New Scientist

WEEKLY August 9 - 15, 2025
No3555 US $7.99 Canada CAN$9.99

HOW OZEMPIC MAKES YOU YOUNGER

THE REAL REASON WOLVES BECAME DOGS

LIFE FOUND IMPOSSIBLY DEEP IN THE OCEAN

DESTROYING INFINITY

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On the cover

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What if the only way to truly understand reality is to do away with infinity for good?

Vol 267 No 3555
Cover image: Brian Stauffer

News

Views

CARLOS GRILLO/ISTOCKPHOTO/GETTY IMAGES

Features

The back pages

Ozempic for everyone?

If semaglutide drugs can reverse ageing, let's consider testing them in healthy people

AUTHOR Mark Twain once noted that "life would be infinitely happier if we could only be born at the age of 80 and gradually approach 18". The pursuit of youth has inspired legends and literature for centuries, but what if we are finally getting somewhere with it?

A recent study suggests that taking the GLP-1 drug Ozempic, whose active ingredient is semaglutide, could knock three years off people's biological age. One place where this effect was most pronounced was the brain, which raises the possibility that drugs like Ozempic could help stave off conditions like dementia. It also seemed to de-age the inflammatory system, which is linked to health issues including heart disease, chronic pain, depression and more.

Semaglutide was developed for type 2 diabetes and has also transformed how we treat obesity. But it should be noted that its effects on ageing were seen specifically for those with a condition called HIV-associated lipohypertrophy, which causes excess fat and accelerated cellular ageing.

"Ozempic seems to de-age the inflammatory system, which is linked to many conditions"

Still, the study authors are confident the effects will apply to other people, too.

It is tempting to think we should all now be taking these drugs to reap their age-reversing, disease-defying benefits. But without robust evidence from large, placebo-controlled trials in healthy people, we can't be sure that's a good idea. To carry these out would be controversial: there is a risk of side effects, so we would need to be confident the benefits outweigh this. And if supplies dwindle, priority should always go to those who are most in need.

Even so, many healthy people seem – at least anecdotally – to already be taking these drugs for weight loss "off label" without knowing if that is safe. Trials would give us a clearer picture of the risks of this, and tell us other things, like how rapid weight loss affects lean muscle mass.

As the list of health benefits of these drugs grows, perhaps it is now time to consider testing them in people without medical conditions, so we can finally see whether ageing can be slowed, and stop speculating about the elixir of youth. ▮

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US Newsstand **Tel** +1 973 909 5819
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Post New Scientist, PO Box 3806, Chesterfield MO 63006-9953

New Scientist ISSN 0262 4079 is published weekly except for the last week in December by New Scientist Ltd, England. New Scientist (Online) ISSN 2059 5387. New Scientist Limited, US 600 Fifth Avenue, 7th Floor, NY 10020

Periodicals postage paid at New York, NY and other mailing offices. Postmaster: Send address changes to New Scientist, PO Box 3806, Chesterfield, MO 63006-9953, USA. Registered at the Post Office as a newspaper and printed in USA by Quad, 555 South 108th Street, West Allis, WI 53214-1145

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News

Environment

Volcano awakens after six centuries

Ash rose to 6 kilometres above sea level after Krasheninnikov volcano in Kamchatka, Russia, erupted for the first time in 600 years. The eruption, on 3 August, is thought to have been caused by the 8.8-magnitude earthquake that struck off the coast of the Kamchatka peninsula on 29 July. The Russian emergency ministry said no populated areas were in the ash cloud's path.

INSTITUTE OF VOLCANOLOGY AND SEISMOLOGY FEB RAS HANDOUT/EPA/SHUTTERSTOCK

Quantum physics

Quantum world gets weirder

Particles of light travelling through a maze of devices seem to have passed a famous test for entanglement – without being entangled at all, says **Karmela Padavic-Callaghan**

PARTICLES that don't seem to be entangled have earned a high score on a famous test of entanglement. The experiment could offer a fresh look at what makes the quantum world so strange.

Nearly 60 years ago, physicist John Stewart Bell devised a test for whether our world is best described by quantum mechanics or by a set of more traditional theories. The key difference is that quantum theory includes "non-locality", or effects that can span any distance – even very large ones.

"The photons may have had another unusual quantum property: indistinguishability"

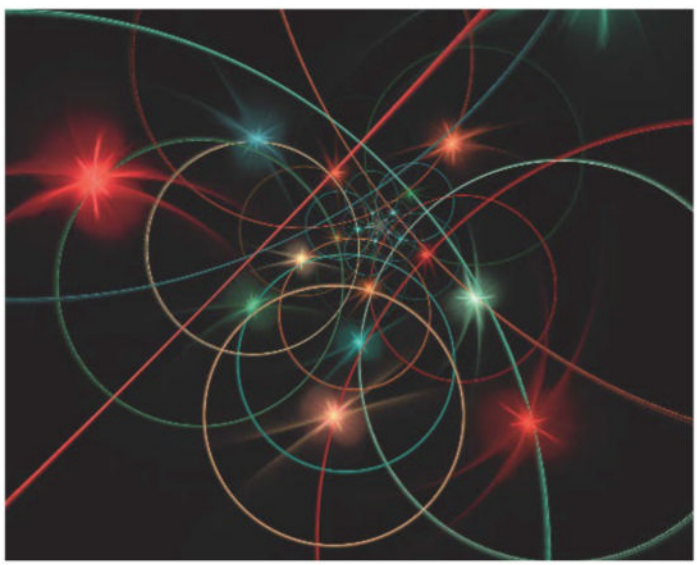
Strikingly, all of the experiments that have implemented Bell's test to date have affirmed our physical reality is non-local, suggesting we live in a quantum world.

However, those experiments included particles inextricably linked via quantum entanglement. Now Xiao-Song Ma at Nanjing University in China and his team say they aced the Bell test without entanglement. "Our new work may provide a new perspective to people's understanding of non-local correlations," Ma says.

The experiment started with four special crystals, each of which emitted two particles of light, or photons, when illuminated with lasers. The photons had several properties the researchers could measure, including polarisation and phase, which describes the way light wiggles when seen as an electromagnetic wave. The researchers made these photons travel through a maze of optical devices, such as crystals and lenses, before hitting a detector.

In a typical Bell test experiment, two hypothetical experimenters, Alice and Bob, measure the properties of entangled particles. They can then determine whether the particles are linked in a non-local way by plugging their findings into an "inequality" equation.

The new experiment included Alice and Bob, each represented by a set of optical devices and detectors, but not entangled photons. In fact, the researchers added devices to their setup that prevented the particles' frequencies and velocities from becoming entangled. And yet, when the researchers put Alice's and Bob's measurements into the inequality equation, they found the photons were linked more strongly than could be explained by any local effect (*Science Advances*, DOI: 10.1126/sciadv.adr1794).



NATALI ART/ALAMY

Can things really have the properties of entanglement without being entangled?

Mario Krenn at the Max Planck Institute for the Science of Light in Germany says this may be because the photons had another quantum property: they were created in such a way that it was impossible to tell which photon was "born" at which crystal, and their paths were indistinguishable, he says. In the past, Krenn, Ma and their colleagues used this property – called "indistinguishability by path identity" – to entangle photons, but they made sure it was the only type of quantum weirdness present.

The team doesn't yet have a definitive theory for why it could reproduce the results of

Passing on quantum effects

Quantum entanglement (see main story) is an important resource for quantum computing and communication – and in some cases, it may be a resource that can be shared nearly indefinitely.

Many quantum calculations, such as transferring very securely encrypted quantum information, require the entanglement of some number of particles. While there are standard ways for doing this, Ujjwal Sen and his colleagues at the Harish-Chandra Research Institute in India wondered whether entanglement, instead of being produced from scratch, could be shared.

To find out, he and his team developed a mathematical model where two hypothetical experimenters, called Alice and Bob, share entanglement. For example, each experimenter might have a particle, and those two particles would be entangled. The researchers then considered another pair – Charu and Debu – who urgently need entanglement, but can't produce it by themselves.

Their calculations showed that, if Charu has a particle that interacts with Alice's particle, and the same is true for Debu and Bob, then the first pair can pass on some of their entanglement to the second (*Physical Review A*, doi.org/pzp8). Kornikar Sen, who is also at the Harish-Chandra Research Institute, but isn't related to Ujjwal Sen, says that the situation is similar to Charu and Debu not being able to interact with each other, but both being able to tap into the same "entanglement bank".

In fact, she and her colleagues calculated that this entanglement-sharing procedure could be adapted so it works for infinitely many successive pairs of experimenters who can't generate their own entanglement.

entanglement in the Bell test without using entanglement, but Ma says several other fundamentally quantum phenomena have indistinguishability as a requirement. So, it could also be a basic ingredient needed to create non-local correlations, even in a recipe that doesn't include entanglement.

'Beautiful extension'

One possible issue with the experiment may lie with the "post-selection" technique the team used, where only some photon detections are considered, says Stefano Paesani at the University of Copenhagen in Denmark. In his view, this makes it unclear whether their non-entangled photons can be definitively scored as non-local on Bell's test. Without post-selection, the experiment would match more standard scenarios where entanglement is present, he says.

Jeff Lundeen at the University of Ottawa says the new experiment doesn't sufficiently rule out the possibility of Alice and Bob colluding, which would produce correlations that researchers could mistake for non-local effects. "So, the experiment doesn't seem to have the same implications as the famous Bell's inequality violation," he says.

"It really is a beautiful extension of one of the most striking landmark works on entangled photons from the 'glory days' of the 1990s," says Aephraim Steinberg at the University of Toronto. In his view, however, there is still some entanglement in the new experiment. This exists not at the level of photons, but rather in the quantum fields photons arise from.

The team wants to improve its devices to avoid some of these criticisms. "Our collaboration group already identified several key potential loopholes," says Ma. ▮

Neuroscience

Brain ageing may be due to a breakdown in protein factories

Michael Le Page

WE MAY have discovered a fundamental cause of cellular ageing that underlies many other ageing processes in cells.

A study of the brains of freshwater fish called killifish has shown that, as they age, the protein-making structures in cells start jamming while making a key class of proteins, causing a vicious cycle of decline.

The discovery could lead to new ways to tackle brain ageing, says Alessandro Cellerino at the Leibniz Institute on Aging in Germany. "We are mostly talking about improving cognition or preventing cognitive decay, rather than increasing lifespan," he says.

The recipes for making proteins are stored in DNA in our cells. When a protein is needed, copies of these recipes are transcribed into a molecule called mRNA. The mRNA copies are edited and sent to protein-making factories called ribosomes, which translate the recipes into a sequence of amino acids that make up the protein.

Normally, the more mRNA copies there are, the more of a protein is produced. But studies have shown that, as human cells age, this correlation breaks down, so the production of a protein can decline despite no reduction in the amount of mRNA.

Cellerino and his team may now have found out why this happens by studying ribosomes in the brains of killifish as they age. The researchers used a technique that allowed them to take a snapshot of how far each ribosome had moved along the mRNA to which it was bound.

"This phenomenon of ribosome stalling may connect different hallmarks of ageing"

They found that as the killifish's brains aged, there were a lot more ribosomes bound to the sections specifying the amino acids arginine and lysine than would be expected by chance (*Science*, doi.org/g9vtzj). This means the ribosomes are stalling at these points, halting production before the protein is complete.

Arginine and lysine are both positively charged amino acids that are abundant in proteins that bind to DNA or RNA, which are both negatively charged. This means it is these DNA- and RNA-binding proteins that are most likely to be affected by the stalling. That is a problem, as these carry out key functions, such as repairing DNA damage.

"It is known that with ageing, there is DNA damage, there is less production of RNA, there is less splicing, there is less production of proteins," says Cellerino. "What we suggest is that this phenomenon of ribosome stalling connects all these different hallmarks of ageing."

What's more, ribosomes also contain RNA-binding proteins, he says. "So there is this vicious cycle by which there is stalling on the mRNAs that code for ribosomal proteins, which results in less production of ribosomes, which results in less protein synthesis."

The big question is whether this also happens in human brains. Earlier this year, Gene Yeo at the University of California San Diego showed that RNA-binding proteins become depleted in human neurons as they age. To this extent, his findings are in agreement with Cellerino's, he says, but the cause isn't yet clear.

If the findings do apply to people, it could lead to new treatments for age-related brain conditions. In killifish, the stalling of ribosomes triggers a signal that produces an inflammatory response. "The constant activation of this pathway causes chronic inflammation," says Cellerino. "Chronic inflammation is a very important factor in ageing, especially in the brain." There are experimental drugs that can block this pathway and thus might help stave off such conditions, he says. ▮

Tackling ageing in the brain could help keep us playing games as we get older

ALVARO GONZALEZ/GETTY IMAGES

For more on preventing cognitive decline, see page 16

Astronomy

Eye-like cameras let us peer closer at stars

Matthew Sparkes

CAMERAS that mimic human eyesight could have advantages for astronomers, allowing them to capture extremely bright and dim objects in the same image and track fast-moving objects without motion blur.

Traditional digital cameras operate by sampling a grid of pixels many times a second, recording data from every pixel each time. Neuromorphic cameras, also known as event cameras, work very differently. Each pixel is only sampled if the brightness at that spot has changed; if a point on the sensor sees the same brightness as in the previous reading, then no new data is stored. This is similar to how sensory information is collected by the human eye.

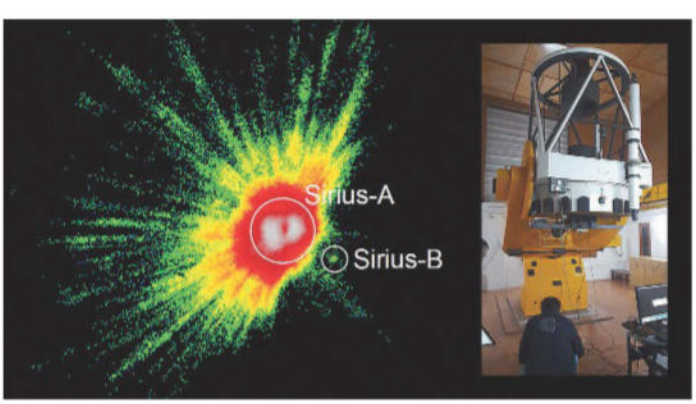
This approach has several benefits: it stores less data for the same video because only changing pixels are recorded, and it can operate at much higher frame rates. On top of this, such cameras can capture extremely dim objects even if they are next to very bright objects that would saturate frames taken on a traditional camera, because the pixels detect photons in a logarithmic scale rather than a linear one.

To explore the potential of this technology for astronomy, Chetan Singh Thakur at the Indian Institute of Science, Bengaluru, and his colleagues installed a neuromorphic camera on a 1.3-metre-mirror telescope and a 20-centimetre-mirror telescope at the Aryabhatta Research Institute of Observational Sciences in Uttarakhand, India.

They were able to clearly capture meteorites passing between Earth and the moon, as well as an image of the Sirius binary system, which consists of Sirius A – the brightest star in the night sky – and Sirius B (arXiv, doi.org/pzqq).

Sirius A is about 10,000 times brighter than Sirius B, which means they could never be captured clearly in a single image with traditional sensors, says Mark Norris at the University of Central Lancashire, UK, who wasn't involved in the work.

Neuromorphic cameras are also extremely good at detecting fast-moving objects because of their higher frame rate, says Singh Thakur. "You can really go high speed, like a few kilohertz, and the advantage is if something is moving really fast, you'll be able to capture it. The normal camera would just give you motion blur."



SATYAPREET SINGH YADAV ET AL., INDIAN INSTITUTE OF SCIENCE

The neuromorphic camera (below right) was able to image Sirius-A and Sirius-B together (below left)

Health

Ozempic really could turn back the clock on your biological age

Helen Thomson

THE type 2 diabetes drug Ozempic has been linked to slower rates of ageing, and now we have good-quality evidence that this really does occur.

GLP-1 drugs like Ozempic and Wegovy, both of which contain the medication semaglutide, have gained huge prominence for their effects on obesity, but are also being explored for conditions such as dementia and cardiovascular disease.

Scientists have previously suggested that they might delay biological ageing – the rate at which cells age – largely based on animal studies and observational human data. Now, we have the first clinical trial results providing direct evidence of that, says Varun Dwaraka at diagnostics company TruDiagnostic in Kentucky.

3.1 yrs
Reduction in biological age seen in people taking semaglutide

One way to assess a drug's effect on biological ageing is through epigenetic clocks. These identify patterns of DNA methylation, the chemical tags added or removed from DNA that affect gene activity. These patterns shift with age and can be sped up or down by lifestyle choices, such as our diet, meaning our biological age can be younger or older than our chronological age.

Dwaraka and his colleagues studied the epigenetic clocks of 108 people with HIV-associated lipohypertrophy, a condition that causes excess fat and accelerated cellular ageing. In a randomised-controlled trial, half were given Ozempic once a week for 32 weeks and the other half a placebo.

Using blood taken before and after the trial, the team identified the biological age of 84 of these individuals. "Those on semaglutide became, on average, 3.1 years biologically younger by the end of the study," says Dwaraka. Those in the placebo group showed no significant change. "Semaglutide may not only slow the rate of ageing, but in some individuals partially reverse it," he says.

The researchers also found biological ageing was slowed in several organs and systems, including the heart and kidneys, with the most pronounced effects seen in the inflammatory system and brain – where the drug appeared to delay biological ageing by almost 5 years (medRxiv, doi.org/pzt6).

Dwaraka believes the effects stem from the drug's influence on fat distribution and metabolic health. Excess fat around organs can trigger the release of pro-ageing molecules, which alter DNA methylation in key genes. Semaglutide also stops low-grade inflammation, a driver of epigenetic ageing.

Although the results were in people with HIV-associated lipohypertrophy, many of the biological pathways affected by semaglutide weren't specific to HIV pathology. "Therefore, it is plausible that similar effects on epigenetic ageing could be observed in other populations," says Dwaraka.

It is unsurprising that ageing is slowed by these drugs, says Randy Seeley at the University of Michigan Medical School, since they reduce the metabolic burden on a range of cells and lower inflammation. However, he believes much of this benefit stems from broader improvements to overall health.

Biotechnology

Critics of de-extinction targeted

Some researchers who have been critical of Colossal Biosciences's plans to revive extinct animals say they have been targeted by online articles trying to discredit them, finds **Matthew Sparkes**

ACADEMICS who have questioned the validity of efforts to "de-extinct" animals like the woolly mammoth and the dire wolf have complained of an apparent campaign to discredit them. They believe the attacks are intended to deter criticism of de-extinction projects, a controversial research area attracting attention from the media and investors.

Biotech company Colossal Biosciences has, over several years, announced efforts to recreate animals including the woolly mammoth, thylacine and dire wolf. All these are extinct, but the firm aims to modify the genomes of related creatures still living today to bring them back. Many scientists have said this can only lead to animals with partially modified genomes, not true recreations.

Vincent Lynch at the University at Buffalo, New York, and Victoria Herridge at the University of Sheffield, UK, are two of those who have publicly criticised Colossal's efforts, and now say they have seen blog posts attacking their expertise and credentials.

While neither of the academics has any evidence of who is behind the campaign, most of the content specifically mentions their comments on Colossal and shares similar phrasing and content. Tests for AI-generated content run by *New Scientist* suggest many of the articles were created by chatbots.

Colossal says it has no involvement in these articles. "The de-extinction work that we do is controversial to some and we have a handful of very vocal critics. Neither Colossal, nor any of its investors, are involved in commissioning negative stories about critics," Ben Lamm, chief executive of Colossal, said in a statement to *New Scientist*.

Lynch, a tenured researcher in evolutionary developmental biology, has noticed several critical blog posts, including one on the business news site *CEO Today* by an unnamed author, which claims some aspects of his research have been unsuccessful and this "undermines his credibility in the de-extinction debate".

THE NATURAL HISTORY MUSEUM/ALAMY

The woolly mammoth is one animal some hope to recreate

Jacob Mallinder at Universal Media, which publishes *CEO Today*, told *New Scientist* the story was written by a freelancer and passed on their contact details, but they didn't respond to a request for comment. Mallinder didn't respond to questions about the motivation for running the piece and whether it was paid for by a sponsor.

Legal threats

Lynch, who has criticised Colossal profusely on X, also showed *New Scientist* a letter from Colossal's lawyers warning of legal action if he didn't stop his "increasingly hostile and now defamatory attacks" on Lamm and the company itself. Lamm confirmed that Colossal's lawyers did send this letter, but declined to give details of the comments it referred to.

Lynch says his comments have only constituted fair and open scepticism, and that criticism should be encouraged. "It's the whole basis of the scientific method. We're supposed to be super critical about everything," he says. He believes the efforts are designed to stifle criticism or stop news organisations seeking comment from him about de-extinction stories in the future.

Lynch says he also receives several copyright claims a week on images he has posted to X, and recently his account on X was suspended. He says this was for reported copyright violations for his own images or images in the public domain.

No one from Colossal has requested any copyright takedowns, said Lamm. "We fundamentally believe in free speech and believe everyone has the right to voice their opinion – even if it is not shared by the vast majority."

Herridge, a palaeontologist, has also seen two negative blog posts about her published recently, including one on *BusinessMole*, which was headlined "Are her scientific critiques dangerously unqualified?" In truth, Herridge has a PhD in evolutionary biology and is a presenter of science programmes on radio and TV.

The post doesn't point to any document that casts Herridge's credentials into question. It was removed after *New Scientist* contacted the publication for comment and received no reply.

Herridge says she considers the posts to be "an unfair and unfounded attempt to undermine my credibility" since speaking out about de-extinction. "Seeking to silence critics, rather than answering the criticisms themselves, is the antithesis of good science," she says.

Andrew Chadwick at Loughborough University, UK, who researches online disinformation, says that open discourse is more important than ever. "In today's media environment, with so much noise and competition for attention, I think it's incredibly important that qualified, practising scientists should feel free to express informed opinions about their particular fields of expertise," he says. "This is particularly crucial in highly competitive, controversial fields where much is at stake."

"Seeking to silence critics, rather than answering the criticisms, is the antithesis of good science"

In his statement, Lamm reiterated Colossal's take on all this. "Colossal is focused on bringing back extinct species and developing tools for conservation all while working to instil a sense of excitement and wonder in kids of all ages for science. Our goal is to inspire scientists, not tear scientists down," he said. ▮

Health

Sweeteners may blunt cancer therapy

Sucralose could alter the gut microbiome in a way that impairs the immune system

Grace Wade

PEOPLE who consume the artificial sweetener sucralose are less likely to respond to immunotherapy.

Immunotherapy helps the immune system detect and destroy cancer cells, making it a crucial treatment for numerous cancers. However, it doesn't work for all patients, "and in many cancer types, it only works for the minority of patients", says Abigail Overacre-Delgoffe at the University of Pittsburgh in Pennsylvania.

It isn't clear why that is, though numerous studies indicate the gut microbiome plays a role, as it helps regulate immune responses. Research has also shown that artificial sweeteners can change the composition of gut microbes in humans.

So Overacre-Delgoffe and her colleagues assessed the potential impact of artificial sweeteners on immunotherapy. They tracked treatment outcomes in 157 people who underwent immunotherapy for at least three months. Of the participants, 91 had advanced melanoma, 41 had advanced non-small cell lung cancer and 25 had melanoma that was surgically removed but had a high likelihood of returning.

"Research has shown artificial sweeteners can change the composition of gut microbes in humans"

Before starting treatment, participants completed a questionnaire that assessed their diet over the previous month, which the researchers used to estimate sucralose consumption.

Consuming more than 0.16 milligrams of sucralose per kilogram of bodyweight a day was associated with worse treatment outcomes. Participants with advanced melanoma who consumed less sucralose lived a median of five months longer without their cancer progressing, compared with those who consumed more (*Cancer Discovery*, doi.org/g9vs9r).

For participants with non-small cell lung cancer, the difference was 11 months. In participants at high risk of melanoma returning, those who consumed less sucralose remained cancer-free for a median of six months longer than those who consumed more.

Similar differences were seen among participants who consumed more than 0.1 milligrams of another artificial sweetener, acesulfame K, per kilogram of bodyweight a day.

Further experiments in mice with tumours from common types of cancer – adenocarcinoma or melanoma – showed that adding sucralose to their water during immunotherapy increased tumour growth and reduced survival.

Genetic analysis revealed that T-cells – immune cells leveraged by immunotherapy to kill cancer – were impaired in the mice receiving sucralose. Faecal samples also showed significant changes in the rodents' gut microbiomes, with increased activity in pathways that break down arginine, an amino acid that T-cells rely on to function.

Further experiments showed that arginine supplements improved survival in mice receiving sucralose until their survival odds were about the same as those that weren't consuming the sweetener.

However, it is unclear whether sucralose has the same effect on the gut microbiome and T-cell function in humans, says Jotham Suez at Johns Hopkins University in Maryland. ▮

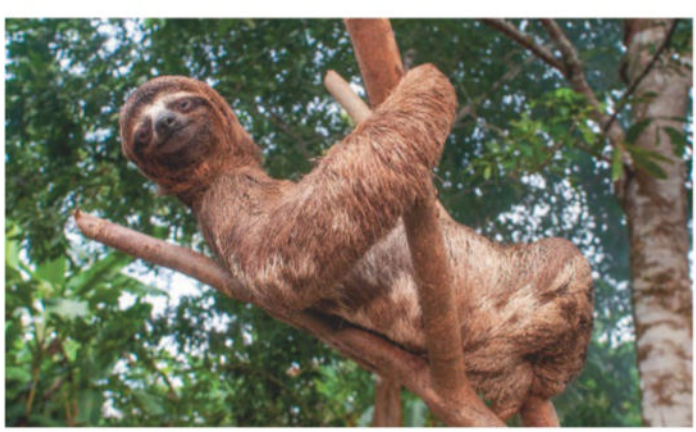
Environment

Forests with robust animal populations store more carbon

TROPICAL forests populated with a diversity of seed-dispersing animals can accumulate carbon up to four times as fast as fragmented forests where these animals are absent or their movement is restricted.

Animals contain just a tiny fraction of the carbon stored in the environments where they live. But their activities can have outsized impacts on their ecosystems' carbon. One important contribution comes from animals like monkeys and birds, which can disperse a great diversity of seeds across a wide area.

Still, "it's been really hard to translate that to the long-scale processes like the carbon recovery of entire landscapes", says Evan Fricke at the Massachusetts Institute of Technology.



SERGI REBOREDO/UNIVERSAL IMAGES GROUP/GETTY IMAGES

The behaviour of animals, like sloths, can have a big impact on their environment

Fricke and his colleagues analysed more than 3000 plots in tropical forests where trees were growing back – and accumulating carbon – after a disturbance. They then estimated the amount of disruption to the movement and diversity of seed-dispersing animals in each plot. The estimates relied on factors like the amount of forest fragmentation and data from tracked animals.

They found that the forests that had the least disruption to their animals' habits grew four times as fast as the most disrupted ones (*PNAS*, doi.org/pzt7).

On average, disruptions to seed-dispersing animals reduced the amount of carbon the plots could accumulate by half. This means the disruptions had an even larger negative effect than other factors limiting tree regrowth, such as fires or livestock grazing.

Conversely, forests with the least disruption accumulated carbon even faster than monoculture tree plantations. ▮

James Dinneen

Pathology

What really killed Napoleon's army in 1812?

James Woodford

IANDAGNALL COMPUTING/ALAMY

The Retreat of Napoleon's Army in 1812 by Ary Scheffer

WHEN Napoleon's half-million-strong army retreated from Russia in 1812, around half the men were wiped out by disease, starvation and the extreme cold. Now, DNA analysis has revealed which pathogens contributed to the catastrophe.

In the summer of 1812, Napoleon gathered as many as 600,000 troops for his invasion of Russia. However, the Tsar's forces had abandoned Moscow and emptied the city of supplies, forcing Napoleon to retreat to the Polish border for the winter. Between October and December 1812, at least 300,000 French soldiers died.

Historical reports suggested that typhus and trench fever were the main causes of death and illness among the troops, which was backed up by genetic testing nearly two decades ago.

Now, Nicolás Rascovan at the Pasteur Institute in Paris and his colleagues have examined microbial DNA from the teeth of 13 of the soldiers buried in Vilnius, Lithuania, where many soldiers died during the retreat, and found no evidence of either typhus or trench fever.

Instead, the team confirmed the presence of *Salmonella enterica*, which causes paratyphoid fever, and *Borrelia recurrentis*, which is transmitted by body lice and causes relapsing fever (bioRxiv, doi.org/pzvb).

The earlier studies relied on a technique that amplifies specific DNA sequences already suspected to be there. Rascovan and his colleagues used more advanced metagenomic analysis, which can detect the genetic material of any pathogens in a sample, making it more comprehensive.

"In light of our results, a reasonable scenario for the deaths of these soldiers would be a combination of fatigue, cold and several diseases, including paratyphoid fever and louse-borne relapsing fever," write Rascovan and his colleagues in their report. The team declined to comment for this story.

Sally Wasef at the Queensland University of Technology in Australia says more soldiers who died in 1812 need to be studied to confirm which diseases were present, as Rascovan and his colleagues also state in their report. ▮

Archaeology

Ancient pots contain 2500-year-old honey

THE contents of an ancient Greek pot found in a shrine near Pompeii are testament to the longevity of a jar of honey.

In 1954, a Greek burial shrine dating to around 520 BC was discovered in Paestum, Italy, about 70 kilometres south of Pompeii.

There were eight pots in the shrine containing a sticky residue, whose identity has been a mystery ever since the pots were found.

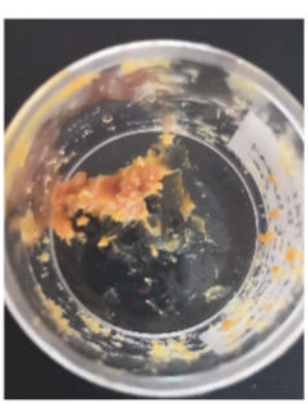
Honey was an early suspect in tests carried out on the contents of one of the pots between the 1950s and 1980s, says Luciana Carvalho at the University of Oxford.

Three separate teams concluded that the jars held animal or vegetable fat contaminated with pollen and insect parts.

Carvalho and her team began by testing the residue's reflection of infrared light to get a sense of its bulk composition. At first, they thought the contents may be degraded beeswax, because of its outward similarity to modern beeswax and its high acidity.

To confirm whether this was the case, the team used gas chromatography combined with mass spectrometry. But this revealed the presence of sugars including glucose and fructose, which are the main sugars found in honey (*Journal of the American Chemical Society*, doi.org/g9vnwh).

This mysterious substance has now been identified as honey



LUCIANA DA COSTA CARVALHO

"We discovered a surprisingly complex mix of acids and degraded sugars," says Carvalho. "The smoking gun for honey was finding sugars right in the heart of the residue."

Further analysis by Elisabete Pires, also at the University of Oxford, revealed the presence of proteins called major royal jelly proteins, which are secreted by honeybees, as well as some peptides whose closest match was from *Tropilaelaps mercedesae*, a parasitic mite that feeds on the larvae of honeybees.

"Confirming honey offerings in a shrine tells us exactly how people chose to honour their deities"

"This parasite is thought to have originated in Asian beehives," says Pires, "so the fragment proteins we found in the residue are probably related to another type of parasite that already affected beehives in ancient Greece."

Carvalho says the cork seals in the bronze jars would have eventually broken down, letting in air and microbes. "We think that those bacteria consumed [most of] any sugar left over, producing additional acids and breakdown products," she says. "Over time what remained of the original residue was just an acidic waxy residue at the bottom and along the walls of the jars."

"Confirming honey offerings in a shrine at Paestum tells us exactly how people chose to honour their deities," as well as their ideas about the afterlife, says Carvalho. ▮ JW

Health

Human milk could help fight bacteria that harm pregnancies

Meagan Mulcair

PAZ RUIZ LUQUE/GETTY IMAGES

Pregnancy can reduce a woman's immune response

A TYPE of sugar in human milk could help treat infection by a common strain of *Streptococcus* bacteria, which can complicate pregnancies when it infects the vagina.

"[Human milk] is the second-most important liquid in the universe after water, and we don't know much about it," says Steven Townsend at Vanderbilt University in Tennessee.

Researchers are beginning to unpack the properties of helpful sugars found only in it: human milk oligosaccharides, or HMOs. Although they were once thought to be random sugars, recent studies suggest they are extremely effective prebiotics, "kind of like personalised medicine" for newborn babies, says Townsend.

Previous studies have focused on how they might benefit the gut microbiome. Townsend and his team decided to instead study their effect on the vagina. They wanted to better understand how HMOs may help regulate the proportion of healthy bacteria and potentially dangerous Group B Streptococcus, or GBS.

"Group B Strep is a bacteria that all of us have," says Townsend. "It typically is going to cause us no harm, and we're not even going to know we have it." However, GBS can cause

"The sugars in breast milk promoted the growth of healthy bacteria, which outcompeted the bad"

disease in immunocompromised people. During pregnancy, GBS in the vagina can cause a variety of problems, like preterm birth, so it is typically treated with antibiotics.

Townsend and his team tracked the growth of GBS and healthy *Lactobacillus* bacteria in the presence of HMOs. They studied three different scenarios: the bacteria and sugars on their own, on lab-engineered vaginal tissue and in living mice. In all three cases, HMOs promoted healthy bacteria, which outcompeted the GBS (*ACS Infectious Diseases*, doi.org/pzqp).

The result is likely due to a "nice little storm of positive effects", says Townsend. GBS cannot grow in an environment with HMOs, he says, whereas the healthy bacteria can eat HMOs and grow prolifically, further stifling the growth of GBS. On top of this, as the healthy bacteria consume the HMOs, they produce fatty acids that make the environment more acidic, killing even more harmful bacteria.

The finding suggests more ways to potentially regulate and restore a healthy vaginal microbiome. "Anything that points to new tools or methods to do that are of high therapeutic value for women and their newborns," says Katy Patras at Baylor College of Medicine in Texas. However, she says a potential therapy is still several steps down the road.

Even when a usable therapy becomes available, the researchers say the best course of action to treat a GBS infection is still to take antibiotics. "What we're doing is not to replace antibiotics," says Townsend. "We're doing this research to try to save antibiotics", because overuse of antibiotics can lead to antibacterial resistance that renders the drugs ineffective. A therapy using HMOs to regulate the microbiome could be used in tandem, reducing the amount of antibiotics required to treat GBS.

"I think those synergistic interactions could be extremely useful," says Lars Bode at the University of California, San Diego. ▮

Physics

Super-tough hexagonal diamond made in the lab

Matthew Sparkes

A HARDER form of diamond that has eluded scientists for decades can now be synthesised in the lab, and could be used to make extremely tough cutting and drilling tools.

Diamonds as we know them have a cubic arrangement of atoms in their crystalline structure. But for at least 60 years, we have been aware of another form – hexagonal diamond – that is much tougher, thanks to its crystals having no uniform shear lines along which breaks can propagate.

Natural hexagonal diamond occurs in meteorites, but only in mixtures with cubic diamond. Previous attempts to synthesise hexagonal diamonds have yielded only tiny traces that are similarly impure.

Now, Ho-Kwang Mao at the Center for High Pressure Science and Technology Advanced Research in China and his colleagues have succeeded in creating a relatively large sample of hexagonal diamond that is 1 millimetre in diameter and 70 micrometres thick, with close to 100 per cent purity.

While normal diamond has been synthesised for some time, the researchers explored a range of pressures and temperatures to find a sweet spot in which hexagonal diamonds were produced. This ended up being 1400°C at 20 gigapascals – 200,000 times the atmospheric pressure on Earth (*Nature*, doi.org/pzmz).

Such a material has never been made before, so it will need to be thoroughly studied to determine its properties, says Mao. "It's incredibly valuable," he says.

If hexagonal diamond can be synthesised with sufficient thicknesses, it could be used to make harder and more resilient tools for a range of uses in industry, such as drilling for geothermal energy, says James Elliott at the University of Cambridge. ▮

Biotechnology

E. coli genome has been remade

Rewriting the bacterium's genetic code from scratch could make it more useful commercially

Michael Le Page

WE HAVE gone further than ever before in creating life that is unlike anything that has evolved naturally. The genome of an *Escherichia coli* bacterium has been redesigned on a computer to use just 57 of the 64 genetic codes, which were made from scratch and then put into a living bacterium.

"This was a gargantuan effort," says Wesley Robertson at the Medical Research Council Laboratory of Molecular Biology in Cambridge, UK.

His team did this to prove it is possible, but the 57-codon *E. coli*, called Syn57, could have commercial uses. With further changes, Syn57 could be made resistant to viral infections, an advantage for industrial brewing of proteins for medicines or food. That is because viruses rely on their host to make proteins, so if the code is changed, viral proteins will come out wrong.

A protein is a chain of amino acids assembled in the specific sequence laid down in a gene. Each set of three DNA letters, known as a codon, tells the cell's protein-making factories which amino acids to add next, or when to stop because a protein is complete.

There are four DNA letters, which makes for 64 different codons. But living organisms on Earth usually make proteins with just 20 kinds of amino acids, so there is a lot of redundancy, with two or more different codons specifying most amino acids.

If all the instances of one codon for a particular amino acid are replaced with another codon for the same amino acid, that first codon is freed up for other purposes. For instance, it can be used to code for a non-natural amino acid, allowing the creation of new kinds of proteins.

In theory, up to 43 codons could be freed up in a living organism because only 21 are needed: 20 for the standard set of amino acids, plus a stop codon. This isn't yet achievable in practice because the more changes that are made to a genome, the higher the likelihood that some are unintentionally detrimental.

"The researchers have made 101,000 changes to the genome, testing them in living bacteria"

Making thousands of gene edits is very laborious, so Robertson and his team instead synthesised DNA from scratch. In 2019, they announced the creation of Syn61, with 18,000 changes to the 4 million DNA letters in *E. coli*'s genome, freeing up three codons. A spin-off company called Constructive.Bio is developing commercial applications for it.

Now, the researchers have made 101,000 changes to make Syn57, freeing up seven codons. To achieve this, small fragments of the recoded genome had to be tested in living bacteria to identify and correct the many detrimental changes. This arduous process was repeated with larger and larger fragments until the genome was complete (*Science*, doi.org/pzp4).

"This is a significant achievement and the result of years of work," says Akos Nyerges at Harvard Medical School. Nyerges's team is also working to free up seven codons in *E. coli*, but by recoding different codons. ▮

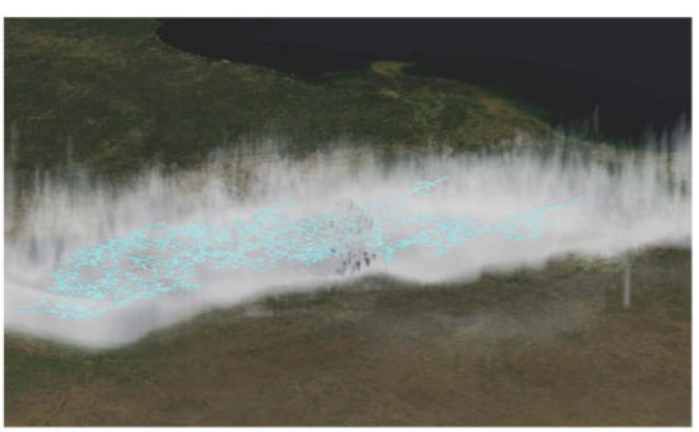
Meteorology

Longest lightning 'mega-flash' sets a shocking new record

A LIGHTNING "mega-flash" over the US Great Plains region stretching 829 kilometres is the longest on record. The flash spanned five states, ranging from eastern Texas to Missouri.

Such mega-flashes – extremely long-lasting or long-distance lighting discharges – occur within the huge clusters of thunderstorms that regularly form over the US Great Plains and other lightning hotspots. But it remains an open question why some of these storms generate mega-flashes and others don't.

The lightning occurred in October 2017 and lasted just over 7 seconds. But it was too long to be fully mapped by ground-based lightning sensors at the time.



MICHAEL PETERSON, GTRI

Visualisation of the recording-breaking lightning flash

To see its full extent, Michael Peterson at the Georgia Institute of Technology and his colleagues revisited data from a geostationary satellite equipped with cameras that continuously monitor lightning. They used newly developed software to comb through millions of separate light pulses and traced the lightning as it zigzagged and branched through the storm.

"Each time we see a new pulse, we get an impression of how that flash is growing over time," says Peterson. "By playing connect-the-dots, we can essentially map out the entire structure."

They found the most distant points of the flash, when measured along a straight line, spanned 829 km, give or take 8 km. The total length along the lightning bolt itself would stretch well beyond 1000 km. "A mega-flash can go a megametre," says Peterson.

The World Meteorological Organization, which keeps records of weather extremes, certified the flash as the longest on record, surpassing the previous record holder from 2020 by about 61 km.

"We were able to see over 100 cloud-to-ground strokes from this single flash," says Peterson. "Even though these mega-flashes are very rare, they individually are extremely impactful." ▮

James Dinneen

Health

Flu might awaken dormant cancer

Malignant cells increased 100-fold in the lungs of mice that had been infected with swine flu

Carissa Wong

RESPIRATORY viruses may trigger the growth of dormant cancer cells that have spread to the lungs.

Cancer deaths often occur when tumour cells migrate from their original location in the body. It is difficult to detect when this occurs, as these cells can lie dormant for decades before forming tumours.

What triggers these cells to proliferate is unclear, but prior studies suggest that when cancer cells reach the lungs, inflammation caused by respiratory viral infections may play a role.

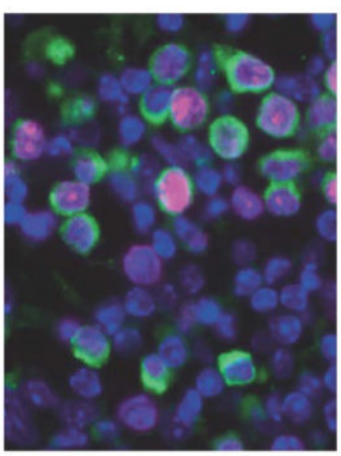
To learn more, James DeGregori at the University of Colorado and his colleagues used mice that were genetically engineered to grow tumours in their mammary glands. At around 2 months old, each mouse had mammary gland tumours and fewer than 10 dormant cancer cells in their lungs.

They infected half of the mice with the H1N1 strain of the influenza virus, also known as swine flu. Nine days post-infection, the number of cancer cells in their lungs had increased 100-fold, but hardly changed in the other mice.

When the researchers repeated the experiment with the SARS-CoV-2 virus, they saw about a 10-fold increase in cancer cells, but still no changes in the uninfected mice (*Nature*, doi.org/pzdr).

The researchers hypothesised that viral infections increase levels of an inflammatory molecule called IL-6, which helps the immune system destroy viruses, but can promote tumour growth.

Cancer cells (green) in the lungs of mice infected with swine flu



BRYAN JOHNSON

To validate this idea, they repeated the experiment in mice that were genetically engineered to lack IL-6, and found they had substantially fewer cancer cells in their lungs compared with mice with typical IL-6 levels.

Another experiment revealed that IL-6 seems to reawaken dormant cancer cells that had already migrated to the lungs, rather than increasing the spread of these cells from the breast.

But IL-6 levels subside once infections have been cleared. At this stage, the team found that cancer cells in the mice's lungs stopped proliferating, but had gained properties – such as changes in gene expression – that have been linked to tumours spreading, says DeGregori.

To explore if the findings might apply to people, the researchers analysed health records from 36,800 women in the US who were diagnosed before the covid-19 pandemic with breast cancer that wasn't thought to have spread.

The women with a positive covid test during the first three years of the outbreak were much more likely to have a diagnosis of secondary lung cancer over this period than those whose swabs came back negative or who weren't tested at all. But some may have had asymptomatic infections, and so not sought a test, while others may not have had access to one, which would reduce the validity of this result, says DeGregori.

"If I were a cancer survivor, I would make sure I was vaccinated against viruses like flu and covid-19"

Further studies in people are needed to verify the research and explore how various respiratory viruses and cancer types interact, says Ann Zeuner at the National Institute of Health in Rome, Italy.

DeGregori thinks the results are another reason to get vaccinated. "If I were a cancer survivor, I would make sure I was vaccinated against the common respiratory viruses like flu, covid, so on," he says. ▮

Marine biology

Creatures found in hostile deep-sea environment

ECOSYSTEMS fed by chemicals from tectonic plate collisions have been found more than 9500 metres beneath the surface of the north-west Pacific Ocean.

"Their resilience and beauty left me in awe," says Mengran Du at the Chinese Academy of Sciences in Sanya.

Du and her colleagues completed 24 dives in a crewed submersible between 8 July and 17 August 2024, exploring 2500 kilometres of the Kuril-Kamchatka trench and western parts of the Aleutian trench, at depths ranging from 5800 to 9533 metres. The hadal zone, a near-freezing area more than 6000 metres deep, is devoid of light and has crushing pressure.

The life there is called the hadal biosphere. It survives by either harvesting energy from organic matter that descends from the surface, which was created via photosynthesis, or by chemosynthesis, where chemicals are the energy source.

Taxonomic and genetic data gathered during the dives revealed that a lot of life in the hadal zone uses compounds such as hydrogen sulphide and methane that are released as fluids and gases, seeping from the fault lines created when tectonic plates slide beneath each other (*Nature*, doi.org/g9vpc9).

"We discovered thriving chemosynthesis-based communities at an astonishing depth of 9533 metres," says Du. These were found in 19 of the dives, demonstrating how widespread they are.

9533

The depth, in metres, at which the communities were discovered

The chemosynthetic communities were dominated by bivalve molluscs and marine tube worms called siboglinid polychaetes. Some consisted of thousands of individual animals, stretching for kilometres.

"While other life, such as sea cucumbers and amphipods et cetera, inhabit even greater depths, they are not capable of utilising chemicals like hydrogen sulphide to produce energy for survival, but have to rely on organic matter," says Du.

The discoveries represent the "deepest and the most extensive chemosynthetic communities known to exist on our planet", she says. ▮

James Woodford

Botany

Peeling back the potato's origin story

James Woodford

THE humble potato, it turns out, is the product of a tryst between an ancient tomato plant and a lesser-known South American lineage named *Etuberosum*.

Etuberosum plants are often described as looking like a potato plant, except for one crucial difference: they don't produce the starch-rich tubers that have made cultivated potatoes one of the world's most important food staples.

Sandra Knapp at the Natural History Museum in London and her colleagues studied the genetics of three groups of plants in the genus *Solanum*: *Petota*, with 107 species, including cultivated potatoes (*Solanum tuberosum*); the tomato group, with 17 species; and *Etuberosum*, with three species. The three lineages shared a common ancestor around 14 million years ago.

The team looked at 450 genomes from cultivated potatoes and 56 wild potato species and found there was, in every one of them, a steady mix of tomato and *Etuberosum* genes.

DOUGAL WATERS/GETTY IMAGES

The potato's lineage stretches back around 8 million years ago

Reshuffling of genes

The results suggest that the potato lineage stems from a hybridisation event between the ancestors of the tomato and *Etuberosum* groups, probably around 8 million years ago in what is now Chile (*Cell*, doi.org/g9vtc4).

Knapp says the hybridisation event allowed for new gene combinations to occur, creating innovations like tubers. "This event led to a reshuffling of genes such that the new lineage produced tubers, allowing these plants to expand into the newly created cold, dry habitats in the rising Andes," she says.

This shows that hybridisation is a "powerful force in the evolution of diversity", says Knapp.

"Actually, the parts of the tomato and potato we eat look different, but the plants themselves are quite similar," she says. "If you by luck get a potato plant that produces fruit, it's a green, tomato-like berry – but don't eat it, it tastes terrible."

Brett Summerell at the Botanic Gardens of Sydney, Australia, who wasn't involved in the study, says the new work provides comprehensive evidence of hybridisation and subsequent species radiation – something that has been lacking for this group of plant relatives.

"The study also highlights the importance of protecting wild crop relative species in order to better understand how important crops have evolved and are likely to adapt to challenges in the future," says Summerell.

"Many of the relatives of species like potatoes are threatened with habitat destruction and the impact of climate change." ▮

Environment

Meltwater bursts through Greenland ice in first-of-its-kind eruption

Madeleine Cuff

AS GREENLAND'S glaciers melt, water usually drains to the bedrock below before flowing out to the ocean. Satellite data has revealed the moment when a huge torrent of meltwater from a subglacial lake

"We know lakes beneath Greenland drain. But we've never seen water erupt through the ice sheet"

burst out of the surface of the Greenland ice sheet, leaving 25-metre mounds of ice and giant crevasses in its wake.

"We haven't observed anything like this before," says Malcolm McMillan at Lancaster University in the UK.

"We know that lakes beneath Greenland drain. But what we've never seen before is this fracturing and the water actually erupting through the surface of the ice sheet," he says.

McMillan and his colleagues began to investigate after spotting the sudden appearance of a crater 85 metres deep in the surface of the ice sheet, captured by satellite in August 2014. They used satellite data and numerical models to reconstruct what happened to cause the crater.

They found the crater had emerged after the rapid draining of a subglacial lake within a 10-day period in July and August 2014. About 1 kilometre downstream from the crater, the team spotted a huge disturbance of the ice where the water had emerged (*Nature Geoscience*, doi.org/pzdj).

The team concludes that the water pressure in the subglacial lake had increased enough to force it back above ground through

CPOM/LANCASTER UNIVERSITY

Satellite imagery shows the fracturing of the ice sheet where the outburst occurred

fractures in the ice, eventually bursting out of the ice sheet and leaving huge crevasses and ice towers in its path.

The meltwater was forced upward because it was surrounded by ice frozen to the bedrock, explains McMillan. "What seems to have happened here is that when you put water into a situation where the ice was kind of frozen in the surrounding region, you could actually build up a lot more pressure, and you could cause this unexpected effect," he says.

McMillan now wants to identify whether similar eruptions have happened using satellite imagery, and whether this is a process driven by the ice sheet rapidly melting as global temperatures increase.

"This is a first view of a new phenomenon that we didn't know existed before, and the challenge now is to understand the implications and the processes of that," he says. ▮

Entomology

Whopper of a stick insect weighs as much as a golf ball

A NEWLY named species of giant stick insect found in Australia's Wet Tropics rainforests is thought to be the heaviest insect ever found on the continent.

***Acrophylla alta* weighs 44 grams, about the same as a golf ball, and is approximately 40 centimetres long. Only two female specimens have been collected so far, while a third individual was photographed but released by amazed locals.**

Although the genus of these insects has been known since 1835, the species has remained undiscovered by science until now, probably because of its habitat, says Angus Emmott at James Cook University in Townsville, Australia.

ANGUS EMMOTT/JAMES COOK UNIVERSITY

The stick insect, named *Acrophylla alta*, is about 40 centimetres long

The Wet Tropics in north-east Australia are a true wilderness, covered in cool rainforest and home to other unusual animals like tree kangaroos.

So far, *Acrophylla alta* has been found only on mountain ranges with an altitude above 900 metres and in tree canopies up to 60 metres above the ground, near Millaa Millaa and Mount Hypipamee, both in Far North Queensland (*Zootaxa*, doi.org/pzdq).

The species name *alta*, meaning high, refers to both the altitude of the forests where the insect lives and the height of the forest trees it frequents.

"It's got quite substantial wings, but it can only sort of use them for gliding down to the ground, because it's got such a bulky body as well," says Emmott.

Whether or not it is rare is currently unknown. "Because it's up in the canopy, we really don't know," says Emmott.

"It's restricted to a small area of high-altitude rainforest and it lives high in the canopy, so, unless you get a cyclone or a bird bringing one down, very few people get to see them." ▮

James Woodford

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Health

Strict routine slows cognitive decline

Lifestyle changes really do seem to help people at risk of dementia, particularly if they get regular, structured support from groups and trained facilitators, finds **Chris Simms**

A STRUCTURED course of exercise, diet, cognitive challenges and social engagement seems to be particularly effective at warding off cognitive decline, compared with more relaxed, self-guided efforts.

The brain's capacity to remember, use language and solve problems tends to decline with age, often leading to dementia. Yet, research has shown up to 45 per cent of global dementia cases may be preventable by modifying 14 risk factors, such as lack of education and social isolation.

To investigate ways of staving off this decline, Laura Baker at Wake Forest University School of Medicine in North Carolina and her colleagues have been running an investigation called the US POINTER study.

They selected more than 2100 participants who were deemed to have a high risk of cognitive decline because they were between 60 and 79 years old, had a sedentary lifestyle, ate a suboptimal diet and met at least two other dementia-related criteria, such as a family history of memory impairment.

The participants were randomly assigned to one of two regimens, which both aimed to encourage physical and cognitive activity, a healthy diet and social engagement, but went about it in different ways.

One was very structured, with 38 small group meetings over the two years, at which trained facilitators gave out plans. This regimen also involved regular exercise at a community centre, guidelines for following an anti-dementia diet and weekly web-based sessions using brain-training software.

The other group was more self-guided, with just six group meetings over the two years. These participants received publicly available education materials and $75 gift cards that were intended to support a change in behaviour, such as attending gym classes.

PETER MENZEL/SCIENCE PHOTO LIBRARY

Exercises classes are one way to stay sharp in your old age

Two years later, both groups showed improvements on a cognitive scoring system that tested their memory, executive function and processing speed. The structured group improved by 0.24 standard deviations per year, compared with their average scores at the beginning of the trial, while the self-guided group improved by 0.21 standard deviations per year – a small but statistically significant difference (*JAMA*, doi.org/pzbw).

"It is impressive that the structured care group did better," says Gill Livingston at University College London. But she points out the study didn't involve a control group that received no intervention to compare the structured and self-guided participants against.

Baker says her team has modelled how big a decline in cognitive scores could be expected without either regimen, and estimates the benefit would be significant. "The two-year structured intervention is slowing the cognitive ageing clock by one to nearly two years," she says.

"We could take people at risk of dementia and empower them to take control of their health"

It is possible both groups improved because they were expecting to get better, a phenomenon similar to the placebo effect, says Baker, and she adds all the participants thought they had been randomised to the group with the best expected outcomes.

Claudia Suemoto at the University of São Paulo in Brazil argues the small difference in cognitive scores between the groups probably wouldn't be noticeable to the participants or their families. Dementia is also typically a slowly progressing condition, so it would take longer than two years to see clear effects, she says.

Encouraging good habits

Baker says the US POINTER study has a four-year extension period, so the team will follow some participants for a total of six years. "These are very subtle changes [we're observing], because they're cognitively normal people and we're just slowing down a slow decline over time," she says. "We're just really excited about the possibility that we could take people who are at risk of dementia and we could empower them to take control and responsibility for their own health."

She also thinks the heavily structured approach could be feasibly applied outside of trials. It isn't about spending a lot of public money to bring about these good habits, but rather about caregivers and medical professionals encouraging people to do them, she says.

"Generally, dementia care is so expensive that reducing its burden would make a cost saving," says Livingston. "I think this study is important because it shows that lifestyle improvement helps and people did a bit better with guided help, but this does not mean it is the only way to do it." ▮

Technology

Solar-powered ambush drones can wait for targets like land mines

David Hambling

SMALL racing quadcopters carrying explosives, known as first-person-view drones, or FPVs, have become the dominant weapon in the war in Ukraine. And some are fitted with solar cells so they can wait for extended periods to ambush targets, turning them into a new type of land mine.

"The drone can sit by a road or choke point and when it acquires its target, it can then do a quick sprint to the target," says Robert Bunker at US consultancy firm C/O Futures.

Drone ambushes, where the devices land beside a road or on a building and wait for a target, are already commonly carried out by both Russian and Ukrainian forces. But even with their engines turned off, their camera and radio communications drain the drones' battery, limiting waiting time to a few hours at best.

Now, Russian FPV ambush drones have been spotted with solar-charging panels. They can't power a drone in flight, but will fuel its other electronics. Ukrainian drone warfare expert Serhii "Flash" Beskrestnov shared images of the solar setup on his Telegram channel to warn of the new development.

The panels are sold as camping supplies for about $50, fitting over a backpack to recharge phones and other mobile devices. Hobbyist sites on the internet already show how to fit solar cells to drones.

"The first-generation solar system is clunky, but it's a proof-of-concept," says Bunker, noting that the configuration seen will severely affect the aerodynamics and lift of the drone.

A 5-watt solar charger weighs a few hundred grams and will power the drone on the ground. Future versions are likely to be more sophisticated.

"A drone could maybe have a solar roll that flips out and creates a solar-charging surface after landing, then just detach when it goes into combat mode," says Bunker. "New variants will be worked out [that] we have not even considered."

SERHII BESKRESTNOV

A Russian solar-powered drone in Ukraine

A solar-assisted drone can wait to ambush targets for as long as the sun shines, powering up again at dawn the next day to resume its vigil. Solar cells could also slowly recharge the drone's batteries over the course of a day or more, allowing it to fly, land, recharge and fly on.

Meanwhile, both Russia and Ukraine are also introducing drones with artificial intelligence capabilities to identify and attack targets without a human operator. Combined with solar recharging, these could saturate the battlefield with lethal units that are flown into position and left to find targets.

"It's the evolution of a point land mine, one you step on, to an area land mine that has [a] sensing ability and fires off something, to a mobile system with area sensing that can then precisely home in on the acquired target," says Bunker.

Unlike a traditional minefield, a field of solar-enabled drones could repair itself, closing up gaps where drones were expended or destroyed. Alternatively, the field could slowly move towards the enemy over several days with successive charging cycles.

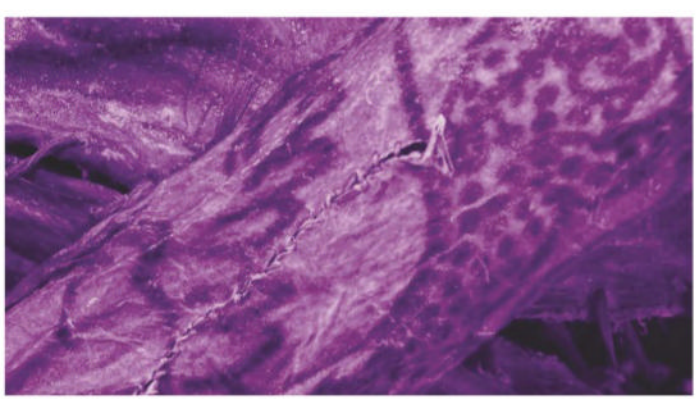
The current solar drones look like experimental prototypes and only a few have been seen. But the easy accessibility of parts means the design could spread rapidly. ▮

Ancient humans

Siberian ice mummy was covered in animal tattoos

ELABORATE tattoos featuring tigers, birds and a fantastical animal have been revealed on an ice mummy from more than 2000 years ago. The remains are those of a woman from the Pazyryk culture of Siberia, part of the wider Scythian world.

Gino Caspari at the Max Planck Institute of Geoanthropology in Germany and his colleagues examined the body of a semi-nomadic Iron Age pastoralist from the Altai mountains in Siberia, who was about 50 when she died in the 3rd or 4th century BC. She is one of a handful of people in that area whose deep burial chambers were encased in permafrost, which turned them into "ice mummies", preserving their skin, but leaving it dark and desiccated.



G. CASPARI & M. VAVULIN

Tattoos of animals, such as leopards, were visible on a mummy's forearm

The tattoos weren't visible to the naked eye, so Caspari and his team used high-resolution, near-infrared photography to uncover them (*Antiquity*, doi.org/pzh2).

"We have herbivores being hunted by tigers and leopards, and in one case by a griffin, and on the hands, we have depictions of birds," says Caspari.

The team also learned how the body art was made. "Our analysis shows that the tattoos were created using the direct puncture method, as opposed to being incised or 'stitched' into the skin," says team member Aaron Deter-Wolf at the Tennessee Division of Archaeology.

Cross-cultural data suggests this was done using a method known today as hand-poking, where a needle is dipped in ink and poked into the skin, creating an image dot by dot. The woman's tattoos were also made with carbon pigments, probably derived from charcoal, soot or ash. ▮

Chris Simms

Race car vs. excavator: pushing the limits of hybrid technology

Operating globally with over 65,000 employees, Komatsu has been at the forefront of innovation within mining, construction and forestry for over 100 years. The Japanese company's dedication to cutting-edge technology has made it a pioneer in its field, notably going to market with the first ever hybrid hydraulic excavator in 2008.

This relentless drive for innovation was an instigating factor for its reignited partnership with the iconic British Formula 1 team Atlassian Williams Racing. The two brands first worked together in the 1990s, when Komatsu produced gearbox components for the World Championship-winning FW18 and FW19 F1 cars. In this new era, Komatsu and Williams are focused on shared values, talent development, and their surprisingly similar technologies.

At first glance, the 37 tonne Komatsu HB365LC-3 excavator and high-speed Williams FW47 car look as if they are from completely different worlds. But dig a little deeper and there are myriad common engineering principles and elements, most notably in the form of the hybrid system.

Hybrid on a huge scale

Inside the HB365LC-3 lives Komatsu's cutting-edge hybrid system, which works alongside a six-cylinder internal combustion engine. How it works is that the machine's electric swing motor-generator captures energy as the immense structure slows. The regenerative energy produced during deceleration is then converted into electricity and stored in a capacitor. This source can subsequently be used by the generator-motor to supplement the machine's power and help the engine accelerate, or to perform the excavator swing function.

The use of hybrid technology during this process can reduce overall fuel consumption by up to 20% compared to a traditional excavator. It also increases productivity, minimising running costs and lowering emissions for customers.

Komatsu has over a century of experience in electrification, with a track record of producing electric drive mining trucks, ultra-class electric wheel loaders and electric mining and rope shovels. Looking towards the future, the company is now developing the next generation of Power Agnostic mining trucks that will work in conjunction with Komatsu's Autonomous Haulage Systems.

'The use of hybrid technology can reduce overall fuel consumption by up to 20% compared to a traditional excavator'

High-speed hybrid

Moving over to the FW47, the principles and purpose of its hybrid system mirror that of the Komatsu excavator – the aim is to optimise efficiency.

Coupled with the V6 engine of the Williams FW47 is a hybrid system in the form of a battery and two Motor Generator Units: an MGU-k (kinetic) attached to the gearbox and an MGU-h (heat) which is connected to the turbocharger. When the driver brakes, the MGU-k converts kinetic energy that would usually be lost as heat through the braking system into electricity which is stored in the

Powerful partnership: the Komatsu HB365, left and the Williams FW47, right

battery. That stored energy can then be used to accelerate the car as it powers out of corners, providing supplementary energy to the combustion engine. This function of recovering and deploying energy that would normally be lost dramatically increases the efficiency of the car's power unit.

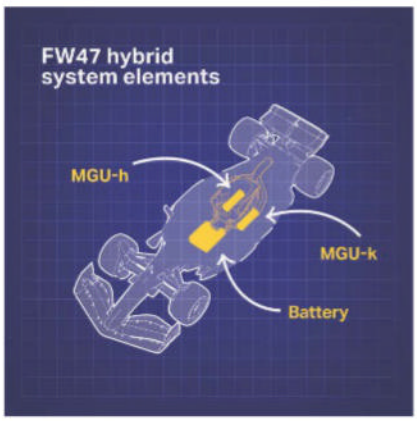
The other element of the FW47's hybrid system, the MGU-h, harvests waste energy from the exhaust, which can then go on to either charge the battery or power the other MGU attached to the gearbox, aiding in the propulsion of the car around the circuit. Alternatively, this energy can go back into the turbocharger itself and help provide the car with an additional boost as it exits corners.

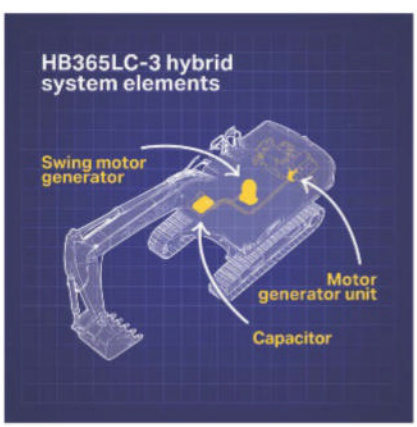
Thanks to the nature of the hybrid system, the current generation of Formula 1 car – including the Atlassian Williams Racing FW47 – hosts one of the most efficient internal combustion engines ever produced. This is only set to increase in 2026, with the new regulations increasing the cars' reliance on hybrid power to 50%, another step forward in the sport's journey to net zero.

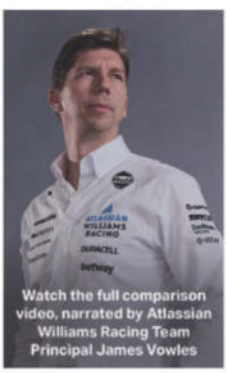
Engineers of the future

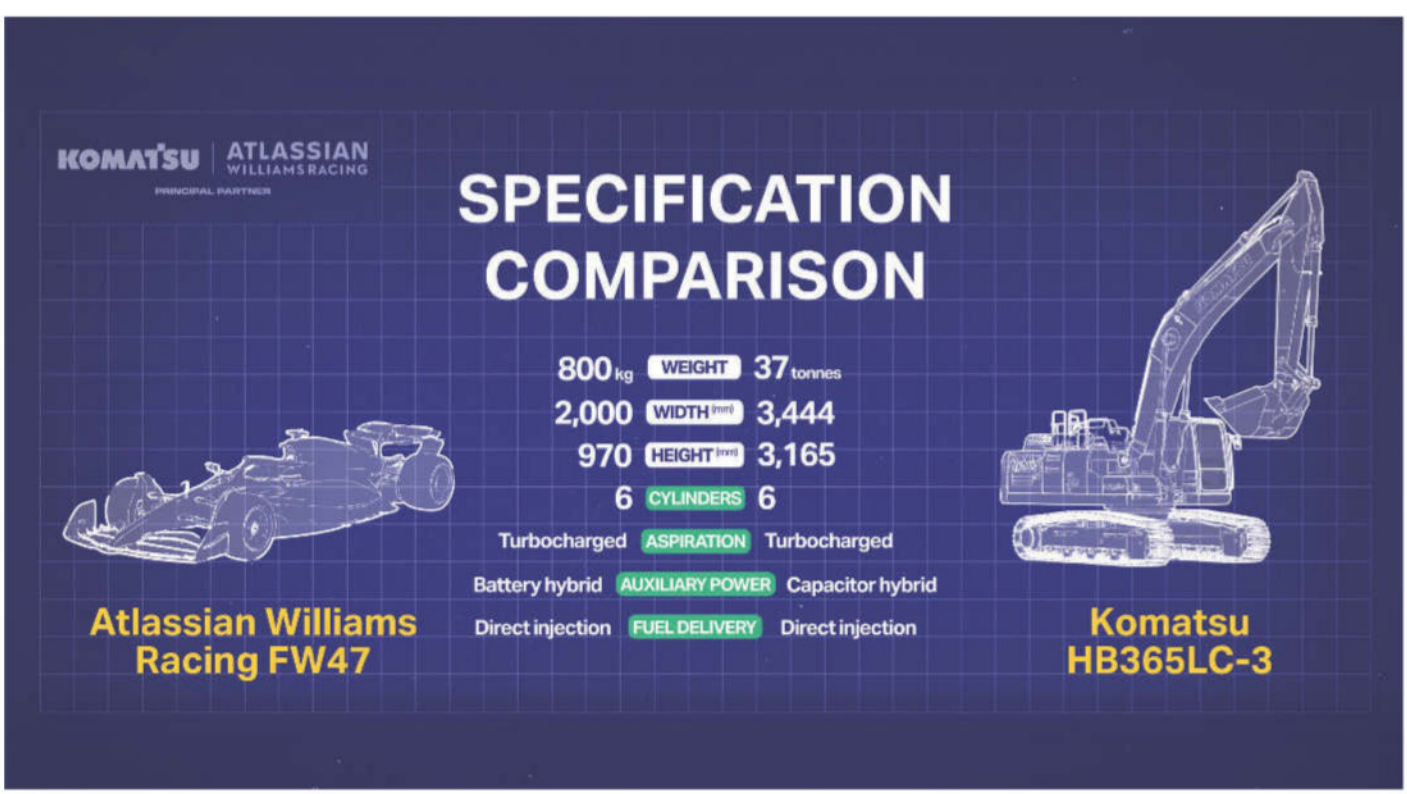
Away from the machines, Komatsu and Williams continue to work together on initiatives designed to inspire the next generation of engineering talent. The Komatsu-Williams Engineering Academy was born out of this strive for change, with the programme offering a prime opportunity for 16–20-year-olds from around the world to take the next steps into their STEM futures. Access to mentorship, internships, learning materials and facilities from both companies gives the cohort unparalleled resources to develop their engineering skills.

As a partnership, Komatsu and Williams are creating value together, as well as pushing the boundaries of engineering. Whether it be in some of the harshest conditions on the planet or on the world's most iconic racing circuits, both companies are dedicated to maximising the power of hybrid technology.






Watch the full comparison video, narrated by Atlassian Williams Racing Team Principal James Vowles



Comment

Finding emotion in motion

Fear of illness hasn't motivated us to exercise. Perhaps instead it is time to highlight the enjoyable aspects of movement, says **Dawn Teh**

IN 2013, the World Health Organization (WHO) set an ambitious goal: reduce the global physical inactivity rate by 10 per cent compared with 2010 levels by 2025. Well, the deadline has finally arrived – and, despite numerous public health campaigns and efforts to capitalise on the sporting excitement of multiple Olympic Games, people are moving less than ever.

The latest data, from 2022, indicates that 31 per cent of adults worldwide aren't meeting physical activity guidelines, a 5-percentage-point increase from 26 per cent in 2010. Among teens, the numbers are worse: a staggering 81 per cent aren't moving enough. We're not just missing targets – we're slipping further behind on them.

So, what went wrong? From public health policy to urban design issues, there are numerous, complex ways to critique current strategies. However, some experts are taking a step back to ask a more fundamental question: have we been promoting physical activity all wrong this whole time?

For years, public health campaigns have relied heavily on the "exercise is medicine" narrative to promote physical activity. We have all heard it time and again: get active if you want to prevent illnesses like diabetes and cardiovascular disease. It is a message based on strong scientific evidence, and you would think that the promise of good health is the best possible motivator.

SIMONE ROTELLA

However, Benjamin Rigby, a public health researcher at Newcastle University in the UK, and his colleagues argue in a recent opinion article that framing movement solely as a way to prevent disease oversimplifies why people choose to be active. "The truth is, people move for so many more reasons that have nothing to do with avoiding illness," says Rigby. "We want to play, to laugh, to explore, to dance, [and] feel proud of ourselves. Ultimately, to have fun and feel good." Excluding these other, positive motivations from public health messaging could be why people aren't connecting with it.

A growing number of studies support this idea of shifting the spotlight away from health-focused narratives. When researchers from the University of Edinburgh in the UK analysed 123 studies on physical activity messaging, they concluded that health reasons aren't necessarily what motivate people to get off the couch. The most effective messages highlight the short-term rewards of being active – like feeling good, reducing stress or having fun with friends – not the threat of illness decades down the line.

What might messaging that focuses on the immediate benefits of physical activity look like in a campaign? Some researchers suggest phrases like "a little movement for a little mood improvement" to highlight mental well-being, or "physical activity is an opportunity to connect with others" to capture social-based motivations.

Robust evidence also shows that people are more likely to stay active when it's fun. Enjoyment is linked to young people consistently participating in sports. And remember *Pokémon GO*? That craze had its most engaged users walking an extra 1473 steps a day on average, just because they were excited to "catch 'em all". Given the evidence, why haven't public health messages aligned more closely with motivations centred on enjoyment?

Sticking to health-based narratives has a strong appeal to institutions. Their effects are more measurable, and they fall neatly within the serious tone we expect from official messages. But with the next 2030 target of reducing physical inactivity by 15 per cent from 2010 levels looming, this is the moment for radical change. It's time to stop prescribing physical activity as a bitter pill and start selling it as an opportunity for fun, exploration and connection. ▮

Dawn Teh is a freelance health writer based in Australia

Field notes from space-time

Losing energy

When it comes to cosmology, answering one question only leads to more. Just take light: what happens to its energy when it redshifts, asks **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an associate professor of physics and astronomy at the University of New Hampshire. She is the author of *The Disordered Cosmos* and the forthcoming book *The Edge of Space-Time: Particles, poetry, and the cosmic dream boogie*

Chanda's week

What I'm reading
Riley Black's When the Earth Was Green: Plants, animals, and evolution's greatest romance *is beautiful.*

What I'm watching
I'm rewatching Star Trek: Strange New Worlds *from the beginning.*

What I'm working on
I'm thinking about what the NewAthena X-ray observatory will teach us about the interior of neutron stars.

This column appears monthly. Up next week: Graham Lawton

MOST of us can relate to being worried about inflation: we are all concerned about the cost of living and what our political leaders are doing to address it. Sometimes, I have to remind myself that we have a bit of a nomenclature issue in physics, because inflation means something completely different for us.

Cosmic inflation is a model that explains why our universe looks the way it does on the biggest scales. In this scenario, space-time rapidly expanded for a tiny fraction of a second. This means that parts of the universe that currently wouldn't have any way of being in contact with one another could have been so in the past.

It can be hard to have a sense of the enormity of the scales involved. How can we be so confident that we even understand these distances, which are far beyond our everyday sensibilities? In last month's column, I tackled this question by explaining how we measure distances. But questions have their own kind of inflation: answering this conundrum begat yet more (good!) questions.

In that column, I explained that one important tool for measuring cosmic distance is a phenomenon called redshift. Think about a balloon with some squiggly lines drawn on it. Now imagine the balloon being blown up. The squiggles stretch out, with the length of the peaks and valleys growing longer. This is what happens to light as it travels across the length of space-time. The light gets stretched out and the wavelength gets longer – and therefore redder, hence the name.

This stretching of light helps us measure distances. We calculate the wavelength of light that we expect to see from distant objects and compare that with what we actually measure. The difference between the two tells us how much space-time has expanded between us and the object we are looking at. This, in turn, allows us to estimate the distance. Redshift measurements have been validated over and over by astronomical observations and laboratory experiments.

But a question lurks in the background. From the point of view of quantum physics, the wavelength of light corresponds to how much energy the light has. The bluer the light, the more energetic. This means that when light is redshifting, it is turning into lower-energy light. On the face of it, this isn't really bothersome, just a cool feature of quantum science in conversation with cosmology.

> **"Energy conservation is the rule in everyday physics, but even cosmic rules occasionally get bent or broken"**

The problem? We like our physics to be consistent with other physics. And one of the tenets of everyday physics is conservation of energy, the idea that energy can't be created or destroyed, just transformed. So, if we assume that conservation of energy applies to redshifting light, this invites the question: what happens to the light's lost energy? An astute reader has asked me this very question.

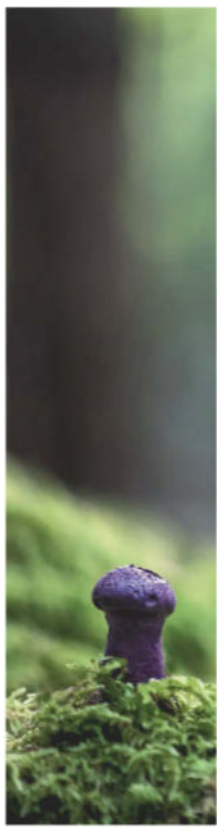
The answer is perhaps surprising: energy conservation is the rule, but even cosmic rules occasionally get bent or broken. In the case of cosmic distances, the governing principle is Albert Einstein's theory of general relativity. This concept, which is most famous for introducing the idea of space-times with curvature, is also why we can show mathematically that it is possible for space-time to expand.

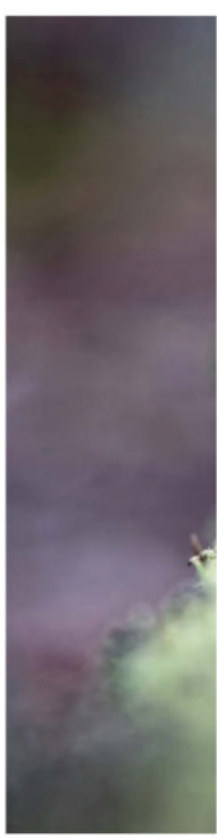
Another feature of general relativity is that energy isn't conserved. In other words, when the light loses energy as it redshifts, the theory says this doesn't really matter. The energy doesn't have to be going somewhere. It can just disappear.

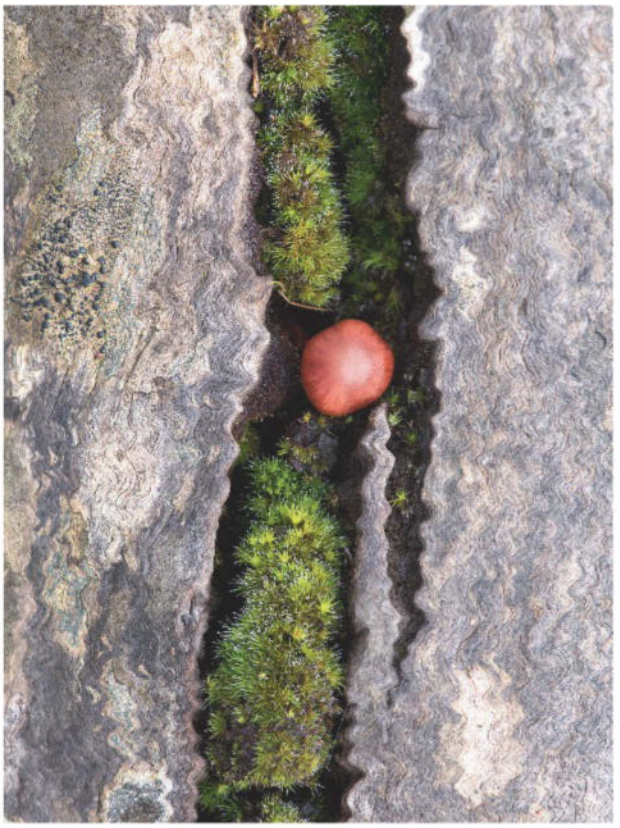
At least, that is one way of talking about it. Alternatively, we have to account not just for the energy of the light, but also the energy associated with gravity – with the amount of curvature in space-time. Over the years, these two apparently divergent ways of thinking about the situation have caused a lot of trouble. There are genuine disagreements about which description is more legitimate. There are also those who see them as two sides of the same coin.

My personal take is that this comes down to what energy is. Though energy is hard to define, we can have some sense of what it is and where it is due to material objects like particles or stars. But once we say "the curvature of space-time has energy associated with it", things get murky. Where is the energy? Everywhere in space-time? How much of that energy is at any given point? And so on. It's question inflation!

So I am inclined to agree with people who say that conservation of energy isn't a useful concept here. What we can say with confidence is that the curvature of space-time and the energy associated with matter shape one another. Space-time's motion tells matter where it can go, and matter's mass (which is equivalent to energy) tells space-time how it can move. ▮







Funky fungi

Alison Pouliot
University of Chicago Press

"I'VE been hanging around fungi for more than 30 years now, working more at the scientific end. But this time I wanted to really explore the aesthetics of fungi," says photographer, writer and ecologist Alison Pouliot. "Many of them are aesthetically beautiful. But they are also bizarre, unusual and crazy. I guess I was trying to challenge people's notions of what a fungus is."

Images from Pouliot's new book *Funga Obscura: Photo journeys among fungi* showcase some of the most striking members of this often-overlooked kingdom of life. One of her favourites is the cage fungus (far left), native to Australasia, which somehow moulds its fruiting body into something resembling a wonky buckyball. "It's not within our concept of how fungus should look," she says.

The giant bolete (bottom, near left) has a familiar mushroom shape, though this specimen has seen better days. "For me, this was about persistence, resilience," says Pouliot. She also loves the violet webcap (top middle), and not just because of its vivid colour. It also has an amazing, velour-like texture. "It's exquisitely soft," she says.

Last but not least are the ephemeral and overlooked fungi, such as the short-lived *Mycena* bonnet mushroom (bottom middle) and an unnamed, button-sized fungus she found amid moss in a crack in a dead branch (top, near left).

Funga Obscura: Photo journeys among fungi is out in Australia (UNSW Press) and will be published in the UK and US by Chicago University Press on 18 August.

Graham Lawton

Who's really running things?

Exposing the unseen gender-based power dynamics and cognitive biases that shape our everyday lives is fascinating – and enraging, finds **Helen Thomson**

Book
Breadwinners
Melissa Hogenboom
Canongate Books
14 August, UK

WHY do unemployed men feel better if their partner is also out of work? Are women more nurturing and empathetic? Why does a messy room seem messier if it belongs to Jennifer rather than John? These are just some of the key questions explored by Melissa Hogenboom in *Breadwinners: And other power imbalances that influence your life*, which exposes the hidden power dynamics and unconscious cognitive biases shaping our lives.

This isn't just about who out-earns whom in a relationship; it is a sharp, evidence-based account of how stereotypes and invisible imbalances influence everything from who empties the dishwasher to who advances at work.

Fair warning: it will make you angry – and rightly so. Take housework. Studies show that domestic chores default to women in heterosexual relationships unless consciously corrected. Women do more chores, even when they do longer hours at work. According to Hogenboom, some researchers suggest this may be an unconscious "compensation" mechanism for a non-traditional setup outside of the home.

The gender expectations underlying power imbalances start early. Mothers describe more movement during pregnancy if they know they are having a boy; fathers talk more about emotion with daughters and physical achievements with sons. Fathers' brains even respond more strongly to their daughters' emotions.

This reinforces a belief that women are naturally more nurturing or empathetic – expectations that shape everything from childcare to leadership opportunities. In fact, empathy, while influenced by genes, shows no genetic differences between sexes, implying any we see are almost entirely down to social factors.

When some of these expectations are stripped away, a different reality appears. "When there's no social expectation about which parent stays at home and looks after the baby, the idea that either of you would do it single-handedly seems crazy," says one male case study, in a same-sex relationship, cited by Hogenboom. "If my husband had suggested going back to work after two weeks I'd have thrown the television out of the window."

Likewise, writes Hogenboom, mothers in same-sex relationships also experience fewer blocks in their career progression after going back to work than those in heterosexual relationships – suggesting that being a mother itself doesn't determine such penalties.

The book focuses mainly on the often invisible power wielded by men – the unseen systemic inequalities that are considered normal. At times, the book feels like it could be subtitled: "Women, here's all the evidence you need to justify why you feel so damn exhausted all the time."

"The myth of mutuality deludes couples that they have achieved a good balance of labour"

Yet the plight of men isn't entirely forgotten. Men who try to rewrite power imbalances often face hurdles, too. One survey of managers Hogenboom cites found that men requesting part-time work were treated with more suspicion than women or teased with comments like, "Where's mum?" They are denied flexibility more than women, judged as less committed for taking it and can face difficulties forming friendships in parenting groups.

Even couples who think they have cracked equality might be surprised by Hogenboom's take on invisible power. These systemic inequalities, she writes, are still the most dominant form of power in relationships, constantly at play without couples even realising it.

The myth of mutuality deludes couples that they have achieved a good balance of labour. But in not tracking whose needs have actually been met and who put the work in, they may be fooling themselves, says Hogenboom. A husband may "do all the cooking", for instance, but who planned the meals, bought the food, washed up and stretched the budget?

Thankfully, there is practical advice as well. Struggling with mental load? Complete the tasks end-to-end, Hogenboom says: "In taking ownership of the whole task, the hidden work is removed."

Her advice comes as a welcome respite from the onslaught of evidence. While authoritative and precise, Hogenboom's style of writing leaves little time to marinade in its implications.

But marinade you should. *Breadwinners* makes a compelling case for recognising the influence of hidden power dynamics where they occur and identifying where and how to rebalance them. The result is fairer relationships, improved well-being more successful careers – and maybe even a few saved marriages. ▮

CLASSICSTOCK/ALAMY

Despite many changes since the 1950s, women are still doing more chores at home

Helen Thomson is a writer based in London

Finding your niche

Exploring how neurodivergent people fare working in the conservation sector is a fascinating read, says **Richard Smyth**

Book

Neurodivergent, By Nature
Joe Harkness
Bloomsbury

WESTEND61/GETTY IMAGES

For many neurodivergent people, the outdoors is a more manageable, simpler place to be

WE begin with moth genitalia. Joe Harkness was planning to write a book about "niche nature interests": ecologists, naturalists and conservationists with obscure passions for woodlice, or taxidermy, or yes, the examination (for ID purposes) of moth genitals. Then a suggestion from an editor set him on a new track: might some of these niche nature interests intersect with neurodivergence?

Harkness had himself been diagnosed with ADHD not long before. It wasn't, he writes, "the biggest shock" to learn, on returning to his interviewees, that many of them had received an autism or ADHD diagnosis, or had been diagnosed with one of the conditions beginning with "dys" (dyslexia, dyspraxia, dyscalculia).

What follows in *Neurodivergent, By Nature: Why biodiversity needs neurodiversity* is a timely and interesting study of the value and meaning of "nature" to neurodivergent personalities and a rigorous survey of how neurodiversity is accommodated in the UK's conservation industry.

We quickly encounter a striking and unexpected contrast. On the one hand, Harkness and his interviewees characterise the wild outdoors as a "safe space", a "non-judgmental" place that can offer stimulation without overload, somewhere that (as one autistic National Trust ranger puts it) seems "a more manageable, logical and simple place to be". On the other, it soon becomes clear that most of Harkness's subjects are making their living in an intensely competitive industry, where high barriers and low pay are the norm. "You can't gloss over the exploitation that so evidently occurs in this sector," says Harkness. And that's even before neurodivergent conditions are factored in.

Pinning down precise definitions of neurodivergent experience is, of course, a hazardous and perhaps foolhardy enterprise. Harkness is happy to keep things open-ended. A key concern in his book is that the "unique neurodivergent skillsets" of many conservation workers go unrecognised and unused.

He singles out intense focus, heightened sensory awareness, pattern-spotting and "a moral compass that only points in the direction of the natural world". But he is aware of drawbacks, too: hyperfocus goes with unhelpful hyperfixation, thinking laterally with thinking too literally, and, while "we might be amazing at analysing data, if you don't understand my spreadsheet, you're an idiot".

Harkness also acknowledges a tension many neurodivergent conservationists will always have to negotiate: "We'd rather spend our time with the thing that we most want to keep safe than the people who wreak havoc upon it. However, the paradox is... we need to engage these people... to stand any chance of making positive change happen."

If the book seems to stray from its premise – as when Harkness engages with the issues faced by women, younger people and people from ethnic minority backgrounds – it is a salutary reminder that neurodiversity intersects with a host of social, economic, political and environmental concerns. Very little here is clear-cut.

Harkness is a chatty, enthusiastic guide to a field he knows well, and he speaks with a huge number of people, all with enlightening stories to tell. These can be inspiring, sometimes upsetting and often funny, though I would have liked to hear more in their own words.

If some of the personality is lost later, where Harkness breaks down the hiring policies and workplace culture of some conservation organisations from a neurodiversity viewpoint, it is still fascinating and necessary work. Our climate and eco-crises need all hands on deck. ▮

Richard Smyth is a writer and a crossword compiler for *New Scientist*

New Scientist *recommends*

Liz Else
Senior culture editor
London

London's Kew Gardens is a treat: you never know what lies in wait. My favourite offering to date is **Of the Oak**, a giant installation from art collective Marshmallow Laser Feast (on until 28 September), connecting us to an oak tree's inner life.

And not just any oak. This immersive video (below) focuses on a 250-year-old Lucombe oak (*Quercus x hispanica "Lucombeana"*) that survives nearby, moved as Kew was created. The video screen stands where the tree once did.

Working with Kew's experts and others, the

collective created "a living monument" to the oak, estimated to afford shelter and food to 2300 species. They stitched together thousands of images, used LiDAR to map the tree, CT to scan soil samples and ground-penetrating radar to trace its root system.

Soak it all up, listen to meditation audio (bring a headset) – or even create your own, to help avert the collective's fears that what "once seemed eternal now leans toward fragility, its fate entwined with our capacity to care".

MARSHMALLOW LASER FEAST

The film column

Everything to say In David Cronenberg's *The Shrouds*, Karsh, Myrna and Maury talk – a lot – about mysterious shrouds, improbable tech and ever-more-complex conspiracy theories. Nothing happens, just grief and, er, death, finds **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on X @simonings

GRAVETECH PRODUCTIONS INC./SBS PRODUCTIONS

Karsh (Vincent Cassel, left) and Maury (Guy Pearce) in *The Shrouds*

Film

The Shrouds

David Cronenberg

On release, UK and US

Simon also recommends...

Films

The Asphyx

Peter Newbrook

Two Edwardian tinkerers (Robert Stephens and Robert Powell) are on their way to inventing motion pictures when they stumble upon a way to freeze the Grim Reaper, mid-stroke.

Ringu

Hideo Nakata

No one asked us whether we wanted to live, and here we are, halfway dead already. This shocker, about a videotape that kills anyone who watches it after a week, finds horror in mortality.

MYRNA (Jennifer Dale) must have had better blind dates. The edible flowers on her starter look funereal. Her table for two is hemmed in by strange shrouds in tall vitrines. And as she makes small talk with her date Karsh (Vincent Cassel), the restaurant's owner, it becomes clear her surroundings are attached – architecturally, financially and intellectually – to a cemetery.

And not just any cemetery: its headstones have screens. Because the bodies are swaddled in natty, camera-riddled, internet-enabled shrouds, you can come here to watch your loved ones decompose.

In his 50-year career, David Cronenberg has mastered the art of delivering everything at the wrong speed. On paper, and in précis, his films look like satires. Their playfulness is evident. Just look at the characters' surnames: Karsh's is "Relikh", Myrna's is "Shovlin". What's to take seriously about this scenario, with its potshots at internet-of-everything boosterists and "grief tech" start-ups that, among various money-making schemes, let you chat with AI-enabled avatars of the dead.

But Cronenberg doesn't write satires. He writes full-throated screenplays about what you and I might really experience, were these scenarios to come to pass, stretching our sense of ourselves.

Karsh's date with Myrna goes nowhere, but the entrepreneur does find solace (and more) in Terry, the identical twin of his late wife, Becca. Diane Kruger plays both roles and also voices Hunny, an untrustworthy digital assistant programmed by Terry's loser ex-husband, Maury (a wonderfully weaselly Guy Pearce).

> **"After so many films, it's clear that grief is the engine driving David Cronenberg's entire output"**

At night, Becca turns up without a breast, without an arm, as her bone cancer takes hold. Are these nighttime visitations flashbacks or fantasies? Do they humanise Karsh, because he loves his wife, despite the changes? Or do they damn him, because he very clearly loves how she has changed?

Karsh is caught between guilt, anger and desire, convinced Becca was unfaithful to him with her old professor and first lover – and that said professor was conducting illegal experiments on her. All of this is, however, a smokescreen, concealing a deeper, more political conspiracy involving China, or Russia, or Budapest, or... Meanwhile Terry, who loves a conspiracy, can't help but encourage Karsh's mania.

Cronenberg's wife of 38 years, Carolyn Zeifman, died in 2017, and it is tempting to see *The Shrouds* as an act of cinematic over-sharing. All the stages of grief are explored in Cassel's superb performance, weaponised by fantastical tech or paranoid tech fantasy into a welter of unresolved plot MacGuffins: what if the strange growths on Becca's dead bones are surveillance devices? Or China is using our corpses to spy on us? Or Maury coded the growths?

While *The Shrouds* may be an expression of purely personal grief, after so many films it is clear that this grief is the engine driving Cronenberg's entire output. It is a wordy film, whose characters explain ever-more-unlikely tech to each other, convince each other of ever-more-complex conspiracy theories and assert themselves in ever-more-outlandish ways. Nothing actually happens because, you know... death. Calm, slow, relentless.

This is one of those devastating chamber pieces great directors sometimes make when they have nothing left to prove, and everything still to say. ▮

Editor's pick

Sociopathic competitive streak may doom society

12 July, p 38

From Roger Arnold, Sunnyvale, California, US

Kudos for a cogent article on a vital subject: competition vs cooperation and the individual vs the group. Nature requires both. Without competition, evolution can't operate. Without cooperation, it can't produce interesting results.

As suggested, when we ask if human nature is selfish or altruistic, we are asking the wrong question. We are instinctive game players, equipped with a repertoire of strategies and behaviours. Those we deploy depend on circumstance, culture and individual experience. Genetic predisposition plays a role, but isn't overwhelming. Where altruism is celebrated, we tend towards altruism. In places where sociopathic behaviour is tolerated or, worse, where the rewards it brings to individuals are taken as marks of status, we tend towards sociopathy. But societies that reach that point aren't long for this world.

Falling birthrate could help us reverse inequality

12 July, p 26

From Geoff Harding, Sydney, Australia

Apart from the environmental destruction of the planet, perhaps the greatest tragedy for humanity is extreme and rising inequality. So it is essential to ask whether it can be alleviated or reversed by the falling birthrate highlighted in the book you review, *After the Spike*. Fewer children should allow greater opportunities for the best possible education at every level, with smaller class sizes and less pressure on resources. The consequent reduced population of workers should result in higher wages and greater choice in employment. The problem in many countries of unaffordable (for many) housing due to overpopulation and inadequate supply would be alleviated and ultimately eliminated. Best that governments adjust to the inevitability of falling birthrate and its positives rather than attempting to prevent it.

From Louise Quigley, Braintree, Massachusetts, US

The book lamenting humanity's falling birthrate is off the mark. Instead of decrying this trend, economists should try to figure out how an economy can thrive without relying on unsustainable continual growth!

The revolution is just around the corner, again

12 July, p 34

From Sam Edge, Ringwood, Hampshire, UK

So "AI companies and tech analysts alike say the agentic AI revolution is just around the corner". That would be in the same way as commercial nuclear fusion, fully autonomous all-road cars, personal flying vehicles, paperless offices and world peace, then?

From Peter Brooker, London, UK

The creators of AI agents that will run our lives for us need a posh motto. I suggest: "Living? Our servants will do that for us." It is from the play *Axël* by French writer Auguste Villiers de l'Isle-Adam.

On contact lenses and the chopping of onions

Letters, 12 July

From Joe Oldaker, Nuneaton, Warwickshire, UK

Agatha Windig is probably on to something with her observation that contact lenses stop the tears while chopping onions, but not that it involves the iris and pupil. A rigid gas-permeable lens would probably filter out the volatiles that the onions release, keeping them from irritating the surface of the eye, the cornea, which would prevent tears. The iris and pupil wouldn't be involved, as such – the iris is an internal structure and the pupil is an aperture in it.

Orcas, please let us know the result of human tests

12 July, p 19

From Dyane Silvester, Arnside, Cumbria, UK

I see that orcas, by offering what appear to be gifts for us, are experimenting on us, presumably to determine our intelligence and whether we are worth teaming up with (or maybe domesticating). I'd love to know their conclusions.

Do weird fig trees have built-in fire retardant?

12 July, p 15

From Carol Stevenson, London, UK

I was fascinated by the report of fig trees that produce calcium oxalate, but the question is how this benefits them. Samburu County, Kenya, where they are native, is prone to bush fires. Do we know if these fig species are more fire-resistant than other plants that don't produce calcium oxalate?

Computer to test free will is impossible to build

Letters, 12 July

From Samir Varma, Cos Cob, Connecticut, US

Howie Firth posed a superb scenario related to the question of whether we have free will: "If every action we make is predetermined by the laws of physics, then it is possible to imagine constructing a computer that could predict what I will do at a particular moment". He then suggests that, knowing its prediction, he could simply choose to do something else.

Having written a book about this, the short answer is that you can't build such a computer, even though the laws of physics are deterministic. There are three fundamental reasons: complexity (the sheer number of variables); chaos (sensitivity to initial conditions); and, most importantly, computational irreducibility – even simple rules can produce outputs that can't be predicted without running the entire computation. It is precisely this lack of predictive ability that constitutes what I call "free will in practice". This form of free will not only exists, but must exist, even in a deterministic universe.

Another example of public health gains

5 July, p 38

From Susi Arnott, London, UK

Devi Sridhar's take on public health initiatives as key to longer, more enjoyable lives, rather than individual striving, brought to mind an important project in south London. Guy's, King's and St Thomas' hospitals use any and all interactions with patients to look at their "vital five": key burdens of disease that, if addressed, can shrink "privilege gaps" in healthy life expectancy. Even just asking about these – use of tobacco and alcohol, weight, blood pressure and mental health – can have an impact, but getting a baseline enables tracking and improving metrics over time, with a positive impact on well-being and healthy life expectancy.

For the record

Carl-Friedrich Schleussner is at the International Institute for Applied System Analysis in Laxenburg, Austria (26 July, p 8)

Influenza viruses have an RNA genome (12 July, p 16).

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The end of infinity?

Extremely large numbers are holding back science, say some mathematicians – and they have a radical plan to do something about it, finds **Karmela Padavic-Callaghan**

HOW many atoms are there in the observable universe? Current estimates point to a number we would write as 1 followed by 80 zeroes, or 10^{80}. If you peered inside each of these atoms and counted their subatomic particles, you could count a bit higher. But what happens beyond that? Take 10^{90} – even if you counted every atom and subatomic particle in the known universe, you wouldn't reach this number. In some sense, 10^{90} has no relation to physical reality.

But it gets worse. If 10^{90} invites suspicion, then what about infinity? For some people, infinity is a stand-in for a process, such as counting, that could go on forever, but doesn't necessarily do so. For others, it means an unknowably large number. In any case, relating it to human experience becomes difficult, even if we turn to the biggest thing we know of. While the standard picture of cosmology tells us that the universe is endlessly, boundlessly infinite, we also know that it does, in some sense, have an "edge" – a bubble within the cosmos that we call the observable universe, marked out by the light that has been travelling towards us since the big bang. Anything beyond this is, effectively, unknowable.

Does this matter? Since the 1960s, a small but relentless contingent of mathematicians, philosophers, computer scientists and physicists have argued that, yes, it does. Calling themselves ultrafinitists, they warn against being overly trusting of numbers like 10^{90} that elude our real-world experience. And don't even get them started on infinity. "That is just an illusion," says Doron Zeilberger at Rutgers University, New Jersey.

Historically, the ultrafinitist movement has often been dismissed as both radical and incoherent, but its proponents say that huge numbers and infinity are undermining the foundations of science, from logic to cosmology. Now, the number of ultrafinitist sympathisers has grown large enough – though, they would be keen to stress, finitely so – that they can't be ignored.

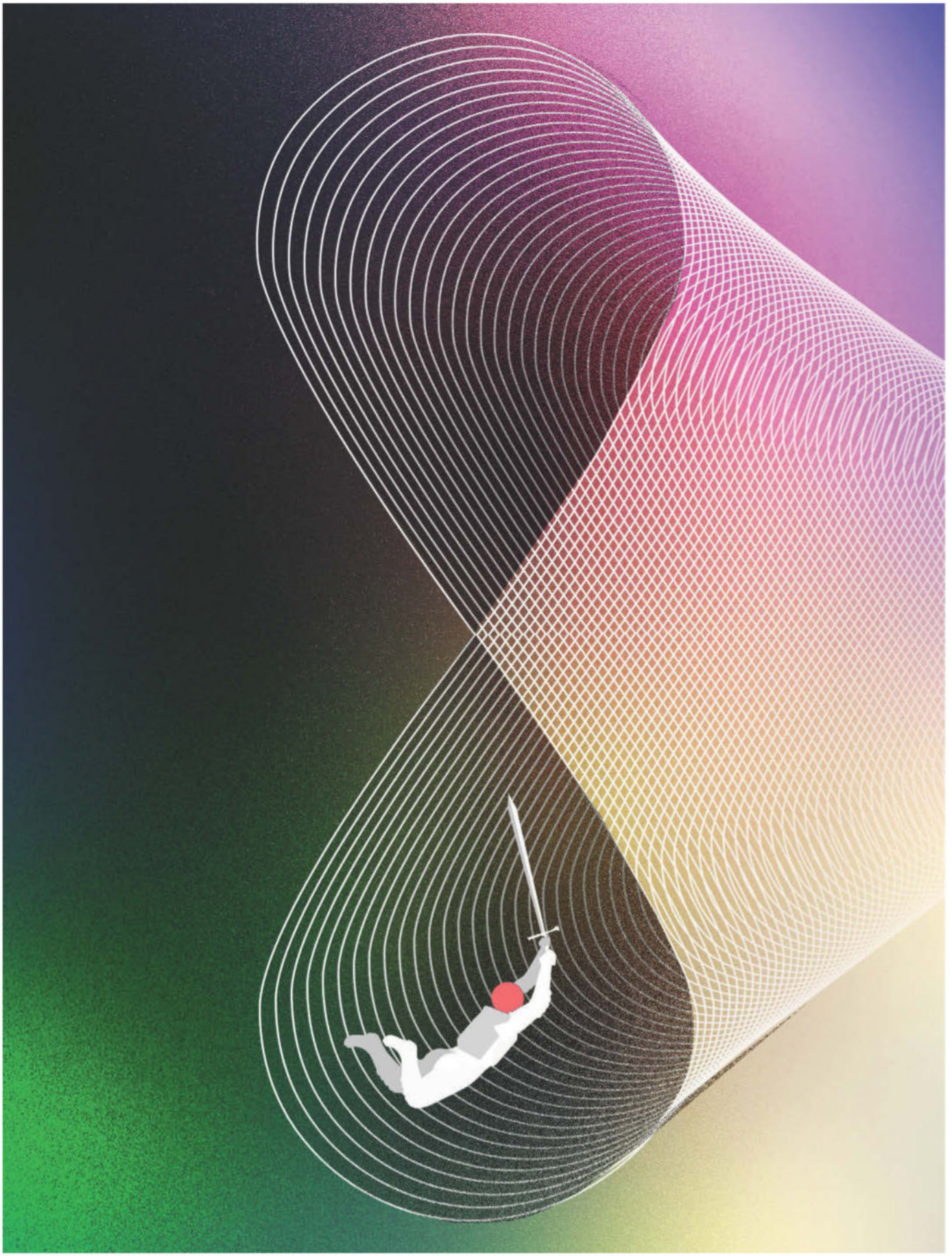
"There's a critical mass now of people who have thought enough about these issues," says Justin Clarke-Doane at Columbia University in New York. "As it stands, there's never been a collection or canonical text written on ultrafinitism, because the problem has been seen as too hard or too radical. There's now potential for progress."

> "Infinity may or may not exist, but there is no need for it in mathematics"

In April, he hosted an ultrafinitist conference at Columbia, packing a room with researchers from across different disciplines who, if not all strict adherents to the ultrafinitist creed, were at least concerned about the role that infinity plays in mathematics. "My hope is that this conference will mark a turning point in research on ultrafinitism," Clarke-Doane said in his opening remarks. "Commentators should no longer be able to dismiss the view."

Strong views were certainly on display. "Infinity may or may not exist, God may or may not exist, but there is no need for either in mathematics," declared Zeilberger halfway through the first day of the conference. Most mathematicians would disagree. Modern mathematics relies on a shared framework known as Zermelo-Fraenkel set theory combined with the axiom of choice, usually abbreviated as ZFC. Essentially a list of statements that are assumed to be true, this serves as a rulebook for doing maths. One of these statements, or axioms, explicitly asserts the existence of infinity.

For most purposes, ZFC works very well – but, shockingly, a giant question mark has hung over its validity for almost a century. In 1931, mathematician Kurt Gödel showed that it is impossible to prove that the axioms of ZFC ›



BRIAN STAUFFER

COLSTRAVEL/ALAMY

Is there a limit to the size of the biggest number?

are consistent within the framework itself. "Nobody's showed it's inconsistent, but there's no deep sense in which we'll ever convince ourselves that it's consistent," says Clarke-Doane.

Mathematical bomb

Yet this isn't keeping many researchers up at night, as it is easy to leave ZFC operating in the background. "Nowadays, mathematicians use the ZFC theory as foundation, without necessarily embracing it explicitly," says Zuzana Haniková at the Czech Academy of Sciences.

But 30 years after Gödel placed a bomb at the heart of mathematics, an unexpected character refused to simply wait until it exploded. Instead, Alexander Esenin-Volpin, a Russian mathematician, poet and dissident (see "The rebel mathematician", right), claimed to have outlined a programme for proving the consistency of ZF theory. While only a subset of the ZFC rulebook, this programme still stood a chance of solidifying contemporary mathematics' bones with an audacious trick: abandoning infinity.

Exactly how remains unclear, as Esenin-Volpin's ideas never fully reached the mainstream of mathematical research. "These were not well-understood at the time and the details remain murky," says Walter Dean at the University of Warwick in the UK. One contemporary review, which coined the term "ultrafinitist", called Esenin-Volpin's 1961 paper "not particularly convincing".

But other mathematicians picked up the ultrafinitist torch. In 1971, Rohit Parikh at the City University of New York wrote a paper that cleared up some of the murkiness, showing that the idea of a "small number", though hard to define precisely, can be embedded in a useful theory. He developed a mathematical theory where all numbers were kept smaller than a certain largest number, such as 2 "tetrated" to 1000, which is equal to 2 raised to the power of 2 raised to the power of 2 and so on 1000 times. While this is far larger than the 10^{80} atoms in the universe, it could still be deemed "feasible" within Parikh's theory. By requiring that proofs within his framework must also be kept to a feasible length, Parikh showed that it could remain internally consistent. While unable to fully replace standard mathematics, it was the first successful attempt at a truly ultrafinitist way to do proofs.

> "One argument for losing infinity is that computers can only ever approximate it"

What makes a number, or a proof, feasible? This question is at the heart of the ultrafinitist project. Though the issue connects to age-old paradoxes, such as exactly how many grains of sand you have to put together to make a pile, for Parikh, the key concern is to avoid losing track of mathematics' connection to humanity. "You have to draw a line somewhere. Things have to be related to human activity," he says. In his view, the ultrafinitist way of thinking orients researchers towards our experience, and he says that, while this approach is still incomplete, "an incomplete approach is better than nothing".

Others draw inspiration from elsewhere. For Zeilberger, a computer scientist, the fact that computers can only ever approximate infinity – and so are unable to use the fuzzy "very large number" concept that humans rely on – is an argument for doing away with it. His affinity for ultrafinitism started when he first learned calculus, which uses infinitely large or small numbers rather heavily, to his distaste. The rise of calculus in the 17th century cemented infinity's place in mathematics, but Zeilberger sees this as a historical fluke, a consequence of computers not having been developed earlier, and says that he would love to teach his students calculus without it.

Even non-ultrafinitists concern themselves with the limits of computation – indeed, there is an entire field dedicated to it, called computational complexity. Dean sees ultrafinitism and computational complexity as two sides of the same coin, one more philosophical and the other more practical.

One famous example of computational complexity theory at work is the P versus NP problem, often called the most important problem in theoretical computer science. It captures the difficulty of determining how much computational effort is required to solve certain types of mathematical problem, and whether those solutions can be easily checked.

In the 1980s, building on the work of pioneers such as Parikh, Sam Buss at the University of California, San Diego, developed

THE REBEL MATHEMATICIAN

Born in the Soviet Union in 1924, the ultrafinitist Alexander Esenin-Volpin was the son of two poets – and a rebel across the board. He completed a PhD in mathematics and was also an active translator of mathematical works from Europe, because he spoke French. But, for decades, his career as a mathematician, including the development of what would become the rejection of infinity (see main story), was put on hold in favour of protesting against the Soviet regime. More than once, he was arrested and confined to a psychiatric institution for writing and performing anti-Soviet poetry, and he organised some of the first public demonstrations against the Soviet government.

In 1972, he finally emigrated to the US and started working at Boston University. Rohit Parikh at the City University of New York, who would go on to develop Esenin-Volpin's ideas about ultrafinitism, met him at a conference in 1975 and the Russian scholar lived with him for a month. "Unfortunately, even though I thought Volpin was a genius, I also came to realise that he didn't quite understand his own work," says Parikh.

But even in the face of resistance, Esenin-Volpin would stick to his assertions about infinity, often with good humour. In a 2002 lecture, logician Harvey Friedman recounted asking him about whether a series of progressively larger numbers, 2^1, 2^2, 2^3... 2^{100} are real. For the first number in the series, Esenin-Volpin "virtually immediately said yes", but as Friedman asked about ever larger numbers, Esenin-Volpin answered with longer and longer delays. "Sure, he was prepared to always answer yes, but he was going to take 2^{100} times as long to answer yes to 2^{100} [than] he would to answering 2^1. There is no way that I could get very far with this," recalled Friedman.

"A frazzled dumpling of a man... his face and body marked by the vivid traces of what the Soviet system had done to him," as mathematician Roy Lisker described him in 1993, Esenin-Volpin died in 2016. His obituaries tended to cite his political work more than his long-lived disdain for infinity.

"bounded arithmetic", a set of tools for linking mathematical and computational limits when evaluating whether problems can be solved. Using these tools, he was able to identify some problems that are easy to solve and have solutions that are easy to verify. Characterising such matchups as generally as possible is at the core of what it will take to resolve the P versus NP conundrum. "This continues to be a fairly big deal and a central aim of complexity theory," says Dean. Buss says this work has only become more important with the growth of buzzy new technologies like artificial intelligence and quantum computing, which are raising new questions about the limitations of computation.

Maths vs physics

Seen in this light, computational complexity becomes a tool for translating the rarefied realm of mathematics into physical reality, because computers are real, physical objects. Traditionally, mathematics is seen as a mere language for expressing physical truths, but some ultrafinitists go even further. For example, writing in 2013, Pavel Pudlák at the Czech Academy of Sciences argued: "One can, in principle, represent any finite mathematical structure by a physical object. Hence a theorem about finite mathematical structures is also a physical law."

While this is a non-standard view, Clarke-Doane points out that it isn't unreasonable. "No one has ever given an intelligible story of how to draw a sharp boundary between math and physics," he says. "If the physical world is partly mathematical, then you have to take the math seriously in a way that you don't when you dismiss it as a language."

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An ultrafinite universe might be stuck on repeat, always returning to its initial state

If the ultrafinitist project succeeds in removing infinity from our mathematical toolbox, we may then have to grapple with the possibility that the universe, even beyond the bounds of the observable universe, may actually be finite. How could the laws of physics possibly allow that? During the conference, physicist Sean Carroll at Johns Hopkins University in Maryland outlined a physical model for an ultrafinite universe.

Constructed within the framework of quantum mechanics, Carroll's model universe is still spatially infinite, but it only has a finite number of allowable quantum states. The result is a universe that is periodic in time – it changes, but eventually always returns to its initial state. This is in stark contrast to the widely accepted view that our universe had a starting point in the big bang and, following physics laws such as those dealing with thermodynamics, continues to expand. Yet, Carroll showed that by carefully tuning his model – for instance, by limiting the ways in which the entropy, or disorder, of this universe can fluctuate – he could avoid violating those laws. In doing so, he provided a bare-bones basis for how a finite universe would work, and how the complexity of reality, such as the shape of space-time, might emerge from it.

In his presentation, Carroll didn't argue that we live in this type of finite universe, but he didn't fully dismiss it either, saying it was "perfectly conceivable". And this isn't his first attempt at examining a finite universe: previously, he and his colleagues have estimated the number of all possible quantum states in the observable cosmos to be 10 raised to the power of 10^{122}. "None of this is definite, but it gives us licence to think finite," said Carroll at the conference. Intriguingly, this number is derived from efforts to tie together theories of gravity and quantum mechanics, suggesting a link between ultrafinitism and the grand challenge of formulating a theory of "quantum gravity" – a definitive physics theory of everything.

Most physicists would baulk at accepting Carroll's finite universe as a true model of reality, but the idea of destroying infinity within physics, or at least of infinity being ›

ECLICKTIQUE PHOTOGRAPHY/ALAMY

"Can maths be rebuilt to acknowledge infinity as something else?"

a problem, isn't without precedent. Take quantum field theory, which is instrumental for our current understanding of particles and forces in the universe, yet often yields infinite results. As Clarke-Doane puts it, even when physicists speak of the universe as if it were finite, "the math they're using is up to its ears in infinity". Physicists use a trick called renormalisation to avoid such infinities within the theory, by doing things like restricting analysis to the behaviour of a particle with a specific range of energies or velocities, rather than any possible particle.

But Tim Maudlin at New York University says this doesn't mean there is an innate finitist tendency within quantum physics. If a calculation of the probbility of two particles colliding produces an infinite number, then that calculation has simply failed, he says. Using renormalisation in this case isn't banishing infinity, but rather finding a mathematical tool that can coax a meaningful answer from the theory. "To say you wanted a finite result isn't because you say, 'I reject infinite results', but what you're calling an infinite result just isn't a result," he argues. In his view, these encounters with infinity have no bearing on whether space is infinite or if there are infinitely many objects in the universe.

He says that to accept an ultrafinite universe, it would have to be a consequence of a new theory of physics, rather than its starting point, similar to how Albert Einstein's theory of special relativity uncovered a finite speed of light. Without that motivation, Maudlin compares the ultrafinitist project to an author wanting to write a novel without the letter "e" – an immense technical challenge at least partly motivated by aesthetics, rather than a universal necessity.

Infinite horizons

Still, with potential benefits across a number of scientific disciplines, is it time to take ultrafinitism seriously as an alternative view of the foundations of mathematics, even if only to serve as a comparison against standard approaches? Haniková, who isn't an ultrafinitist, thinks it could play a role here. She points to Czech mathematician Petr Vopěnka's work developing a similar alternative mathematical theory in the 1970s.

Relating big numbers to human experience is hard

Vopěnka wondered why the infinity of mathematics can faithfully model our finite real experience. He wasn't a strict ultrafinitist seeking to banish the infinite completely, but he still saw actual infinity as living beyond our "perceptual horizon". He instead spoke of "natural infinity", and developed a theory that negates the axiom of infinity that appears in standard mathematics and, to make up for it, deals with two types of mathematical objects: those that are as definite and sharply defined as usual, and some that are more "blurred", representing a path towards some infinite horizon. This allowed Vopěnka to have a notion of infinity not just as something that is "beyond" any large collection of objects, but as something that is also somehow a part of them, says Haniková.

Could something like this reasoning be the future of ultrafinitism? Does infinity really have to go, or can mathematics be rebuilt to simply acknowledge it as something different? "This approach continues to be inspiring for mathematicians and philosophers alike," says Haniková. For instance, it remains relevant for studies of vagueness that crop up in linguistics, ethics and mathematical logic.

Clarke-Doane is also sympathetic to the idea of encoding the vagueness of the border between the finite and the infinite into future alternative theories of mathematics' foundations, but he concedes that ultrafinitists have a tremendous amount of work ahead of them. Even just articulating a consistent ultrafinitist theory is mostly uncharted territory.

Does this matter? "It's very often the case that you don't need to care for practical purposes. But sometimes you do, and if there's no one who has a coherent philosophical story about the foundations, that's a serious problem when things go wrong," says Clarke-Doane. If a pipe breaks in the cellar of science, you hope that someone knows how to fix it before it becomes a flood, he says.

The ultrafinitists are on standby, building up their toolkit to prepare for philosophical emergencies. ▮

Karmela Padavic-Callaghan is a physics reporter at *New Scientist*

How dogs came in from the cold

Unexpected discoveries are rewriting how we think our lovable pets evolved from fierce, wild wolves, says **Taylor Mitchell Brown**

IN 1881, zoologist John Murdoch took part in an expedition to Point Barrow, Alaska, at the northernmost tip of the US. The goal was to conduct a two-year, unbroken observation of meteorological and magnetic phenomena and to document the nature and wildlife of the Arctic along the way. Travelling north through Alaska, Murdoch and his crew witnessed a peculiar act: an Iñupiat family captured two wolf pups and took them back to camp. The family carefully fed and nurtured the pups, raising them to adulthood before killing them for their fur. Murdoch was observing an ancient tradition. It turns out this Iñupiat practice might also hold the key to understanding the origin of modern dogs.

How ancestral grey wolves were transformed into humanity's best friend has long been debated. For the past several decades, the prevailing hypothesis has been that wolves domesticated themselves. They initiated the process by first wandering around the periphery of human settlements and feeding on rubbish tips. Over time, they became habituated to the presence of people and formed mutually beneficial relationships with them. Only then did curious humans select and breed individuals with traits like docility and gregariousness, eventually giving rise to the pet canines we know and love today.

Through this unguided and unintentional process, wolves scavenged their way to domestication. Or so the theory goes. Recent evidence, however, has led many scientists to abandon the idea of self-domestication. If the revisionist thinking is correct, then humans, not wolves, were the driving force – and the domestication of dogs is evidence that humanity has a deep and complex relationship with wild animals that was born long ago.

Popular perceptions of dog domestication have been shaped in large part by the late Raymond and Lorna Coppinger, who wrote a series of highly readable books on the subject at the beginning of the 21st century. The husband-and-wife team of biologists based much of their argument on "pariah" dogs that prowl human garbage dumps, feeding off leftovers and sometimes receiving direct aid from local people. "These animals are ownerless and survive largely on scraps of food waste from human settlements," says archaeologist Loukas Koungoulos at the University of Western Australia. "They make up a majority of the species *Canis familiaris* worldwide – in some estimates up to 70 per cent of all dogs presently alive."

The first dogs

Pariah dogs are the perfect analogue for wolves at the beginning of their domestication, the Coppingers argued. The idea they championed was that self-domestication occurred when humans transitioned from hunting and gathering to farming. This was when our ancestors became sedentary, living in larger groups and producing enough waste to attract wolves, in much the same way that pariah dogs are attracted to settlements today. This shift began around 12,000 years ago in the Middle East.

"Finds of considerably earlier dogs would naturally disprove the idea," says Koungoulos. And such finds have now emerged.

Palaeontologists have discovered around two dozen fossil specimens of dogs ranging in age from 35,500 to 13,000 years old across Eurasia, in countries including Spain, France, Belgium, Italy, Switzerland, Germany, Ukraine and Russia. These Palaeolithic dogs have a variety of physical characteristics that distinguish them from wolves. They weigh 31.2 kilograms on average, while Pleistocene wolves weighed around 41.8 kilograms. They also have shorter snouts, a slightly wider palate and shrunken canine teeth. These differences in morphology represent a changing body form that many scientists argue illustrates the budding signs of domestication. In addition, genetic analysis of ancient canid DNA points to south-west Asia and East Asia as the original centres of domestication. Although scientists are still calibrating the exact dates, it now seems clear that dogs emerged over 36,000 years ago in several locations independently. In other words, domestication long predates the transition from hunting and gathering to farming.

Some supporters of the self-domestication idea have tried to salvage it by pointing out that Palaeolithic hunter-gatherers killed large mammoths and herd animals like bison and deer, so they could have generated enough leftovers to attract and feed meat-hungry carnivores, including wolves. But this argument also has its problems. For one, we know Stone Age people were experts at using all kinds of animal resources and seldom left surplus waste, especially not close to where they were living. Besides, the practices of modern hunter-gatherers suggest that if our ancestors kept excess meat, they would have stored it away from scavengers on platforms or up in trees.

An even bigger obstacle is research showing that wolves are often seen as ›

PATRICK REYMER

dangerous pests. If they get too close and comfortable with humans, they will occasionally prey on young children or other vulnerable members of society. There are documented instances of people killing wolves when they feel threatened by their presence.

It was evidence like this that turned Koungoulos firmly away from the self-domestication model. "I became pretty convinced that there are deep, consistent, almost structural barriers to self-domestication posed by the innate behaviour of wolves and the typical attitudes of traditional societies towards canids, which are, for the most part, rightly considered dangerous animals," he says. "[Self-domestication] might make sense for some other domesticated species, but not for large carnivores like this."

If not self-domestication, then what?

One clue pointing to a different origin story comes from a growing understanding of wolf behaviour. Wolves are born blind and don't develop eyesight until they are about 2 weeks old. During this critical period, they are highly adaptable and able to habituate to humans, which means they can form an attachment to a human caretaker, allowing pups to be safely nurtured and making it less likely they will attack anyone in the future. "If people are willing to put in the work, they can handle practically any type of canid as a companion," says evolutionary biologist Raymond Pierotti at the University of Kansas, who has raised wolf pups himself. The key is to begin when they are still very young.

Pup abduction

Other clues can be found in the archaeological record. "Palaeolithic dogs are generally, but not always, found in Palaeolithic sites," says archaeozoologist Mietje Germonpré at the Royal Belgian Institute of Natural Sciences. But they don't just occur in close association with ancient humans and their settlements; there are also signs that these people had deep connections to dogs and other canids. At a site called 'Uyun al-Hammam in Jordan, for instance, a fox was buried alongside two humans around 16,000 years ago. The excavators of this grave hypothesised the canine wasn't a grave good, but a companion, buried together with its owners like part of the family. Numerous sites across Europe, Asia and North America suggest similar relationships.

Germonpré's work on Palaeolithic dogs has made her an early and prominent advocate of an alternative model of domestication that is now taking hold among a growing body of academics. It sees wolf pups slowly becoming domesticated after first being adopted by humans as pets. Stone Age people would have taken wolf pups from the wild and nurtured them to adulthood. Then, later, by selectively breeding those with the most desirable traits, domestication would have gradually been achieved. Germonpré calls this the human-initiative model of dog domestication.

In fact, it isn't a new idea. Probably the earliest and simplest version of it comes from Francis Galton, Charles Darwin's cousin. Galton, a Victorian polymath most notorious for founding the field of eugenics, was an extensive traveller and documentarian. This, along with his many connections to the elite of his day, made him aware of the practices of Indigenous populations – including ones who took young wild animals as pets. Galton wrote about Indigenous peoples in North America who captured bear cubs and wolf pups, South Americans who caught and raised birds, and African populations who adopted young buffalo and antelope. This practice of taking young pets, thought Galton, could be the origin of domestication.

DEBBIE STEINHAUSSER/ALAMY

Modern ethnographic reports paint a similar picture. There are accounts from Russia of groups, including the Khanty and Mansi, keeping fox pups as pets and later killing them for their fur. In North America, the Inuit regularly adopted bear cubs into their families, allowing them to play with children and even sleep in their igloos. The Siberian Ket families also adopted young bear cubs, particularly if they had no children. The Ainu of northern Japan and eastern Russia did something similar, adopting and raising young bear cubs to later sacrifice in ritual ceremonies.

Anthropologists have recorded many instances of hunters taking young carnivores back to camp and these animals being breastfed by women, a practice also mentioned by Galton. We now also know the tendency for cross-species adoption isn't even confined to humans. Dolphins have been observed to adopt individuals from other species, as have monkeys. This hints that the desire to affiliate with and care for the young of another species has deep evolutionary origins.

However, the modern version of Galton's hypothesis goes beyond humanity's fondness for puppies. Germonpré became interested in the earliest manifestations of canid domestication when studying the relationship that Stone Age hunter-gatherers had with cave bears (*Ursus spelaeus*). Cave bear bones, including skulls, were often burned, painted with ochre and deposited beneath rock slabs, indicating that these fearsome beasts were imbued with symbolic and ritual meaning. This might have given people another reason to want to adopt and raise bear cubs from an early age. "My interest in the pet model

Was this red fox, buried alongside two people in a 16,000-year-old grave, a companion animal?

2011 MAHER ET AL.

WERNER FORMAN/UNIVERSAL IMAGES GROUP/GETTY IMAGES

Wolf cubs were historically captured and raised by Inuit in order to make fur clothing

"The practice of taking young pets could be the origin of domestication"

as a hypothesis grew from there," she says, "with the idea that other carnivores, such as wolves, must have had symbolic value for Palaeolithic people, together with other worths and utilities."

Archaeological evidence supports this idea. Many excavated prehistoric sites reveal that Stone Age people had a wide variety of uses for wolves. Their teeth were turned into ornaments, perforated skulls hint at ancient rituals, and cut marks suggest people ate wolves and fashioned their long bones into tools. But perhaps the most important resource a wolf provided was its pelt.

Like other species that live at high latitudes, wolves are adapted to thrive in cold conditions, and this includes sporting super-insulated fur with a mixture of long and short hairs. Historical reports recount hunter-gatherers living in northern latitudes across North America, Europe and Asia using wolf fur to line hoods, collars and other clothing. The Inuit historically captured wolf cubs, raised them and killed them for fur, which was also the fate of the Alaskan wolves adopted by the Iñupiat in Murdoch's record. Likewise, wolf fur would have been a precious resource for people living during the last glacial maximum between around 26,000 and 19,000 years ago. For tens of thousands of years around this time, people had to endure some of the coldest and harshest climates of the past few million years. It is also the period to which many of the fossils of Palaeolithic dogs date.

Exactly how the process of domestication might have unfolded is unclear. "The specific Asian wolf that was ancestral to today's dogs is gone forever, so the domestication of the dog can never be recreated under experimental conditions," says Koungoulos. Nevertheless, he and others think there may have been parallels with a much more modern interaction between humans and wild canids. "One of the best analogues we have is the dingo and its relationship to Australian Aboriginal people – some of the only traditional hunter-gatherer peoples to have, until recently, maintained domestic relations with a wild canid," he says.

The dingo provides a clear illustration of what happens when small bands of mobile people adopt young wild canines but don't selectively breed them. Until recently, Aboriginal Australians regularly captured dingo pups and cared for them, but then let them go once they reached adulthood. Dingoes haven't become domesticated despite thousands of years of this sort of association with people. "But this modern example hints at how a long-term tradition of keeping wild-born canid pups as pets could alter the behaviour of the free-living population, or at least parts of it," says archaeologist Adam Brumm at Griffith University in Australia.

In a paper co-written with Koungoulos and Germonpré, Brumm speculates that when returned to the wild to breed, dingoes may have taken up residence near Aboriginal camps, forming a sort of human-associated subpopulation apart from other dingoes. Their pups then also tend to be the ones taken from nearby dens and adopted as pets. "Perhaps something similar happened tens of thousands of years ago with the grey wolf, giving rise to the first canids we would recognise as dogs," says Brumm.

We may never know for sure, but there are still looming questions that canid researchers hope to answer, including exactly where and when domestication originated. Germonpré wants to address these with further studies of ancient canid DNA. Whatever future studies reveal, however, the old story no longer seems plausible. "The self-domestication model still has a number of supporters and popular books out there," says Koungoulos, "but my feeling is that, in the face of contrary evidence, they take increasingly fringe positions."

Pierotti's assessment is more direct: "Do not let yourself be beguiled by the Coppingers and their way of thought." ▮

Taylor Mitchell Brown is a science journalist based in San Diego, California

In search of relief

Constipation isn't just a minor inconvenience – it has been linked with cardiovascular disease and cognitive impairment. So what can you do to get things moving again, asks **Graham Lawton**

WE'VE all been there: the urge to defecate is strong, but the ability to do so isn't. Despite much huffing and puffing, nothing is forthcoming. You rise defeated, if not deflated.

Constipation is one of the occupational hazards of being human. Perhaps because of how common it is, it has long been regarded as an inconvenience, curable by diet and exercise and, if those don't loosen things up, laxatives.

Much of the time, those remedies help and constipation passes quickly. But for many people, being unable to regularly defecate persists for months or even years. And for them, the consequences can be more serious.

That's why researchers and doctors are starting to pay more attention to constipation. It can have a terrible impact on quality of life, leading to haemorrhoids, anal fissures or, in particularly serious cases, impacted bowels caused by the build-up of faeces in the lower intestine, all of which can be debilitating. In severe – but thankfully rare – cases, constipation can damage internal organs and even be deadly.

There's more. Emerging evidence supports the idea that chronic constipation is a causal factor in some more pernicious health problems, including cardiovascular disease, kidney disease and cognitive impairment. Why it might play a role in these conditions isn't entirely clear, which has got researchers on the hunt for potential mechanisms.

What is clear is that being bunged up for a long time can take a real toll on your health and should be avoided. But that is sometimes easier said than done.

There is a natural variation in people's bowel habits, but those who are constipated have unusually infrequent movements – just two or fewer a week. If that persists for 12 weeks, along with at least one more symptom, such as frequent straining, hard or lumpy stools or the need for "manual assistance", the diagnosis is chronic constipation.

Around 16 per cent of people are chronically constipated at any given time. "That means that one in seven [people] globally struggle with symptoms of chronic constipation," says Brian Lacy, a gastroenterologist at the Mayo Clinic in Jacksonville, Florida.

People become constipated for many reasons. In children, the main cause is withholding faeces during and after toilet training, with a peak incidence rate of about 12 per cent between the ages of 2 and 4. Women account for around two-thirds of adult cases of constipation: reproductive hormones suppress bowel motility and childbirth can damage the muscles of the pelvic floor, including those that control the contraction of the rectum.

In fact, dysfunctional pelvic floor muscles in men and women are to blame for about 30 per cent of chronic constipation cases, according to Lacy. The condition becomes more common with age, with the difference between the sexes evening out in the over 70s. The age-related decline of sensory nerves in the rectum means that older people are sometimes less aware of the need to defecate, which can lead to a build-up of faeces in the lower bowel that hardens and becomes more difficult to pass.

Some medical problems can contribute to constipation, including irritable bowel syndrome, hypothyroidism and neurological conditions such as Parkinson's. Constipation can also be a side effect of many drugs,

ANDREA UCINI

especially opiates such as codeine. And, of course, lifestyle choices are a major culprit – a lack of dietary fibre, dehydration and inactivity contribute to at least a third of cases.

Constipation can usually be fixed. But about 10 per cent of people with chronic constipation go for six to eight weeks without a bowel movement, according to Lacy. In a handful of cases, the condition can be fatal. Some of the documented causes of death from long-term constipation include perforated bowel, sepsis and respiratory failure due to compacted faeces crushing the lungs.

Such deaths are very unusual. More common are the associations between persistent constipation and other medical conditions. For instance, the chronically constipated tend to have higher rates of high blood pressure, diabetes, kidney disease and heart disease. These links were assumed to be a correlation, because some of the most common causes of constipation – a diet low in fibre and physical inactivity – have wider health consequences. But that perception is now shifting.

Thinking started to change a few years ago, thanks to tentative evidence that chronic constipation wasn't merely correlated with heart disease and death – it was a contributing factor. In 2016, for example, a team at Tohoku University School of Public Health in Sendai, Japan, found that lower defecation frequency was associated with an increased risk of mortality from cardiovascular disease in older women. But the study was small and other researchers were unable to find a connection.

A couple of years later, a team led by Keiichi Sumida at the University of Tennessee decided to dig deeper. The researchers analysed the ›

"One in seven people have symptoms of chronic constipation"

medical records of over 3.3 million US veterans, a nationally representative population. Of those, they identified people who were constipated based on either having had at least two diagnoses of constipation more than 60 days apart or having been prescribed laxatives more than twice during a certain period of time.

Sumida's team then looked at how many of the veterans had subsequently died, as well as the incidence of non-fatal stroke or coronary heart disease (CHD). The researchers found that among the nearly 240,000 who were chronically constipated, deaths from all causes were significantly higher. Strokes and CHD were also more common in these groups.

When the team re-analysed the data to eliminate confounding factors, such as other illnesses, socioeconomic demographics and prescription drug use, they found that the associations persisted. "Constipation remained significantly associated with higher all-cause mortality, which was very surprising," says Sumida. Veterans with chronic constipation were 12 per cent more likely to die from all causes than the non-constipated and had a similarly elevated risk of stroke and CHD. The worse their constipation, the higher their risk.

Symptom or cause?

Since Sumida and his team published their analysis in 2019, more evidence has emerged that chronic constipation is an independent risk factor for cardiovascular disease. In 2024, a meta-analysis found that people with chronic constipation were 41 per cent more likely to have a stroke than the non-constipated. Also last year, Francine Marques at Monash University in Melbourne, Australia, analysed the anonymised health records of 408,354 people aged 40 to 69 from the UK Biobank project, looking for associations between constipation and cardiovascular disease. She and her colleagues found that people with chronic constipation were more likely to go on to have a major cardiac event.

"People that had hypertension and had constipation were 34 per cent more likely to end up having a heart attack or a stroke than people that only had hypertension, even after we consider all the traditional risk factors such as diabetes or smoking," she says.

Though these studies didn't examine how chronic constipation raises the risk of death and cardiovascular disease, there are several plausible explanations, says Sumida. One is that straining to defecate can put pressure on the vagus nerve, prompting a sudden plunge in heart rate and blood pressure. This can cause fainting – called a "defecation syncope" – and may also temporarily cut off the blood supply to the heart and brain, causing tissue damage. The phenomenon is exacerbated by dehydration, which is both a cause of constipation and a side effect of some laxatives.

Straining can also have the opposite effect on blood pressure, causing it to increase to dangerously high levels. In 2019, for example, researchers at Jichi Medical University in Tochigi, Japan, reported on the case of a woman hospitalised with congestive heart failure who experienced a flash pulmonary oedema – a sudden and potentially fatal influx of fluid into the lungs – after her blood pressure rose to 208/88 while straining on the toilet.

It is also possible that simply retaining stool in the body for long periods is harmful. There are clear differences between the microbial signatures of stool samples from constipated and non-constipated people, suggesting chronic constipation leads to an imbalance of the gut microbiome, or dysbiosis. This can damage the intestinal wall and allow bacteria and their toxic metabolites to flood into the bloodstream, triggering inflammation. Chronic inflammation is a risk factor for cardiovascular disease.

Evidence has also begun to emerge that chronic constipation raises the risk of developing other conditions. For instance, people with chronic kidney disease have long been known to be prone to constipation, which was attributed to dehydration, lack of fibre, inactivity and their use of multiple medicines. But in a study published last year, a team at Inha University College of Medicine in Incheon, South Korea, analysed UK Biobank data and found that chronic constipation often preceded the development of kidney disease.

It is too early to conclude that chronic constipation causes kidney disease, the researchers warn – they couldn't rule out the possibility that it is just an early symptom of kidney dysfunction – but they say there is a plausible mechanism for a causal link. Prolonged retention of stool in the colon gives gut bacteria time to ferment proteins present there, producing toxins such as cresol sulphate and indoxyl sulphate. In animal models, these can enter the bloodstream and damage the kidneys. "That's probably why constipation and kidney disease are linked very closely to each other," says Sumida, who wasn't involved in that study but has also found a potential causal connection between the two.

CALEB DOW/UNSPLASH

JONATHAN KNOWLES/GETTY IMAGES

Caffeine may help get things moving, while a diet high in red meat has long been thought to bung things up

REUTERS/ANDRES MARTINEZ CASARES

Exercise can aid gut motility, helping to relieve constipation

"Those with constipation had significantly worse cognitive function"

Chronic constipation is also linked to anxiety and depression. Though it is a known side effect of antidepressants, a recent study of nearly 450,000 participants found that constipation often comes before people begin taking the drugs. What's more, the study concluded that people with constipation are almost 50 per cent more likely than those without to develop depression over the next 12 years.

There is even a possible link between chronic constipation and cognitive decline. Chaoran Ma at the University of Massachusetts Amherst and her colleagues analysed data from over 110,000 people, mostly women in their 60s, who were cognitively healthy and had kept track of their bowel movements for a year. When Ma followed up with the participants two or four years later, she found that those with constipation had significantly worse cognitive function, equivalent on average to an extra three years of cognitive ageing. She and her colleagues suggested that gut microbial dysbiosis caused by constipation might be the reason.

As this troubling evidence has piled up, however, another worry about constipation has been flushed away. Constipation has long been hypothesised as a cause of colorectal cancer, but the latest research suggests there is no link. Nevertheless, people who are chronically constipated or experience a sudden change in bowel habits should be checked for cancer, says Takaomi Kessoku at the International University of Health and Welfare, Narita Hospital, in Chiba, Japan, who has studied constipation extensively.

More broadly, of course, these recent findings suggest that people with chronic constipation would be well advised to seek help. "Treating constipation may be beneficial for various health outcomes," says Sumida.

If you find yourself backed up, what can you do? The standard medical advice is to drink more fluids and increase fibre intake. Exercise can also be effective; a recent review found that even gentle exertion such as walking and tai chi helps. Abdominal massage for 15 minutes a day, five times a week, was recently found to work, too. Adopting a different posture on the toilet – either leaning forward in the style of Rodin's sculpture *The Thinker* or sitting upright with feet on a footstool – helps to align the rectum and anus, giving stools an uninhibited route out. A doctor can also check for any pelvic floor dysfunction that might be hindering defecation, and physical therapy can help too.

Then there are laxatives. The simplest and cheapest are fibre supplements such as methylcellulose and psyllium husks. Like natural dietary fibre, these bulk up stools and cause them to retain water, making them larger, softer and easier to expel. Another option is an osmotic laxative such as sorbitol, which is found naturally in prunes and draws water out of the bloodstream into the gut to soften and lubricate stool. Stool softeners and lubricants, such as mineral oils, do exactly what they say on the tin.

If those fail, various pharmaceutical agents are available. Muscle stimulants, also known as prokinetics, such as senna, bisacodyl and prucalopride strengthen the contractions of the gut wall. Secretagogue laxatives such as lubiprostone and linaclotide cause more liquid to be secreted into the colon.

The newest additions to the arsenal are ileal bile-acid transporter inhibitors. These work by blocking the reabsorption of bile acids into the body through the small intestine, allowing them to enter the colon. There, they stimulate muscles, encourage the secretion of fluids and resensitise the rectum to the presence of stool. As ever, you should consult with a doctor before starting or making any changes to the medication you take.

But even with this medicine chest, there is still room for improvement. Research shows some people don't respond to over-the-counter laxatives and many who do don't experience complete relief. Lacy recently ran a survey in the US that found only a third of people with chronic constipation were satisfied with their treatment. That is partly down to the side effects: pain, nausea, bloating, diarrhoea and, paradoxically, worsening constipation. Long-term use of stimulant laxatives, for example, can lead to tolerance that ultimately makes the problem worse.

"The general population would say that we need to do better," says Lacy.

New treatments are being explored. Small trials of probiotics, which aim to manipulate the gut microbiome, have been carried out, with largely positive results. Caffeine, too, is emerging as a possible treatment, perhaps because it stimulates bowel muscles. People with high intake – about six cups of coffee a day – have lower rates of constipation.

So if you are chronically constipated, there is hope. "I think that we are fortunate to have a number of treatment options available," says Lacy. "My view is that if you take the time and effort and work with a patient, you can generally find the right therapy, or right combination of therapies, to help the patient and improve symptoms." ▮

Graham Lawton is a staff writer at *New Scientist*

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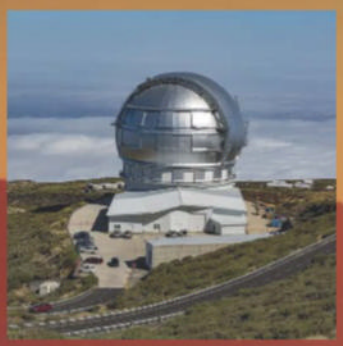

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The back pages

Debunking gardening myths

Peering at peppers

What does the number of lobes on the base of a bell pepper have to do with its sex and taste? **James Wong** explores

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

WHEN I was a kid, my Malaysian grandma used to drag me around the local market, where she spent what felt like hours scrutinising each item of fruit and vegetable before buying it, as only Asian grandmothers can. She would lift every papaya to examine its weight, inspect the pattern on every watermelon and tug on the leaves of every pineapple in her efforts to evaluate their quality.

Imagine my surprise when, over 30 years later, I find social media awash with influencers in $200 yoga pants repeating many of her techniques in the West's art-directed farmers' markets.

Now, many of these techniques are totally straightforward and scientifically valid. But, perhaps unsurprisingly, the ones that go viral tend to be the most colourful. One of the most common tips on my social media feeds right now is the idea that the number of bumps at the base of a bell pepper reveals something about its flavour. The claim is that peppers are either "male" or "female", and that female peppers have four little bumps (or lobes) at their base and are not just sweeter, but better for eating raw. Male peppers, however, have only three lobes, are less sweet and are better for cooking.

The first thing to say is that peppers are categorically not divided neatly into the binary state of "male" or "female", at least not in a biological sense. Pepper fruit are the fertilised ovaries of flowers. Those flowers, like about 90 per cent of all plants, contain both male and female parts.

GARY LENHART/SHUTTERSTOCK

However, that clarification isn't enough to disprove the central thrust of this claim – after all, this labelling of plants is a pretty common cultural construct. In folk medicine, for example, many plant varieties are assigned "male" or "female" labels simply as a way to distinguish between strains whose genetics mean they look slightly different from each other.

And fittingly, the number of lobes a pepper produces is largely determined by the genetics of a specific variety – although far from a binary choice, the peppers can have as few as one lobe or as many as six or more.

So, whatever we decide to call them, are peppers with four lobes sweeter than those with just three? After a pretty exhaustive review of the evidence, I couldn't find a single paper reporting a correlation between sugar content in pepper fruit and its number of lobes.

What we do know is that, like most fruit, their sweetness is closely linked to their ripeness, not only because sugar levels almost double as they turn from green to red, but also because of bitter-tasting alkaloids that can mask a decline in sweetness.

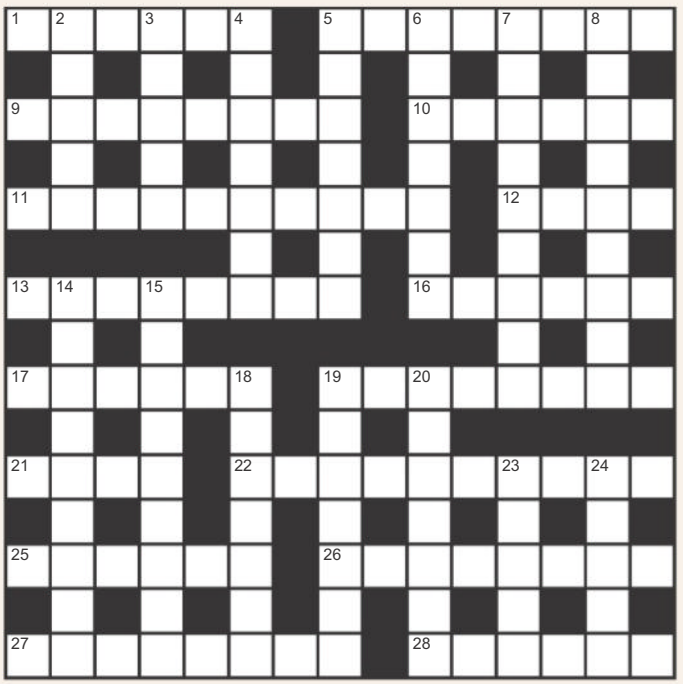
Ironically, these bitter compounds are particularly concentrated in the placenta, the white membrane between each fold of the pepper. So, if anything, the more lobes your pepper has, the less sweet it is likely to taste. Sorry, influencers.

Debunking gardening myths appears monthly

Next week
The science of exercise

These articles are posted each week at newscientist.com/maker

Quick crossword #189 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 A comfortable level of heat (6)
5 IT security mechanism (8)
9 Aluminium tectosilicate mineral (8)
10 Claws (6)
11 Sci-fi novel by Andy Weir (3,7)
12 Swiss-based particle physics research centre (4)
13 Pt (8)
16 Foliage (6)
17 Front part of the upper body (6)
19 Damp (8)
21 Leg joint (4)
22 Flowering plant (10)
25 Point vertically above a given location (6)
26 *The Expression of the ___ in Man and Animals*, work by Charles Darwin (8)
27 Insect-trapping plant also called leadwort (8)
28 Breathe out (6)

DOWN

2 ℵ (5)
3 Modulator-demodulator (5)
4 Blood anticoagulant (7)
5 Fm (7)
6 Vitamin A_1 (7)
7 Informative poster (4,5)
8 Cycle of 12 synodic months (5,4)
14 Relating to the voice box (9)
15 Quadrilateral with one pair of parallel sides (9)
18 Windpipe (7)
19 Electrical generator; X-Men villain (7)
20 Distinct nuclear species of an element (7)
23 Attempt online fraud (5)
24 Concerning the kidneys (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #314
set by Corryn Wetzel

1 What is the name of the telescope that provided the first direct image of a black hole?

2 What type of crystal structure does sodium chloride (table salt) form?

3 Which pigment makes the blood of octopuses appear blue?

4 What is the most common type of star in the Milky Way?

5 What is the medical term for extreme, persistent thirst?

Solution on page 47

BrainTwister
set by Katie Steckles
#85 Factorial squares

N! (N factorial) is the product of all the numbers from 1 to N. For example, 4! = 4 × 3 × 2 × 1 = 24.

Consider the product of the first four factorials (1! × 2! × 3! × 4!). Which of the four factorials can you divide this number by to give a square number?

If we multiplied the first eight factorials, we would get 5,056,584,744,960,000 (which can be written as a product of prime numbers as $2^{23} \times 3^9 \times 5^4 \times 7^2$). Dividing by 3! gives a square number. Which other one of the eight factorials can we divide by instead to get a square number?

If you multiply the first 100 factorials together (1! × 2! × ... × 100!), which one can you divide by to get a square number?

Solution next week

Sweet treat

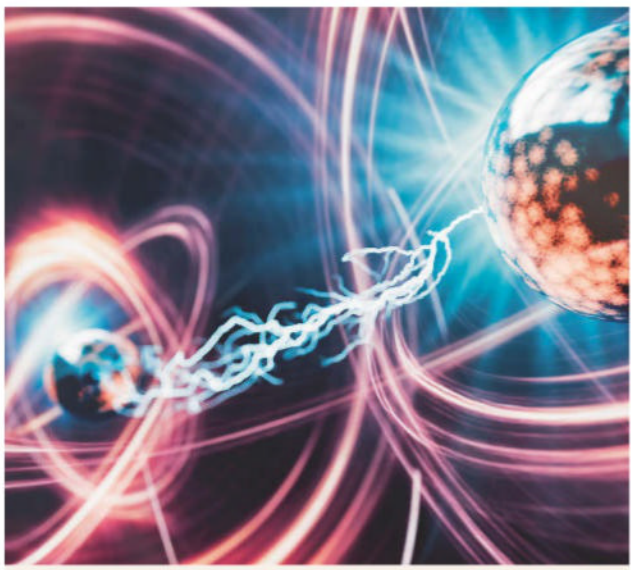
When we eat ice cream on a hot day, does it cool us down or do the calories in it warm us up?

Ron Dippold
San Diego, California, US
A typical scoop of ice cream weighs 60 to 100 grams (let's call it 80g). For generic vanilla the energy content is about 2 calories (kcal) per gram, so 160 calories per scoop. Let's say you did two scoops (I would!), so 320 calories. Say you weigh 60 kilograms and your normal body temperature is 37°C. Those two scoops are typically at -10°C, but weigh only 0.16 kilograms. In theory, to warm that ice cream to your body temperature would take 15 kilojoules (kJ) of energy, which would drop your body temperature by 0.07°C.

On the other hand, the ice cream contains 320 calories – how much will that warm you? That is the same as 1339 kilojoules, so in theory if all that energy is released, it could raise the temperature of your 60 kg body by 6.4°C. But our bodies don't work this way at all. Which is kind of good, right? If your body were suddenly 43.5°C after you ate an ice cream cone,

"If body temperature suddenly rose to 43.5°C after you ate an ice cream cone, that would be very bad"

that would be very bad. In reality, your digestive system does a lot of work to convert the ice cream into sugars in the bloodstream and then your body will just decide, "Oh, I am slightly cold now, better warm up a bit." It expends 1/91th of those calories to warm you up by 0.07 °C. The rest could be stored as fat. Or you could walk 7 kilometres to burn them. Thankfully, our bodies use energy just to exist – about 1 calorie per kg per hour, even while watching television. So, no, the calories don't warm us up.



KOTO_FEJA/GETTY IMAGES

What happens if one entangled particle falls into a black hole?

This week's new questions

Over the edge **If two particles were entangled and one fell into a black hole, what happens to the other? What might we learn from this? *Christina Cheers**, Sunbury, Victoria, Australia*

Turn, turn, turn **Sci-fi shows often feature "space ports" spinning slowly to create artificial gravity. Is this feasible, and how soon? *Perry Brooks**, Fort Saskatchewan, Alberta, Canada*

Eric Kvaalen
Les Essarts-le-Roi, France
The heat obtained from burning the calories would definitely be more than the cooling, but you don't burn the calories just because you ate them. You may burn them eventually (if they don't go into making body fat), but eating the ice cream will probably result in your eating less of something else later, because of our system of regulating appetite.

There is another effect, however, called diet-induced thermogenesis. This is heat generated after eating, largely due to the catabolism, or breakdown, of proteins to amino acids. This effect is 20 to 30 per cent of the caloric value of the protein. If ice cream is, say, 3 per cent protein, then this thermogenesis would be about 30 kcal per kilogram of ice cream, whereas to melt a kilogram of ice cream would require around 80 kcal. So the net effect would probably be to cool you down.

Time rules

Why are there 60 seconds in a minute and 60 minutes in an hour? Who decided on this and when? (continued)

Peter Simons
via email
Several correspondents recently pointed out how the division of hours into 60 minutes and minutes into 60 seconds (and a full turn into 360 degrees) is almost certainly based on the Sumerians' very sensible use of base-12 numbering. One correspondent mentioned how one can count to 12 using the finger joints of one hand. Another one I worked out for myself – though others have done so too – is how to count to 31 on one hand and 1023 on two. Using Leibniz's binary system, let your right pinky be worth 1, the next finger to the left worth 2, the next worth 4 and so on, to your left pinky worth 512. I find it easiest to count with my hands resting on a surface. A finger off the surface counts 0, and down on the surface counts 1. Then a bit of musicianly raising and lowering of fingers allows you to count to a maximum of 10 fingers down, or 1023. Allowing a third state for each finger – half-bent – gives the possibility of counting to 59,048. My fingers sadly don't seem to want to bend that way, but for those who want to do their tax returns on their fingers, practise that bending!

Peter Bursztyn
Barrie, Ontario, Canada
For the most part, animals are either diurnal (active in daylight) or nocturnal (night owls). Humans are diurnal and, at night, our visual acuity drops sharply and colour vision is lost.

For many millennia, our ancestors sought shelter from carnivores, such as big cats, which had excellent night vision. Many millennia later, after our predecessors learned to control fire, we might have set fires at the entrance, which predators fear and avoid. Against that background, our ancestors would have started looking for shelter well before dark, using the sun's height in the sky as a crude clock. Timekeeping precision would have been limited to "meet you at the large rock tomorrow morning".

Ancient Egypt is credited with inventing the solar clock, or sundial. The oldest known solar clock dates back 3500 years. However, the way the pyramids

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Tom Gauld
for New Scientist

were built (around 4500 years ago) precisely aligned with the north-south meridian. Egyptians would have achieved that by planting a vertical pole in the soil and observing its shadow.

The shortest shadow would point to astronomical north, with the noon shadow line itself indicating the north-south meridian. Clearly, the shadow of such a pole could indicate time, but how was it calibrated?

The story of how it was done begins 2700 years ago in Babylon where mathematician-astronomers divided "the heavens" into 12 sectors. Each sector was named after a prominent constellation. Ancient Greece adopted this scheme, translating the Babylonian names into those we recognise today: Gemini, Leo, Pisces, Aquarius, Virgo, Cancer, etc. Where we count to base 10 today, the Babylonians used base 60. While base 10 has only two divisors yielding whole numbers (2 and 5), base 60 has many (2, 3, 4, 5, 6, 10, 12, 15, 20 and 30). Babylonians subdivided each

"Our system of time units began in Babylon, where mathematician-astronomers divided 'the heavens' into 12 sectors"

of their 12 sky sectors into 30 smaller units, yielding 360 subdivisions. The Greeks adopted this into their geometry, so a circle has 360 subdivisions (degrees). Two millennia on, we continue to use this same scheme!

Since the sun traverses the 12 sectors daily, an obvious sun clock calibration would divide the day time into 12 parts. We call them "hours". Nighttime was similarly divided. In the 1600s, the pendulum clock's precision made it sensible to add a minute hand to every clock. Since this hand made a full rotation every hour, the ancient Babylonian scheme of dividing a circle into 360 small units (degrees) was pressed into service. Each degree became a minute, and 1440 such minutes make up a day.

Inés Antón Méndez
Madrid, Spain

The sexagesimal (base 60) system was developed by the Babylonians millennia ago. It was them who decided to divide each hour into 60 minutes, and each minute into 60 seconds.

This may seem an odd choice from our point of view, but the system itself has quite a few advantages. To start with, 60 has more divisors than 10. Also, counting can be done just as easily and far more efficiently with the help of our fingers.

It is to the Egyptians, however, that we owe the division of the day into 24 hours. They assigned 12 hours to the night and 12 hours to the day.

So, here we are in our own era with a decimal system for most measures (that is, if you live in places where the metric system won and the King´s Foot and other such odd units went out of fashion) and an anachronistic sexagesimal system to parse time and, not coincidentally, the circle. ▮

Answers

Quick quiz #314 *Answers*

1 Event Horizon Telescope

2 Cubic lattice

3 Haemocyanin

4 Red dwarf

5 Polydipsia

Cryptic crossword #167 *Answers*

ACROSS 1 Butcher, **5** Sloop, **8** Comet, **9** Diurnal, **10** Runtime error, **12** Quartz, **14** Adjust, **17** Inconsistent, **21** Tangelo, **22** Xeric, **23** Dross, **24** Fishery

DOWN 1 Buck, **2** Tempura, **3** Hit it, **4** Radome, **5** Sauteed, **6** Owner, **7** Polarity, **11** Squirted, **13** Tinkers, **15** Unnerve, **16** Rip off, **18** Condo, **19** Texts, **20** Achy

#84 Wild ones *Solution*

A total of 12 can be made using seven ones: (1 + 1) × (1 + 1) × (1 + 1 + 1)

Using nine 1s we can make 27: (1 + 1 + 1) × (1 + 1 + 1) × (1 + 1 + 1)

51 can be made using 12 1s by first making 16 using eight 1s – which can be done by multiplying (1 + 1) four times, or using (1 + 1 + 1 + 1) to make 4 and multiplying this by itself – adding 1 to make 17, then multiplying by 3: ((1 + 1) × (1 + 1) × (1 + 1) × (1 + 1)) + 1) × (1 + 1 + 1)

Dirty videos

Feedback is nothing if not productive. Even when it looks like we are mucking about doing nothing, we are actually working. We are the epitome of #grindset. For instance, we recently wasted a lot of time on online videos and now we are going to tell you about it.

Feedback, as so often happens, fell down a YouTube rabbit hole. Fortunately, it wasn't anti-vaccine conspiracy theories or the manosphere. Instead, we just watched a lot of footage of people cleaning carpets and rugs. This sounds unbelievably boring, but we liked that one of the cleaning companies uses devices called R2-CLEAN2 and Dirt Reynolds.

Furthermore, we found it was weirdly satisfying to watch layers of dirt being stripped away and the patterns of the rugs gradually reappearing. Hours passed. The stresses of daily life fell away. Feedback was a Zen master, our mind empty and crystal clear. There were no urges, no pressures, no past or future. There was only the rug, gradually being cleaned.

Then we came out of the trance and realised that there were some fascinating dynamics at play: an interaction between humans and technology. You see, there has clearly been an arms race among the various cleaning YouTubers to be the one to clean the filthiest rug, and therefore create the most dramatic header and thumbnail image. After all, if millions of people don't watch you clean the rug, you don't get a meaningful amount of advertising money.

As a result, you will struggle to find any videos showing a rug that is merely dirty. The typical rug in a cleaning video looks like it has been transported down a muddy ravine, colonised by fungi and passed through the digestive system of a dyspeptic hippopotamus. In some cases maggots are involved. The videos show people spending hours and hours, using litres of water and buckets of cleaning products, to get rid of the muck.

The whole thing is a strange microcosm of the world in which we live, in which even the most banal of activities – cleaning a rug – has been driven to its most exaggerated and ridiculous form, not because anything is achieved by it, but because a technology company is trying to make money by grabbing our attention.

Right, enough of the philosophising. That video of someone speedrunning *Super Mario Odyssey* isn't going to watch itself.

Twisteddoodles *for New Scientist*

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Send it to feedback@newscientist.com
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Ramble rumble

In common, we suspect, with many readers, Feedback has been agog at the ongoing claims about Raynor Winn, bestselling author of *The Salt Path* and other books about long walks. *The Observer* newspaper accused her of having misled the public about how she and her husband came to be homeless. It also raised questions about quite how ill her husband is, and how much he recovered while the pair walked the UK's South West Coast Path. Winn has denied all wrongdoing.

This all came out just weeks after the film adaptation of *The Salt Path* was released, causing maximum embarrassment for everyone involved, but as far as Feedback is concerned, the biggest shock is that Winn's official name is the distinctly apt Sally Walker.

Literary devices

In July, Feedback wrote about a potential new use for generative AIs like ChatGPT: rewriting difficult literary novels to make them more accessible. In particular, we looked at pithier rewrites of some famous opening lines, none of which lost anything of importance in the abbreviation. This evidently struck a chord with you.

Eric Bignell highlighted Macbeth's despairing soliloquy from act 5, scene 5: "Tomorrow, and tomorrow, and tomorrow / Creeps in this petty pace from day to day / To the last syllable of recorded time; / And all our yesterdays have lighted fools / The way to dusty death. Out, out, brief candle! / Life's but a walking shadow, a poor player / That struts and frets his hour upon the stage / And then is heard no more. It is a tale / Told by an idiot, full of sound and fury / Signifying nothing." That is all a bit much, isn't it? Eric asked ChatGPT to simplify, which it did: "Life is short, meaningless, and full of empty noise."

A lot of you also wrote in with your own suggestions for how an AI might rewrite various famous passages. Consider the instantly sinister opener to George Orwell's *Nineteen Eighty-Four*: "It was a bright cold day in April, and the clocks were striking thirteen." David Aldred boiled it down to: "It was one in the afternoon on a bright cold day in April." See? Nothing lost, really!

By far the most popular choice was the opening line of Charles Dickens's *A Tale of Two Cities*: "It was the best of times, it was the worst of times..." Ian Glendon suggested a gleefully literal reimagining: "The clock was fine when I bought it, now it no longer works". However, three people – Simon Bird, David Strachan and Rod Newbery – all came up with essentially the same simplification, which Feedback thinks may be impossible to top: "On average, it was OK."

Simon also had an alternative to the infamous first line of Edward Bulwer-Lytton's *Paul Clifford*: "It was a dark and stormy night". Bird suggests something we suspect even the best AIs wouldn't come up with: "Welcome to Scotland."

However, Stuart Bell gets the last word, suggesting letting an AI loose on James Joyce's legendarily impenetrable *Ulysses*. Not because it would make it any better, but because the book "should break any AI, or at least give it a headache".

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