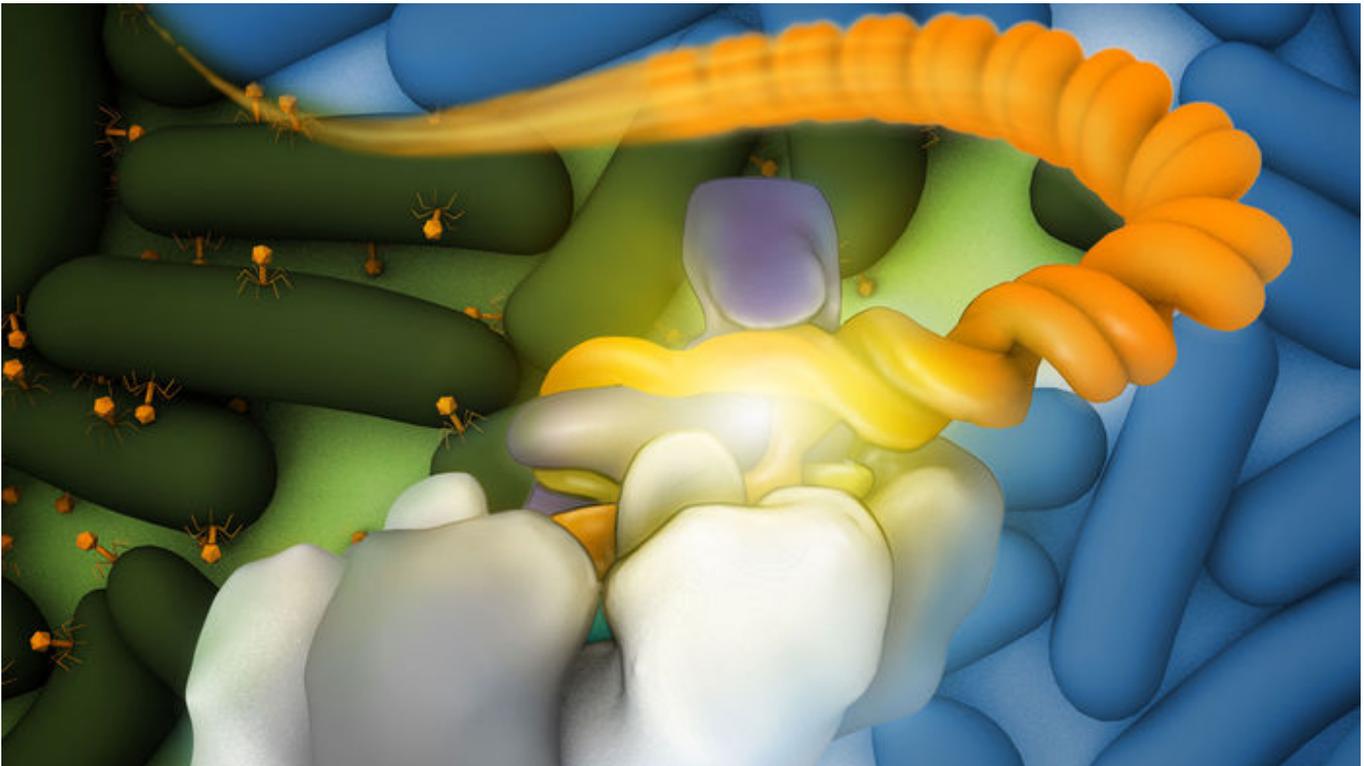
Researchers have identified the genetic trait that controls whether the parrots widely known as budgerigars (*Melopsittacus undulatus*), or budgies, will be yellow and green or blue and white.

By sequencing DNA from 234 budgies, Carlos Bustamante at Stanford University in California and his colleagues determined that a pigment that gives yellow feathers their colour is linked to an enzyme called MuPKS. Yeast expressing the enzyme turned the same bright yellow as the parrot feathers. The researchers found that a single amino-acid substitution in MuPKS halted its activity, making feathers blue and white in some birds.

MuPKS does exist in the genomes of other bird species, but it is expressed at a rate hundreds to thousands of times higher in parrots. And that's why, for example, we don't see any crows or chickens in vibrant blues or yellows, the authors say.

Cell (2017)

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CRISPR systems are used by microbes to fight off attacks, such as from the *Pseudomonas aeruginosa* bound to an invading phage DNA (shown in orange here). V. Falconieri/Subramaniam lab/NCI/NIH

Molecular biology

10 October 2017

CRISPR seen in action

Cryo-electron microscopy paints a picture of how the system binds to DNA.

Electron-microscope images reveal how a CRISPR system marks specific DNA sequences for destruction.

Microbes use CRISPR as a defence system to fend off viruses and other invaders, and geneticists have harnessed it to alter DNA sequences in a process called gene editing.

Sriram Subramaniam at the National Cancer Institute in Bethesda, Maryland, and his colleagues used cryo-electron microscopy to watch a CRISPR system from the bacterium *Pseudomonas aeruginosa* as it bound to DNA. The team found that this process causes large structural changes in an enzyme complex called Csy — which recognizes the target DNA — and the fragment of ‘guide’ RNA that steers Csy to its target. These changes could be important for allowing other enzymes to cut the targeted DNA. The team also showed that three viral inhibitors of CRISPR work by preventing the binding of Cys to its target.

Cell (2017)

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Shorter wheat can bring better harvests — but also problems for farmers. Peter Charlesworth/LightRocket/Getty

Plant sciences

04 October 2017

Genes make short work of wheat

Genetic clues to plant dwarfing offer fresh target to wheat breeders.

The identification of genes that could reduce the height of wheat without contributing to drawbacks seen in current dwarf plants has potential to boost crop yields.

In the late twentieth century, plant breeders introduced genes that make wheat less sensitive to the growth-promoting hormone gibberellic acid. This shorter wheat is less prone to falling over and spoiling, and thus results in higher yields — but it can also show undesirable traits such as reduced disease resistance.

In search of alternative genes, Tobias Würschum of the University of Hohenheim in Stuttgart, Germany, and his colleagues found that a region of the genome called *Rht24* seems to influence plant height. The team mapped *Rht24* to a segment of chromosome 6A and identified two genetic markers that can be used to assist breeding. They also found that *Rht24* is present in wheat cultivars from Europe, China and the United States, and that it does not impair sensitivity to gibberellic acid.

Plant J. (2017)

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Mantis shrimp — such as *Gonodactylus smithii* — are top predators with excellent vision. Roy L. Caldwell/UC Berkeley

Evolution

04 October 2017

Insect-like brain region found in crustacean group

'Mushroom bodies' associated with learning were thought to be exclusive to insects.

Mantis shrimp have a type of brain structure associated with memory and learning that has previously been identified only in insects.

Although insects evolved from crustaceans, the latter were thought to lack the brain centres known as mushroom bodies that are common in insects. Nicholas Strausfeld at the University of Arizona in Tucson and his colleagues analysed the brains of a range of crustaceans and identified insect-like mushroom bodies in mantis shrimp, such as *Gonodactylus smithii*. These animals typically show more sophisticated behaviour in activities such as hunting and visual recognition than other

crustaceans do.

Mushroom bodies may have evolved in the ancestor of crustaceans and insects, say the authors, and then been lost in animals such as crabs and lobsters. But it is also possible that similar structures evolved separately in both insects and mantis shrimp.

eLife (2017)

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Cancer

04 October 2017

Mitochondrial mutations contribute to prostate cancer

Links to tumour aggression and the nuclear genome found in a study of 384 people.

Mutations in the mitochondrial genome seem to be linked to the aggressiveness of prostate cancer.

Much of the search for genes linked to this prevalent form of cancer has focused on the nuclear genome, but energy-producing cell structures called mitochondria have their own genome. Paul Boutros at the Ontario Institute for Cancer Research in Toronto, Canada, and his colleagues analysed the mitochondrial genomes of 384 people with prostate cancer. Around half had at least one mutation involving a single-nucleotide change to their mitochondrial genome.

In total, 21 specific nucleotides were mutated in at least 2 patients. One region was mutated in 59 people. Many of the mutation hotspots were associated with aggressive forms of prostate cancer. The researchers also found correlations between some mitochondrial and nuclear mutations.

Mitochondrial mutations are common in prostate cancer, say the authors, and there seems to be a link between these mutations and mutations in the nuclear genome.

Nature Commun. (2017)

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Diprotodon optatum is the largest marsupial known to have existed. Laurie Beirne

Zoology

04 October 2017

First evidence of marsupial migration

Tooth enamel tells the tale of a massive travelling wombat.

A huge wombat-like creature trekked across Australia with the seasons some 300,000 years ago. It represents the only known example of a regularly migrating marsupial.

Gilbert Price at the University of Queensland in Brisbane, Australia, and his colleagues studied enamel from the incisor of a *Diprotodon optatum*, which could reach almost 3,000 kilograms and is the largest marsupial known to have existed. The enamel layers contain chemical signatures of the animal's plant-based diet in the last three years of its life and provide clues to where it grazed. The team concludes that this individual roamed repeatedly north and south in an area of eastern Australia, covering up to 200 kilometres per year, much like the annual oscillations of many mammals in East Africa today.

Modern marsupials are thought to be too small for such long-distance voyages.

Proc. R. Soc. B (2017)

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Physics

03 October 2017

One photon can trigger many reactions

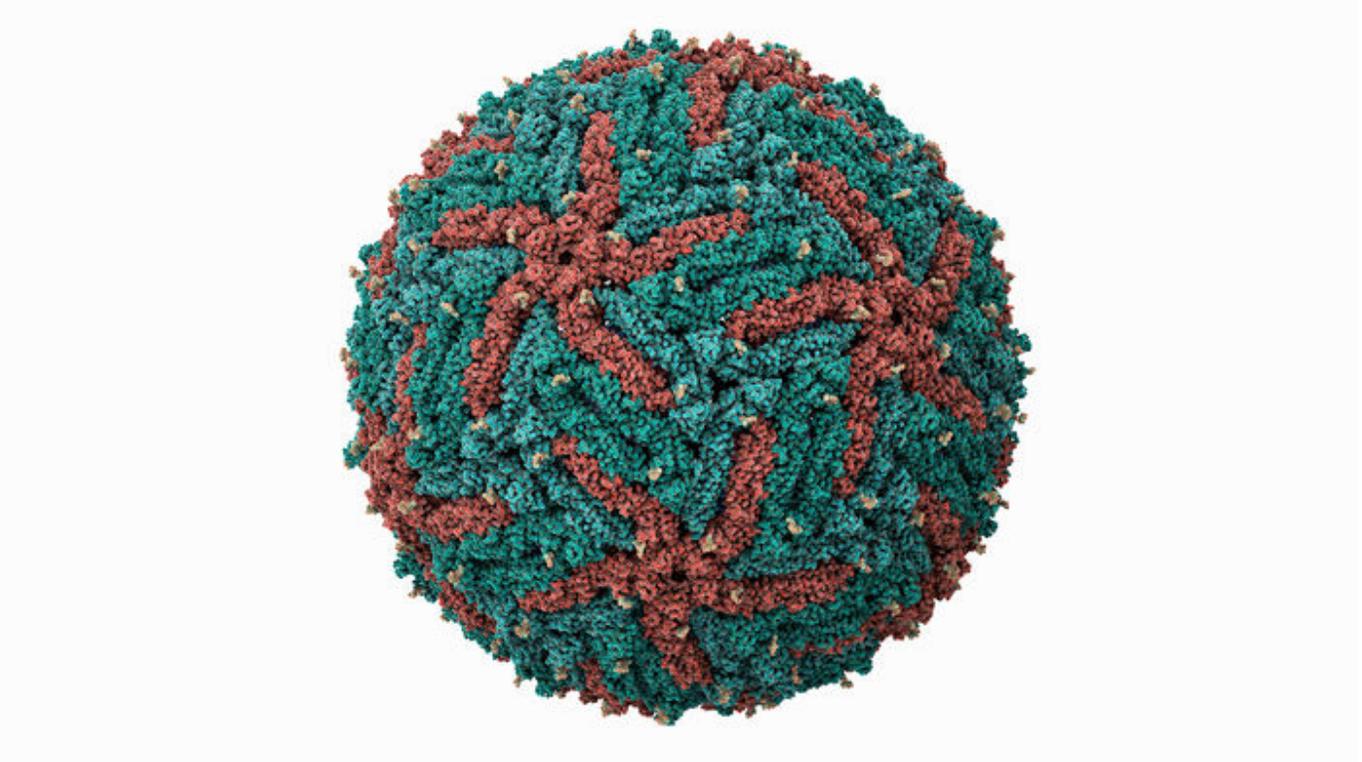
A single photon can set off several molecules and dodge the second law of photochemistry.

A single photon can potentially trigger a chemical reaction involving several molecules, overcoming the second law of photochemistry. When light triggers chemical reactions, as in photosynthesis or vision, the second law holds that each photon reacts with only one molecule — although there are exceptions.

Javier Galego, Francisco Garcia-Vidal and Johannes Feist at the Autonomous University of Madrid reports a new breach of the rule, when the light exists as a standing wave contained by mirrors. They suggest that as light resonates in this optical cavity, it could trigger reactions with all of the molecules there. This would allow a single photon to interact with many molecules at the same time, inducing all of them to release stored energy. If proved experimentally, the principle could be used to develop ways to store and release solar energy, the authors say.

Phys. Rev. Lett. (2017)

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Concern about the Zika virus has increased since it was first linked to microcephaly in around 2015. Laguna Design/SPL

Virology

03 October 2017

Zika microcephaly linked to single mutation

Mutation that arose in 2013 helps virus spread in brain cells.

Birth defects caused by the Zika virus are due to a single mutation in the virus's genome.

In South America, the virus has been linked to microcephaly — undersized heads and brains — in children whose mothers were infected while pregnant.

Cheng-Feng Qin at the Beijing Institute of Microbiology and Epidemiology and his colleagues injected fetal mouse brains with either a strain of Zika currently circulating in the Americas or a Zika strain isolated in 2010 in Asia, where the virus is thought to have originated. The newer strain caused more severe birth defects — including abnormally small brains — than the Asian

strain.

When the researchers sequenced both strains' genomes, they found that a single mutation in the later virus made it better able to spread in mouse and human brain cells. The mutation seems to have arisen in 2013, the authors say, around the time of the first reports of Zika-related birth defects.

Science (2017)

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