New Scientist

WEEKLY July 19-25, 2025 No3552 US $7.99 Canada CAN$9.99

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WHAT SHAMANISM REVEALS ABOUT THE HUMAN MIND

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This week's issue

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Cover image: Sara Gironi Carnevale

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JIM GOLDBERG/MAGNUM PHOTOS

Features

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Elsewhere on New Scientist

NS Live

The future of human reproduction

Cutting-edge technologies are shaping the future of how we create life. On 18 October at Excel London, Helen O'Neill will explore the amazing world of assisted reproduction, guiding you through topics ranging from the latest advancements in in vitro fertilisation to the implications of using genetic diagnosis for screening embryos.

newscientist.com/nslive

Tour

Renaissance astronomy in Kepler's Prague: Czech Republic

Discover the giant legacy of the Renaissance-period astronomers Johannes Kepler and Tycho Brahe in Prague. Accompanied by astronomer and historian Martin Griffiths, you will explore Prague's historical marvels and walk the streets as Kepler and Brahe did. This six-day tour starts on 14 September and costs £2169.

newscientist.com/tours

Podcast

The world, the universe and us

This week, the team discusses the controversial idea of whether we need to start geoengineering our climate sooner rather than later to protect a key ocean current. Discover the search for huge numbers that take us to the edge of what is knowable in modern mathematics. Plus, find out how exercise may reduce tumour growth.

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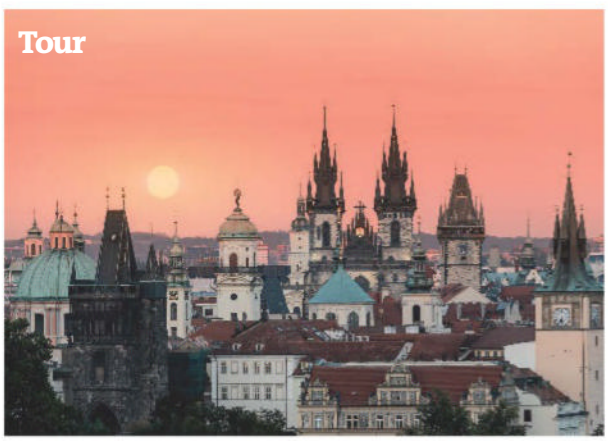

JOHN KELLERMAN/ALAMY

City of 100 spires Explore Prague's astronomical legacy

Currents of time See a 30,000-year-old voyage brought to life

Video

Researchers re-enact a 30,000-year-old sea voyage

Archaeological evidence shows that 30,000 years ago, Palaeolithic people travelled from the island now known as Taiwan to the southern islands of Japan. Yousuke Kaifu at the University Museum of the University of Tokyo and his team built a dugout canoe to put this journey to the test.

youtube.com/newscientist

Newsletter

Our Human Story

Genetic studies tell us that all living non-African peoples are descended from a small group that left the continent around 50,000 years ago. But there are many instances of modern humans living outside Africa much earlier than that. Is the genetic data misleading us?

newscientist.com/our-human-story

Newsletter

"The reason the last out-of-Africa migration succeeded so wildly is: people need people"

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World-altering consequences

Geoengineering may be a bad idea, but the alternative could be worse

WE ARE heading towards a future that is so much hotter we won't just be able to carry on as normal. Along the way, there is a very high risk of triggering "tipping points" that would make the climate chaos dramatically worse. Given our failure to cut carbon emissions, the appeal of geoengineering to cool the planet is growing – but is it the right thing to do?

As we report on page 8, some researchers are coming round to the idea that pumping sunlight-reflecting aerosols into the stratosphere could prevent tipping points like the shutdown of vital ocean currents. But the risks of geoengineering are huge.

For starters, there is no prospect of getting international agreement on this soon, but if one country went it alone, things could go very wrong, shifting rainfall around the world, for example. And if one nation felt it were being harmed by another's geoengineering, we could end up in a climate war in which geoengineering is used as a weapon.

Even if there were agreement, things would be far from straightforward. Done wrong, geoengineering could make things worse, not better. There has been far too little computer modelling and real-world testing of any geoengineering ideas for us to have any confidence that they will pan out as intended.

> **"We could end up in a climate war in which geoengineering is used as a weapon"**

The thing is, the clock is ticking. The sooner we start geoengineering, the better the chance of averting dangerous tipping points. It is an option that we should at least explore.

Still, many scientists are opposed to even doing research on geoengineering. One fear is that it will be used as an excuse to not cut carbon dioxide emissions. Yet that argument holds less sway in a world where US President Donald Trump is reversing climate action without bothering with an excuse of any kind (see page 10).

Geoengineering may be a terrible idea – but we won't know that unless we carry out significantly more research. The time to do that is now, before we are forced to take drastic action without robust science to guide us. ▮

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Antidepressant withdrawal may not be common p15

Environment

Close encounters of the berg kind

This giant white wall looming over the village of Innaarsuit in Greenland isn't a mountain, but a huge iceberg that has drifted very close to the village's harbour. As *New Scientist* went to press, the iceberg had been in position for a week and authorities were warning people to stay away from it due to fears of a collision or that it could break apart.

DENNIS LEHTONEN/SWNS

Climate change

Geoengineering debate heats up

Urgent measures to reflect sunlight may be the only way to prevent climate tipping points, but there is so much we still don't know about the risks, finds **Michael Le Page**

ONE of the many dangers of continuing to pump carbon dioxide into the atmosphere is that we could trigger tipping points such as the shutdown of crucial ocean currents. Now, a modelling study suggests that injecting aerosols into the stratosphere to reflect sunlight will reduce this risk – but also that this action will be much less effective if it starts in 2080 rather than very soon.

"My conclusion from this is if you're serious about preventing tipping [points], you need to take solar radiation management seriously, which means researching its potential benefits and its risks," says Claudia Wieners at Utrecht University in the Netherlands.

Tipping points refer to changes that couldn't be reversed for many centuries, if at all. They include the slowdown or halting of ocean currents that play a key role in global climate by transporting immense amounts of heat.

One is the Atlantic meridional overturning circulation (AMOC), which carries heat from the tropics to Europe. If it collapses, there could be rapid sea level rise in North America, a severe drop in temperatures in northern Europe and serious disruption to monsoons across Asia.

According to a model used by Wieners's team, the AMOC would decline by more than half over the next century in a worst-case emissions scenario. But if stratospheric aerosol injection, a proposed form of geoengineering that involves adding sunlight-reflecting particles to the upper atmosphere, were used to keep the global temperature rise at around 1.5°C, the current's weakening would be reduced, Wieners recently told the Exeter Climate Forum in the UK.

In fact, the AMOC declined less in this scenario than in one with rapid reductions of emissions but no geoengineering. "So, actually, at least for the next 80 years or so, [greenhouse gas] mitigation helps less than stratospheric aerosol injection," says Wieners.

NASA/SCIENCE PHOTO LIBRARY

Geoengineering could let us reflect heat away from Earth

However, if stratospheric aerosol injection is delayed until 2080 and then used to return the global temperature back to 1.5°C above pre-industrial levels after overshooting, there is no recovery in the AMOC, the model suggests.

The team also looked at the North Atlantic subpolar gyre, a circular current linked to the AMOC that flows around areas where cold, extra salty water sinks. If this sinking stops because the sea becomes fresher and warmer, it would also have major effects on Europe's climate.

DAVID COLEMAN/ALAMY

Researchers are calling for artificial cooling to save the Great Barrier Reef

In a worst-case scenario, the model suggests the sinking would end and that stratospheric aerosol injection starting in 2080 would be unable to restart it. But if we began now, sinking would be preserved in two of three key regions. However, the findings need to be confirmed by many more studies looking at more realistic emissions scenarios, says Wieners – and there are several potential dangers. "You could also really badly mess up," she says.

There are unanswered questions about geoengineering's interactions with other efforts to combat climate change (see "A big removal job", right). Success would also require close global cooperation for centuries to come. "You might think of it as the greatest governance challenge that humanity has ever faced," Stephen Gardiner at the University of Washington in Seattle said at the conference.

For instance, if stratospheric aerosol injection were done in one hemisphere only – perhaps because of a lack of a global consensus – it would shift the tropical rainfall zone around the world, warns Wieners. And if consensus collapsed and geoengineering stopped, warming would come surging back.

Accidental cooling

In fact, we have already done this, albeit accidentally. Clouds have been getting darker and reflecting less sunlight as a result of falling sulphate air pollution, and this may be responsible for a lot of recent warming beyond that caused by greenhouse gases.

"Two-thirds of the global warming since 2001 is SO_2 reduction rather than CO_2 increases," says Peter Cox at the University of Exeter in the UK.

Cox and his colleague Margaux Marchant, also at the University of Exeter, came to this conclusion after analysing satellite data that directly measures sunlight reflection. Measurements taken between 2001 and 2019 show a decline in how much sunlight is being reflected, meaning the planet is getting darker – in other words, its albedo is falling – and this results in additional warming.

There are many reasons for the falling albedo, from less snow and sea ice to less cloud cover. But Cox and Marchant focused on sulphate pollution because this type of pollution from industry and ships is known to increase the density of droplets in clouds, making them brighter or more reflective. This is the basis of one proposed form of geoengineering, known as marine

cloud brightening (MCB). Sulphate emissions have been successfully reduced in recent years, partly by moving away from high-sulphur fuels such as coal.

When the pair looked at whether the decline in cloud brightness corresponded with areas with falling levels of sulphate pollution, they found that it did. They presented their preliminary results at the conference.

In some sense, the results are encouraging because the rapid warming in recent years has led some researchers to suggest that Earth's climate sensitivity – how much it warms in response to a given increase in atmospheric CO_2 – is on the high side of estimates. If the cloud darkening were a feedback caused by rising CO_2, it would support the case for high sensitivity and greater future warming. But if the extra warming is indeed due to falling pollution, the effect will be short-lived and rapid warming won't continue.

"If this darkening is a change in cloud properties due to the recent decrease in SO_2 emissions, rather than a change in cloud feedbacks that indicate a higher-than-anticipated climate sensitivity, then this is great news," says Laura Wilcox at the University of Reading in the UK.

But Australia's Great Barrier Reef is already suffering from the increased warming due to the cut in shipping pollution, says Robert Ryan at the University of Melbourne. He and his colleagues simulated the impact of the changes to shipping fuels on cloud cover and solar radiation above the reef over 10 days in February 2022. They used the results of previous studies to estimate the impact those changes would have on sea surface temperatures and bleaching risk at the reef.

They found that shipping emissions at pre-2020 levels boosted the cooling effect of clouds over the area, and the rules curtailing sulphate aerosol pollution have removed much of this effect. As a result, the new shipping fuel regulations caused the equivalent of an additional 0.25°C of sea surface temperature heating, and made coral bleaching conditions between 21 and 40 per cent more likely during the 10-day period that was studied (Research Square, doi.org/pvxv).

2080
Geoengineering could fail if we wait until this year

Ryan is now researching MCB, in the hope that deliberate climate intervention could help cool the reef down again. "If some part of the marine cloud brightening effect from ships has been removed due to changes in sulphate emissions, then I could see how that might make one wonder whether it should be re-implemented in a targeted programme," he says.

Such efforts would need to be done carefully. At the Exeter conference, Jim Haywood at the University of Exeter discussed model experiments showing that using MCB in certain parts of the world could trigger a "mega-La Niña" so intense that air pressure changes would lead to higher sea level rise in the Pacific over the next century than from warming itself.

Now that we know of the risk, it can be avoided, says Haywood. "You just change your strategy."

But many researchers aren't confident we can manage the risks of geoengineering. "Solar radiation management makes it sound like a perfectly manageable thing. Shouldn't we use the term solar radiation interference?" Stefan Rahmstorf from the University of Potsdam in Germany asked Wieners at the conference.

There is also the risk that geoengineering becomes seen as an alternative to cutting emissions. "It does not address the root cause of climate change," says Wieners. "It is, at best, symptom fighting, but maybe if the symptoms are too bad, it could be a good addition to the true solution." ▮

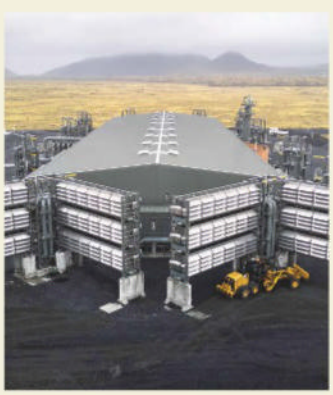
Additional reporting by Madeleine Cuff

A big removal job

The world would have to remove hundreds of billions of tonnes of carbon dioxide from the atmosphere to limit the rise in global temperatures to 1.5°C this century. Even the less ambitious 2°C climate target is now virtually out of reach without large volumes of carbon capture and carbon dioxide removal (CDR), alongside aggressive cuts to emissions.

There is a "debate across scientists that CDR is both essential and impossible", says Candelaria Bergero at the University of California, Irvine.

To get a better handle on what is at stake, she and her colleagues used a simple climate model to estimate the consequences of failing to manage CO_2 across hundreds of different emissions scenarios consistent with the 2°C target. These scenarios included CO_2 removal technology such as direct air capture and nature-based approaches like tree planting. They also included varying amounts of carbon capture and storage for emissions from power plants and other sources.



JOHN MOORE/GETTY IMAGES

The Mammoth carbon removal plant in Iceland is one of the world's largest

They found that failing to capture or remove any CO_2 added about 0.5°C to global average temperatures at the end of the century, while failing to deliver half of the carbon management assumed in the scenarios added about 0.28°C of warming. This would make it nearly impossible to limit the rise in temperature to 1.5°C, even in a scenario where temperatures breach 1.5°C but then are brought back down.

The 2°C warming target might still be just about possible without any carbon management. However, the team found it would require extremely steep emissions cuts equivalent to 16 per cent per year from 2015 onwards. Such a rapid decline seems unlikely given that global emissions have increased over the past decade, says Bergero (cdrxiv, doi.org/pvxn).

James Dinneen

Climate change

Climate will be hit by Trump's big bill

The "One Big Beautiful Bill" signed by President Trump will slash support for clean energy, leaving the US far short of its Paris Agreement pledge, finds **James Dinneen**

CUTS to clean energy spending in the bill President Donald Trump signed into law on 4 July could lead to billions of tonnes of additional carbon dioxide emissions over the next decade, according to early estimates. The US was already behind on its Paris Agreement pledge to cut emissions in half by 2030, and the slowdown will leave the country – the world's second-largest emitter after China – even further off track.

"While other countries are benefiting from accelerated investment in the clean energy economy, the US is taking a step backwards," David Widawsky at the World Resources Institute, an environmental advocacy group, said in a statement.

The sweeping legislation – known as the One Big Beautiful Bill Act – contains more than $4.5 trillion in tax cuts and $350 billion in new spending for immigration enforcement and the military.

Republicans in Congress included funding cuts to clean energy, along with larger cuts to affordable healthcare and food programs, to offset that spending. Over the next few years, the law will end hundreds of billions of dollars' worth of tax credits aimed at boosting low-emission energy sources and uses established by the Inflation Reduction Act, which passed under Joe Biden's administration.

Researchers at Princeton University modelled how the policy change would affect the US energy system and emissions over the next decade. They found the law substantially slows the decline in US greenhouse gas emissions that were expected under the Biden administration's policies, effectively repealing the Inflation Reduction Act.

DANIEL TOROK/WHITE HOUSE PHOTO/ALAMY

IRFAN KHAN/LOS ANGELES TIMES VIA GETTY IMAGES

US President Donald Trump signed his One Big Beautiful Bill Act into law on 4 July (left), which included funding cuts to clean energy (below)

Since a peak of about 6.6 billion tonnes of CO_2 equivalent emissions in 2005, US emissions have declined by about 17 per cent and were set to fall by about 25 per cent by 2030. Under the new law, the decline is expected to be 20 per cent in 2030, a difference of hundreds of millions of tonnes of CO_2.

The difference is even more stark in 2035, when more clean energy projects were anticipated to have been built. Under Biden's policies, emissions were set to fall as much as 44 per cent by then relative to 2005, according to the researchers. Under the new law, they would fall just 25 per cent, a disparity of half a billion tonnes of CO_2 per year.

17%
Decline in US emissions since 2005

44%
Predicted emissions decline by 2035, prior to law passing

25%
Predicted emissions decline by 2035 under the new law

Future consequences

The slowdown would leave US emissions behind its former pledges under the Paris Agreement by about 2 billion tonnes in 2030. In 2035, US emissions would be around 2.5 billion tonnes higher than an emissions trajectory consistent with reaching net zero by mid-century.

The bill includes ending tax credits for electric vehicles this year and phasing out credits for low-emission renewable energy, such as wind and solar, in 2026. Credits for energy efficiency upgrades, such as heat pumps and home insulation, also now end in 2026. The bill cancels the remaining funding for clean energy-related research and development programs.

However, tax credits for other sources of low-emission electricity, including nuclear power, hydropower and geothermal energy, will remain available until 2033.

The bill also maintains support for more speculative technologies favoured by the fossil fuel industry, including a tax credit for low-emissions hydrogen production that lasts until 2028 and credits for capturing or removing CO_2 from the atmosphere.

Climate advocates decried the passage of the bill for its emissions consequences, as well as ways it could run counter to the Trump administration's agenda to lower the cost of energy and expand American manufacturing.

"We urgently need more clean, affordable energy, but this measure would bring the renaissance in American clean energy production to a halt and send good, domestic manufacturing jobs to our foreign rivals," Manish Bapna at the US-based advocacy group Natural Resources Defense Council said in a statement. ▮

Health

Fatal genetic disorder treated by replacing the brain's immune cells

Grace Wade

THE progression of a rare and deadly brain disorder called ALSP can be paused by substituting the brain's immune cells – laying the groundwork for future trials to treat other neurological conditions.

Numerous studies indicate that dysfunctional microglia – specialised immune cells in the brain – contribute to a range of conditions, such as Alzheimer's disease. With ALSP, short for adult-onset leukoencephalopathy with axonal spheroids and pigmented glia, people have mutations in a gene that encodes for a protein essential for these cells' survival, which results in fewer microglia and progressive cognitive decline. There is currently no cure.

So Bo Peng at Fudan University in China and his colleagues turned to an experimental treatment known as microglia replacement therapy. Previous research in rodents has shown that transplanted stem cells – which have the ability to develop into other cell types – can replace microglia.

Peng and his team first tested this strategy in five mice with genetic mutations similar to those in ALSP. When the team transplanted stem cells from healthy mice, the treated mice had about 85 per cent more microglia in their brains, on average, 14 months later than six untreated rodents with the same mutations. Their motor function and memory also improved.

"The approach could one day treat more common brain conditions like Alzheimer's disease"

The researchers next treated eight people with ALSP using stem cells from donors without the condition. Brain scans collected one and two years later were almost no different from those taken before the procedure. In contrast, four people with ALSP who didn't undergo treatment saw significant brain deterioration and lesioning over the same period. This suggests the microglia replacement therapy had halted the condition's progression.

At the start of the study, all of the participants took an exam that measures cognition on a 30-point scale, with lower scores indicating worse cognition. When they took the same test a year later, scores remained stable, on average, for those who underwent microglia replacement – and fell almost 10 points for those who hadn't (*Science*, doi.org/g9sr7s).

These results suggest microglia replacement therapy is an effective treatment for ALSP. Yet as this is the first human trial, "we still don't know the potential side effects", says Peng. "But since this is a rapidly progressive fatal disease, the benefits may be much more important to consider than the potential side effects."

Chris Bennett at the University of Pennsylvania points out that stem cell transplants have been used to treat neurological conditions for decades. "It is thought to be effective specifically due to microglia replacement," he says. In fact, the US Food and Drug Administration recently approved two similar therapies for two other rare brain conditions.

Still, these results highlight the broader potential of microglia replacement therapy. Peng believes the approach could one day treat more common brain conditions. For instance, several genetic mutations that greatly increase the risk of Alzheimer's disease affect microglia. Replacing these cells with ones from people without such mutations could be a promising treatment for the condition. ▮

Space

Interstellar visitor might be the oldest comet ever seen

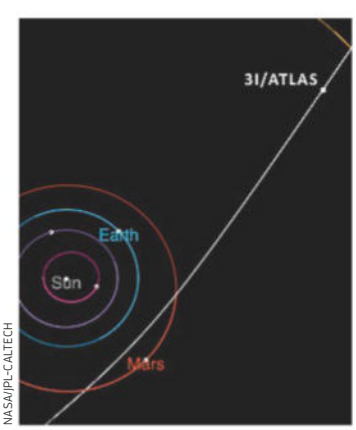
AN OBJECT from outside our solar system that is set to pass near Mars might be one of the oldest comets we have spotted, originating from a star billions of years older than our sun.

Comet 3I/ATLAS was spotted earlier this month near the orbit of Jupiter, estimated to be 20 kilometres across and moving at about 60 kilometres a second. It is the third known interstellar object found in our solar system, and will pass close to Mars in October before heading away from our sun.

Matthew Hopkins at the University of Oxford and his colleagues modelled the comet's speed and trajectory to work out where it came from, using data from the European Space Agency's Gaia spacecraft that mapped a billion stars in our 13-billion-year-old galaxy. It looks like it originated near a region of our galaxy called the thick disc, containing older stars and sitting above the thin disc in which our sun orbits (arXiv, doi.org/pvxm).

"Thick disc objects are faster," says Hopkins, whereas the prior two known interstellar objects – 'Oumuamua in 2017 and Comet Borisov in 2019 – were slower. "Their velocities were what we'd expect for a thin disc object."

The team's modelling suggests 3I/ATLAS comes from a star that is at least 8 billion years old, almost twice the age of our sun, and possibly even older. "It could be the oldest comet we've ever seen," says Hopkins. It is thought that interstellar objects are more likely to be ejected early in a star's life, perhaps flung out by passing stars or interactions with giant planets.



NASA/JPL-CALTECH

The trajectory of the comet will take it close to Mars in October

Older stars are likely to have a lower metal content than our sun, which would also result in a higher water content for their comets, says Hopkins. If that is true, we could start to see large amounts of water spewing from the comet as it nears the sun in the coming months.

This would probably be its first encounter with another star, giving us a glimpse at pristine material billions of years older than Earth. "We think most interstellar objects that we see will be encountering a star for the first time, even if they're 8 billion years old," says Hopkins. ▮

Jonathan O'Callaghan

Environment

Peculiar plant holds Earth's history

Horsetail plants could provide valuable clues for understanding past and present ecosystems

Alex Wilkins

A STRANGE plant that has existed since animals first walked on land can distil water to an extreme degree, making it look more like water from a meteorite than from Earth. As well as being key to understanding ecosystems today, fossils of the plant could shed light on Earth's ancient climate.

Almost all the oxygen atoms in water have eight neutrons, but some are rare, heavier isotopes with nine or 10 neutrons. When water evaporates, lighter isotopes evaporate more than the heavier ones, making the ratio change in predictable ways. Scientists can use this to trace the history of a particular water sample.

However, because the heavier isotopes occur in small quantities, it is difficult to gather good data on how the isotope ratio changes, making some observations tricky for scientists to explain.

When sampling water from desert plants and animals, Zachary Sharp at the University of New Mexico and his colleagues found their data didn't fit with what was expected from models based on laboratory readings.

PIEMAGS/NATURE/ALAMY

The smooth horsetail distils water as it moves up the plant's hollow stem

Sharp and his colleagues think they have now solved this problem, thanks to plants called horsetails, which have grown on Earth since the Devonian Period, around 400 million years ago, and have hollow, segmented stems. "It's a metre-high cylinder with a million holes in it, equally spaced. It's an engineering marvel," says Sharp.

As water moves up each segment of the horsetail stem, it evaporates, distilling many times over. Sharp and his team looked specifically at smooth horsetails (*Equisetum laevigatum*) growing near the Rio Grande, from which they collected isotope readings by sampling the water at many points along the stem.

By the time the water reaches the top of the stem, the isotope ratio is unlike any other water found on Earth. "If I found this sample, I would say this is from a meteorite, because it's not from Earth. But in fact, [the oxygen isotope ratios] do go down to these crazy low values," Sharp told the Goldschmidt geochemistry conference in Prague, Czech Republic, on 7 July.

With these measurements, the researchers could calculate how the water isotope ratio changes under near-perfect conditions and put these values into their models to make them more accurate.

When they revisited their desert plant data with these models, their observations were suddenly explainable. Sharp thinks these values could account for other hard-to-explain observations, too, especially in desert environments.

Ancient horsetails – which grew up to 30 metres high – may have provided even more extreme isotope ratios and could be used to understand ancient water systems and climates, says Sharp. Small, sand-like grains called phytoliths in the horsetail stem, which can survive until the present day, have different isotope signatures according to the humidity of the air, which affects the amount of evaporation. "We can use this as a palaeo-hygrometer [humidity measurer], which is pretty cool," says Sharp. ▮

Space

We may have finally solved a cosmic ray puzzle

WE ARE zeroing in on the true composition of the rarest, highest-energy cosmic rays – which could help reveal their unknown origins.

The universe is constantly showering us with bursts of particles. The most energetic among them, called ultra-high-energy cosmic rays, have more energy than even the accelerated particles in colliders. They are also rare – researchers don't know what produces them or where they come from. Even the particles that make them up have been an unresolved question.

Now, Brian Clark at the University of Maryland and his colleagues have determined their composition using data collected by the IceCube neutrino detector in Antarctica.

Previous ultra-high-energy cosmic ray detections – by the Pierre Auger Observatory in Argentina and the Telescope Array in Utah – disagree on whether these rays mostly consist of protons or if other particles are also in the mix, says Clark.

IceCube's data offers some resolution: it suggests protons account for only about 70 per cent of ultra-high-energy cosmic rays, while the rest is made of heavy ions such as iron. The work will appear in *Physical Review Letters*.

Team member Maximilian Meier at Chiba University in Japan says IceCube's data is complementary to other measurements, which detect cosmic rays directly. In contrast, IceCube primarily detects particles called neutrinos, which are byproducts of collisions between energetic cosmic rays and photons left over from the big bang. Neutrinos themselves are challenging to detect and to simulate on a computer, he says.

YUYA MAKINO, ICECUBE/NSF

The IceCube detector in Antarctica is used to detect cosmic rays

The particles in cosmic rays determine how spaceborne magnetic fields affect their path through space. Understanding their composition is therefore an important part of the difficult task of searching for their origins, says Toshihiro Fujii at Osaka Metropolitan University in Japan. ▮

Karmela Padavic-Callaghan

Space

Alien life may need water – if only to keep cool

Alex Wilkins

THE number of planets capable of hosting alien life may be smaller than we thought, thanks to a new understanding of how water levels drive a planet's climate. Below a certain water level, carbon dioxide in the atmosphere can increase too much and make a planet unbearably hot, which may explain why Venus is as inhospitable as it appears today.

> "A planet existing in the habitable zone isn't enough for it to be potentially habitable"

All life that we know of needs liquid water, which is why astronomers are keen to find planets in the "habitable zone" around their star where temperatures allow liquid water to exist. But now Haskelle White-Gianella at the University of Washington and her colleagues have found that just having some liquid water isn't enough.

The researchers ran around 10,000 different simulations that calculate how the levels of CO_2 would change depending on the amount of water on a planet's surface, assuming it was a similar size to Earth and received a similar amount of light. They found that a planet needs at least 20 per cent of Earth's total surface water for it to be potentially habitable.

That is because water falling as rain plays a key role in storing carbon in the ground by triggering chemical reactions in rocks. Without enough rain, CO_2 will build up in the atmosphere, trapping heat and rapidly raising temperatures above 126°C (259°F) – beyond what life as we know it, even in the most extreme examples, can survive.

"We find that there is a threshold of water needed to maintain a stable climate," White-Gianella told the Goldschmidt geochemistry conference in Prague, Czech Republic, on 10 July.

This means that a planet existing in the habitable zone isn't enough for it to be potentially habitable, says White-Gianella, and that we need to look more carefully at its geologic history.

A similar scenario could also explain how Venus became the scorching, inhospitable environment we see today, said White-Gianella at the conference. While the sun's increasing brightness since the birth of the solar system is thought to be the main reason for Venus's loss of atmosphere and increased temperature, it doesn't fully explain these changes. White-Gianella and her team re-ran their models so that they received Venus-like levels of starlight, and found that even a planet with as much water as Earth may have lost too much CO_2 and become uninhabitable.

It's a compelling explanation for how Venus-like planets become extremely hot, says Benjamin Tutolo at the University of Calgary, Canada, but the picture could be more complicated if planets begin producing less CO_2 over time, which is what we see when looking at Mars's history.

In Mars's case, the liquid water pulled in too much carbon dioxide and stored it as carbonate minerals in the ground, says Tutolo, thinning its atmosphere and cooling the planet.

White-Gianella says her team's simulations focused on planets at Earth-like sizes and distances, and agrees the situation could be different for Mars-like planets. ▮

Health

Hay fever relief minus the side effects

Carissa Wong

DEEPOL BY PLAINPICTURE/TOM MERTON

Inflammation caused by pollen allergy triggers symptoms like sneezing

PEOPLE with hay fever could one day get a "molecular shield" that blocks pollen from entering the lining of the nose, and is unlikely to cause the side effects seen with standard treatments.

Hay fever is an allergic reaction that occurs when pollen binds to molecules called IgE antibodies in the lining of the nose, mouth and eyes, triggering inflammation that causes symptoms such as sneezing. Current treatments aren't always effective and often have side effects, such as drowsiness.

To find an alternative, Kaissar Tabynov at the Kazakh National Agrarian Research University and his colleagues extracted an antibody from mouse blood that isn't involved in allergic reactions, but still binds to the main allergen in mugwort pollen, a major cause of hay fever. This binding blocked the allergen from attaching to IgE antibodies in a lab dish. "It acts like a molecular shield," says Tabynov.

To see if this reduces irritation, the researchers induced mugwort pollen allergies in 10 mice. A week later, they put a droplet of liquid containing the antibody into the noses of half the mice, doing so a total of three times over five days. The remaining animals were given droplets of saline solution. An hour later, the mice were exposed to mugwort pollen at levels similar to those that people are exposed to during peak hay fever season.

After the final droplet, the mice given the antibody rubbed their noses 12 times, on average, over 5 minutes, versus 92 times in the saline group (*Frontiers in Immunology*, doi.org/pvxw).

Examining nose tissue samples showed that the antibody reduced inflammation. This also showed that the treatment had effects deeper within the body, not just where the droplets were applied. "Our study is the first to demonstrate that an allergen-specific monoclonal antibody can be applied intranasally to achieve both local and systemic protection in the context of plant pollen allergies," says Tabynov.

Although the researchers didn't measure potential side effects, they don't expect the approach to cause the adverse events seen with oral hay fever drugs, because it works at the site of allergen entry. ▮

Genetics

Moa next on 'de-extinction' list

After a controversial project claiming to have resurrected the dire wolf, Colossal Biosciences has announced plans to bring back nine species of the extinct moa, says **James Woodford**

COLOSSAL BIOSCIENCES has said it aims to "de-extinct" the New Zealand moa, one of the world's largest and most iconic extinct birds, but critics say the company's goals remain scientifically impossible.

The moa was the only known completely wingless bird, lacking even the vestigial wings of birds like emus. There were once nine species of moa in New Zealand, ranging from the turkey-sized bush moa (*Anomalopteryx didiformis*) to the two biggest species, the South Island giant moa (*Dinornis robustus*) and North Island giant moa (*Dinornis novaezealandiae*), which both reached heights of 3.6 metres and weights of 230 kilograms.

It is thought that all moa species were hunted to extinction by the mid-15th century, following the arrival of Polynesian people, now known as Māori, to New Zealand sometime around 1300.

Colossal has announced that it will work with the Indigenous Ngāi Tahu Research Centre, based at the University of Canterbury in New Zealand, along with film-maker Peter Jackson and Canterbury Museum, which holds the largest collection of moa remains in the world. These remains will play a key role in the project, as Colossal aims to extract DNA to sequence and rebuild the genomes for all nine moa species.

As with Colossal's other "de-extinction" projects, the work will involve modifying the genomes of animals still living today. Andrew Pask at the University of Melbourne, Australia, who is a scientific adviser to Colossal, says that although the moa's closest living relatives are the tinamou species from Central and South America, they are comparatively small.

This means the project will probably rely on the much larger Australian emu (*Dromaius novaehollandiae*). "What emus have is very large embryos, very large eggs," says Pask. "And that's one of the things that you definitely need to de-extinct a moa."

CHRISTOPHER KLEE/COLOSSAL BIOSCIENCES

There were once nine species of moa, all completely wingless

Colossal previously announced it had achieved what it called the "de-extinction" of the dire wolf, a claim disputed by outside experts because the animals it created are grey wolves with a handful of modified genes. Pask says this won't be the case with the moa project and there will be "orders of magnitude" more DNA edits.

"The difference here with the moa is it really is going to be properly trying to re-engineer the moa back," he says. "There will be no one who can question whether this is a moa when that animal eventually gets re-hatched back into our world. It will be a recreated or re-engineered moa at the end of the process."

Exactly where these animals will reside is unclear. Mike Stevens at the Ngāi Tahu Research Centre says his organisation and the local Māori community will need to clearly understand the "viability and morality" of Colossal's work as it progresses. "Once we have done so, we can fully consider where and how any 'Colossal moa' might be located," he says. "That in itself raises a series of fascinating practical and moral questions. But we cannot unpack them in any depth until we have carefully considered other factors – and, of course, the technology proves itself."

"They may superficially have some moa traits, but are unlikely to behave as moa did"

But Philip Seddon at the University of Otago, New Zealand, says that whatever Colossal makes, it won't be a moa, but rather a "possible look-alike with some very different features". He points out that although the tinamou is the moa's closest relative, the two diverged 60 million years ago.

Controversial creations

"The bottom line is that Colossal's approach to de-extinction uses genetic engineering to alter a near-relative of an extinct species to create a GMO [genetically modified organism] that resembles the extinct form," he says. "There is nothing much to do with solving the global extinction crisis and more to do with generating fundraising media coverage."

Pask strongly disputes this sentiment and says the knowledge being gained through de-extinction projects will be critically important to helping save endangered species today.

Jamie Wood at Adelaide University, Australia, says he thinks the project will offer some "interesting new insights into moa's biology and evolution". But he says if the same research path is pursued as that of the dire wolf project, then Colossal may have a "hard time persuading people that the results of this process could be regarded as moa".

"They may superficially have some moa traits, but are unlikely to behave as moa did or be able to occupy the same ecological niches, which will perhaps relegate them to no more than objects of curiosity," says Wood. ▮

For more on de-extinction, turn to page 32

Health

Antidepressant withdrawal symptoms may be less common than we thought

Carissa Wong

WITHDRAWAL symptoms after stopping antidepressants don't occur as often as we thought, at least for short-term use – but questions remain about what happens to people who end their use of the drugs after much longer periods.

We know that people taking antidepressants for conditions such as depression, anxiety and phobias may get withdrawal symptoms that can last for a few weeks, such as nausea, headaches, anxiety and depression. However, while doctors may warn people about this possibility, it is unclear how often they occur.

To find out more, Sameer Jauhar at Imperial College London and his colleagues reviewed 49 randomised controlled trials of antidepressant use. They first analysed a subset of studies that tracked the number of withdrawal symptoms participants experienced one week after either stopping antidepressants, coming off placebo pills or continuing to take antidepressants. The researchers found that those who stopped taking the drugs experienced one extra symptom compared with those in the other two groups.

7.5%

Proportion of people who reported dizziness as a withdrawal symptom

In another analysis, the team looked at another subset of studies that tracked the types of withdrawal symptoms participants experienced after coming off antidepressants or placebo pills. Dizziness was found to be the most common symptom, followed by nausea, nervousness or irritability, and vertigo.

Specifically, 7.5 per cent of people in the antidepressant group experienced dizziness, while this figure was 1.8 per cent in the placebo group. Nausea, nervousness or irritability, and vertigo were each reported by less than 5 per cent of people in the antidepressant group, and less than 2 per cent in the placebo group (*JAMA Psychiatry*, doi.org/g9spr7).

These figures are lower than two prior estimates of withdrawal symptoms. One 2019 review found more than half of people had symptoms, but that included data from online surveys, so may be skewed by people with more severe symptoms being more likely to respond, says Michael Browning at the University of Oxford.

Another estimate, published last year, found that 31 per cent of people reported withdrawal symptoms, compared with 17 per cent in placebo groups. But they didn't give details on the types of symptoms, says Jauhar.

Susannah Murphy at the University of Oxford says the new review addresses some of these issues. "This is really important for the field: it's collecting together and summarising data from many, many robust studies involving more participants than previous ones," she says.

But John Read at the University of East London points out that most studies in the review included participants who were on antidepressants for only eight to 12 weeks, while people often take them for years. "There's a strong relationship between how long you're on these drugs and whether or not you end up with withdrawal, so short-term [use] studies aren't going to tell you much about real-world effects," he says.

As such, you would need more studies involving long-term use to get a true answer, says Mark Horowitz at University College London. ▮

Environment

Thirsty city trees drink water from leaky pipes

TREES growing on city streets are more resistant to drought than those in parks, thanks to an unusual water source: leaks.

After long periods with little rain, water levels and sap flow tend to fall more in trees growing in parks compared with those in streets.

To investigate, André Poirier at the University of Quebec in Montreal and his colleagues took trunk samples from Norway maple and silver maple trees (*Acer platanoides* and *Acer saccharinum*) in parks and streets in two Montreal neighbourhoods. They measured the levels of various lead isotopes – atomically distinct versions of the metal that can indicate unique origins – and then linked the isotope levels to the trees' recent history by counting the trunk rings.

AUSTIN H. KAPP/UMVUTU/ALAMY

Trees in Montreal's streets do better than those growing in parks

While the park trees had lead isotopes associated with air pollution, the street trees had isotopes found in lead water pipes, which were made from geologically old lead deposits in nearby mines.

Maple trees need to consume around 50 litres of water per day. Since street trees can't get much of this from rainwater, which falls on concrete and drains into the city's sewers, Poirier says the most likely explanation is that it is coming from Montreal's leaky pipes, which lose 500 million litres of water per day.

"The good news is that you can keep on planting trees on the street, because it makes people happy to have trees, and they will survive better than in the parks," says Poirier, who presented his work at the Goldschmidt geochemistry conference in Prague, Czech Republic, on 8 July. ▮

Alex Wilkins

Life

Oldest proteins yet recovered found in 18-million-year-old teeth

Meagan Mulcair

THE fossilised teeth of 18-million-year-old mammals in Kenya have yielded the oldest protein fragments ever discovered, a nearly fivefold increase from the previous record age of ancient proteins of 3.8 million years.

Daniel Green at Harvard University, in collaboration with Kenyan scientists, found a variety of fossilised remains, including teeth, in Kenya's Rift valley. Volcanic activity had helped preserve the samples by encasing them in layers of ash – layers that let the researchers date the teeth to 18 million years ago. But in the field, they couldn't figure out whether the proteins in the tooth enamel had endured.

The odds weren't good – the Rift Valley "has been one of the persistently hottest places in the world for going back over 5 million years", says Green. This harsh and unforgiving climate creates "a very challenging environment for [protein] preservation". Still, prior research had managed to find proteins in tooth enamel, albeit none from teeth as old as these. So, to see whether any traces of protein had managed to last, Green used small drills to remove powdered enamel from the teeth.

"We would love to go back in time even further. We're only scratching the surface right now"

The researchers sent these samples to Timothy Cleland at the Smithsonian's Museum Conservation Institute in Maryland for analysis. He used a technique called mass spectrometry to identify each type of molecule in the sample.

He found fragments of proteins that were complete enough to provide important taxonomical information. This revealed that the teeth had belonged to prehistoric ancestors of elephants and rhinos (*Nature*, doi.org/pvv2). Cleland is enthusiastic about being "able to put even these older species into the tree of life with their modern relatives".

Only a small amount of protein material was recovered, but that doesn't diminish the finding, says Frido Welker at the University of Copenhagen in Denmark. He says the ability to cultivate protein and learn anything about a fossil this old is "a massive breakthrough".

Sampling teeth, as opposed to another tissue such as bone, could be key to finding protein fragments as old and informative as these. "The sequences in the enamel proteins are a little more variable," says Cleland, "so we can get a little more evolutionary information."

The make-up of the teeth might also have helped preserve their proteins for such a long time. Because teeth are "mostly rock", says Green, these minerals surround and help protect the proteins in the enamel in what Cleland calls a "self-fossilisation process". And the preservation is also aided because the enamel itself contains only a small amount of protein – about 1 per cent. "Whatever protein is present ends up sticking around a lot longer," says Green.

The fact that protein fragments can survive even in the Rift valley suggests ancient fossils found in other regions might contain them as well. "We can start to really think about other harsh areas of the planet where we wouldn't expect great preservation," says Cleland. "There might be some microenvironmental differences leading to protein preservation."

The researchers hope to find samples from earlier eras. "We would love to go back in time even further," says Cleland. "We're only scratching the surface right now." ▮

Health

A youthful brain and immune system may be key to a long life

WHEN it comes to living a long life, not all organs are created equal – having a youthful brain or immune system seem to be crucial.

We already knew that organs age at different rates. To find out which have the biggest effect on lifespan, Hamilton Se-Hwee Oh at the Icahn School of Medicine at Mount Sinai in New York and his team analysed the levels of nearly 3000 proteins in blood samples collected from more than 44,000 people who enrolled in the UK Biobank study when they were between 40 and 70 years old.

The researchers first looked at where these proteins were abundant in the body, indicating where they had important functions. They then created machine-learning models trained on protein-level data from half the participants, and used these to predict organ and immune system ages for the other half.

YADID LEVY/ROBERT HARDING/ALAMY

It seems that some of our organs are more important for longevity than others

The team found that having one prematurely aged organ, or an aged immune system, was linked to a 1.5- to 3-fold increased risk of death during the follow-up period, which lasted for an average of 11 years.

Having younger organs wasn't generally linked to a reduced risk of death, with the exception of a young brain or immune system, where the risk of death declined by about 40 per cent – rising to 56 per cent if both of these parts of the body were youthful (*Nature Medicine*, doi.org/pvvx).

"The brain and immune system coordinate a lot of other things around the body, so if those go wrong, it's not too surprising they might have outsized effects on lifespan," says Alan Cohen at Columbia University in New York. ▮

Carissa Wong

Mathematics

Revealing the edge of maths

Some numbers are so big that they defy the bounds of mathematics, and mathematicians are closing in on one that may mark the threshold of this abyss, finds **Karmela Padavic-Callaghan**

AMATEUR mathematicians are closing in on an unimaginably huge number – one so large that it brushes up on the edge of what is knowable within the framework of modern mathematics.

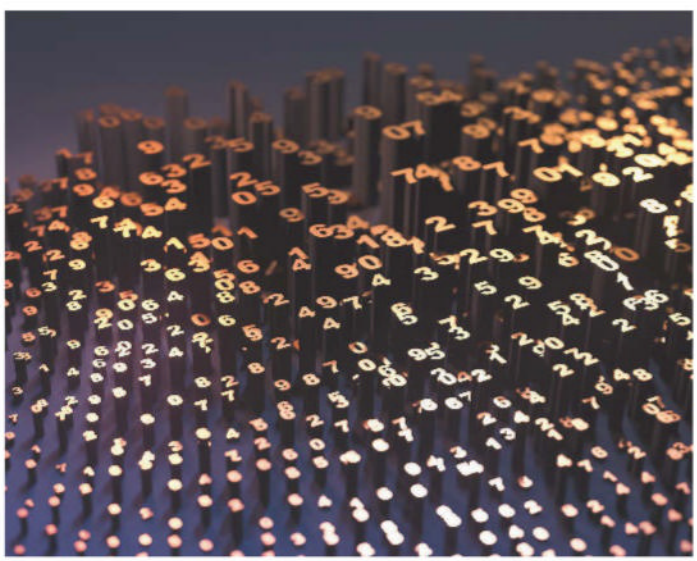
It all stems from a seemingly simple question: how do you know if a computer program will run forever? Answering this starts with mathematician Alan Turing. In the 1930s, he showed that any computer algorithm can be mimicked by imagining a simple "Turing machine" that reads and writes 0s and 1s on an infinitely long tape by following a set of instructions called states, with more complex algorithms requiring more states.

For every number of states, such as 5 or 100, there are finitely many corresponding Turing machines, but it is unclear for how long each of these machines must run. The longest possible run-time for each number of states is called the Busy Beaver number, or BB(n), and this sequence grows incredibly quickly: BB(1) is 1, BB(2) is 6, but the fifth Busy Beaver number is 47,176,870.

The exact value of the next Busy Beaver number, the sixth, is unknown, but an online community called the Busy Beaver Challenge is attempting to discover it – they uncovered BB(5) in 2024, putting an end to a 40-year search. Now, a member known as "mxdys" has discovered it must be at least as big as a number that is so large that even describing it requires some explanation.

"This number is so far beyond physical, it's not even funny," says Shawn Ligocki, a software engineer and Busy Beaver Challenge contributor. He compares the search to fishing in some deep mathematical sea where only odd, exotic bits of code swim in the dark.

The new bound for BB(6) is so large as to require mathematical



KERTLIS/GETTY IMAGES

What is the next number in the Busy Beaver sequence?

language that transcends exponentiation – the practice of raising one number n to the power of another x, or n^x, such as 2^3, which is 2*2*2 = 8. First, there is tetration, sometimes written as ${}^x n$, which involves iterated exponentiation, so ${}^3 2$ would be 2 raised to the power of 2, to the power of 2, which is equal to 16.

Remarkably, mxdys has shown that BB(6) is at least 2 tetrated to the 2 tetrated to the 2 tetrated to the 9, a tower of iterated tetration, where each tetration is, in turn, a tower of iterated exponentiation. The number of all particles in the universe looks puny in comparison, says Ligocki.

But the Busy Beaver numbers aren't important just because of their absurd size. Turing proved that there must be some Turing machines whose behaviours cannot be predicted under ZFC theory, a foundation that undergirds all standard modern mathematics. He was inspired by mathematician Kurt Gödel's "incompleteness theorem", which showed that the rules of ZFC itself cannot be used to prove that the theory is guaranteed to be absolutely free of all contradictions.

"The study of Busy Beaver numbers is making the phenomena discovered by Gödel and Turing nearly a century ago quantitative and concrete," says Scott Aaronson at the University of Texas at Austin. "Instead of merely saying that Turing machines must elude the capability of ZFC to determine their behaviour after some finite point, we can now ask, does that happen already with 6-state machines or only with 600-state machines?" Researchers have so far proven that BB(643) would elude ZFC theory, but many of the smaller numbers haven't been explored yet.

"The search is like fishing in a deep mathematical sea where only odd, exotic bits of code swim in the dark"

"The Busy Beaver problem gives you a very concrete scale for pondering the frontier of mathematical knowledge," says computer scientist Tristan Stérin, who launched the Busy Beaver Challenge in 2022.

Unsolved problem

In 2020, Aaronson wrote that the Busy Beaver function "probably encodes a huge portion of all interesting mathematical truth in its first hundred values", and BB(6) is no exception. It seems to be related to the Collatz conjecture, a famously unsolved mathematical problem that involves repeating simple arithmetic operations on numbers and seeing whether they eventually become 1. Finding BB(6) seems to be related to a Turing machine that would have to mimic some of the steps of this problem in order to halt. If such a machine were found to halt, it would indicate that there is a computational proof for a version of the conjecture.

The numbers the researchers are dealing with are incredible in their magnitude, but the Busy Beaver framework provides a metre stick for what would otherwise be a seemingly unintelligible region of maths.

There are still several thousand "holdout" Turing machines whose halting behaviour hasn't been checked, says Stérin. "Around the corner, there could be a machine that is unknowable," says Ligocki, meaning that it is independent of ZFC and beyond the bounds of modern mathematics.

Could the exact value of BB(6) also be around the corner? Ligocki and Stérin both say that they know better than to try to predict Busy Beaver's future, but recent success in bounding the number gives Ligocki an "intuition that there's more coming", he says. ∎

Climate change

Vanishing snow will cut forest carbon storage

James Dinneen

DOUGLAS RISSING/GETTY IMAGES

Snow cover keeps soil from freezing, helping trees grow in winter

MANY forests are losing their winter snowpack as global temperatures rise, and that could substantially slow their growth – and reduce the amount of carbon they remove from the atmosphere.

Current projections "are not incorporating that complexity of winter climate change, so they are likely overestimating what the future carbon storage will be", says Emerson Conrad-Rooney at Boston University.

Warming temperatures are expected to boost growth in temperate forests. However, models largely don't account for changes during winter – especially the loss of snow.

To get a better handle on this, Conrad-Rooney and their colleagues simulated how a global temperature increase of 5°C would affect the growth of red maple trees (*Acer rubrum*) in an experimental forest in New Hampshire. In some plots, they used buried cables to warm the soil during the growing season. In others, they also removed snow during winter and warmed the soil to induce cycles of freeze and thaw.

Measured over 10 years, the trees in both plots grew more than trees that were left alone. However, the plots where the snow was removed grew much more slowly, adding about half as much growth (*PNAS*, doi.org/g9sm3d). The researchers attribute this to root damage caused by the snowless soil being more exposed to changing temperatures.

"The snow typically acts as an insulating blanket to keep soils from freezing," says Conrad-Rooney. "With less snow, there are more freeze-thaw cycles."

Extrapolating to similar forests across the north-east US, the researchers estimate the loss of snowpack expected by the end of the century would reduce carbon storage by a little over 1 million tonnes per year, compared with models that don't account for disappearing snow.

"Snowpacks that come and go throughout the winter diminish the stable soil conditions our north-east ecosystems require for long-term storage of carbon," says Elizabeth Burakowsi at the University of New Hampshire.

Technology

Surgical robot operates without human help

Chris Stokel-Walker

AN AI-powered robot was able to separate the gall bladder from the liver of a dead pig in what is said to be the first realistic surgery by a machine with almost no human intervention.

The robot is powered by a two-tier AI system trained on 17 hours of video that encompassed 16,000 motions made in operations by human surgeons. When put to work, the first layer of the AI system watches video from an endoscope monitoring the surgery and issues plain-language instructions, such as "clip the second duct", while the second AI layer turns each instruction into three-dimensional tool motions.

In all, the gall bladder surgery required 17 separate tasks. The robotic system performed the operation eight times, achieving 100 per cent success in all of the tasks (*Science Robotics*, doi.org/g9spv2).

"Current surgical robotic technology has made some procedures less invasive, but complication rates haven't really dropped from previous laparoscopic [keyhole] surgeries [by human surgeons]," says team member Axel Krieger at Johns Hopkins University in Maryland. "This made us look into what is the next generation of robotic systems that can help patients and surgeons."

"The study really highlights the art of the possible with AI and surgical robotics," says Danail Stoyanov at University College London. "Incredible advances in computer vision for surgical video with the availability of open robotic platforms for research make it possible to demonstrate surgical automation."

But many challenges remain to make the system practical in clinical use, points out Stoyanov.

For one thing, while the robot completed the task successfully, it had to self-correct six times per case. For example, this could mean a gripper designed to grasp an artery missed its hold on the first try.

17

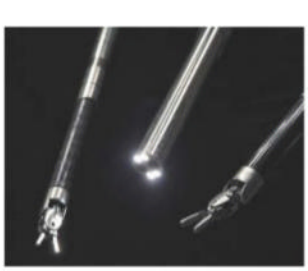
Number of hours of video the AI behind the robot was trained on

"There were a lot of instances where it had to self-correct, but this was all fully autonomous," says Krieger. "It would correctly identify the initial mistake and then fix itself." The robot also had to ask a human to change one surgical instrument for another, meaning some level of human intervention was needed.

Ferdinando Rodriguez y Baena at Imperial College London is enthused about the growing potential of robotic surgery. "The future is bright – and tantalisingly close," he says. "Though to realise this safely in humans, regulation will need to follow suit, which remains a significant open challenge in our sector."

The next step, says Krieger, is to allow a robot to operate autonomously on a live animal.

The robot used to perform autonomous gall bladder surgery



XINHAO CHEN/JOHNS HOPKINS UNIVERSITY

Health

Cancer-killing virus nears approval

The virus could see widespread use after shrinking tumours in people with late-stage melanoma

Michael Le Page

DESPITE many decades of effort and numerous human trials, only one virus that is designed to kill cancers has ever been approved for use in the US and Europe. But a second could get the green light at the end of the month, *New Scientist* has learned, after getting good results for treating melanoma, a serious type of skin cancer.

In previously published results, a genetically modified herpes virus, called RP1, was injected into the tumours of 140 people with advanced melanoma for whom standard treatments had failed. The participants also took a drug called nivolumab, which is designed to boost the immune response to tumours. In 30 per cent of those treated, tumours shrank, including those that weren't injected. In half of these cases, the tumours disappeared.

"Half the responders had complete responses, meaning the complete disappearance of all tumours," says Gino Kim In at the University of Southern California. "We're very excited about these results." The other options for treating people at this stage don't work as well and have more serious side effects, he says.

A later-stage trial that will involve 400 people is now under way, but RP1 could be approved by the Food and Drug Administration (FDA) in the US for treating advanced melanoma in combination with nivolumab long before this trial finishes, In told *New Scientist*. "The FDA is supposed to give us a decision at the end of this month."

It has long been known that viral infections can sometimes help treat cancers, but deliberately infecting people with "wild" viruses is very risky. In the 1990s, biologists began genetically modifying viruses to try making them better at treating cancers, but unable to harm healthy cells.

These viruses are designed to work in two ways. Firstly, by directly infecting cancer cells and killing them by bursting them apart. Secondly, by triggering an immune response that targets all cancerous cells, wherever they are in the body.

"Half the responders had complete responses, meaning the disappearance of all tumours"

For instance, a herpes simplex virus known as T-VEC, or Imlygic, was modified to make infected tumour cells release an immune-stimulating factor called GM-CSF, among other changes. In 2015, T-VEC was approved in the US and Europe for treating inoperable melanoma.

But T-VEC isn't widely used, says In, in part because it was only tested on and approved for injecting into tumours in the skin. Most people with advanced melanoma have deeper tumours, he says.

With RP1, the decision was made to also try injecting it into deeper tumours. RP1 is a herpes simplex virus, like T-VEC, but has been improved in numerous ways. In particular, it makes tumour cells fuse with neighbouring cells, helping the virus to spread through tumours and boosting the immune response.

There have been no directly comparable trials of T-VEC and RP1, but RP1 is more likely to induce shrinking of all tumours, not just the injected ones, says In. "That indicates a more powerful systemic effect."

Therefore, In expects RP1 to be much more widely used than T-VEC if it is approved. It will also provide a big boost to the whole idea of using cancer-killing viruses, he says. "I expect there will be a lot more interest." ▮

Space

New type of plasma wave found in Jupiter's auroras

THE cosmic neighbourhood of Jupiter is one of the more peculiar places in the solar system, and the plasmas that reside there are no exception. They ripple with a never-before-seen type of wave.

Robert Lysak at the University of Minnesota studies auroras – not the mesmerising displays of green and blue light on Earth, but swirls of mostly invisible ultraviolet radiation near the poles of Jupiter. The key to understanding these alien auroras is in the motion of the plasmas – soupy mixtures of charged particles and atoms surrounding the planet – that produce their glow.

NASA/JPL-CALTECH/SWRI/MSSS

Jupiter's poles are home to swirls of invisible ultraviolet radiation

Based on data collected by NASA's Juno spacecraft, Lysak and his colleagues found that Jupiter's auroral plasmas oscillate with a new kind of wave (*Physical Review Letters*, doi.org/pvvs).

The wave is a hybrid of two types of well-understood plasma waves: Alfvén waves, which are produced by the motion of the plasma's charged atoms, and Langmuir waves, which reflect the movement of electrons in the plasma. Lysak says that, because electrons are much lighter than charged atoms, the two types of waves usually jiggle at very different frequencies.

But the area near Jupiter's poles has just the right properties for the two to jiggle similarly and combine. This is because the plasmas there have exceptionally low densities and the planet holds them in a strong magnetic field.

"The observed plasma properties are really unusual, not found before and elsewhere in our solar system," says John Leif Jørgensen at the Technical University of Denmark. ▮

Karmela Padavic-Callaghan

The nuclear frontier

One of the world's leading nuclear security companies is dismantling stereotypes, redefining career paths and championing female talent in science, engineering and beyond

"I will not forget that day." Out on a nuclear test inspection exercise in rural Hungary, Jenny received news from her operations support centre in Vienna that an approaching thunderstorm was threatening the safety of her field team working in a dense forest. The terrain blocked all communications: mobile phone, satellite phone, radio—nothing worked. "We had a rescue team ready to get to that team and tell them to take shelter," she recalls. When they finally got through and gathered the field team in their vehicles, the first lightning strikes hit just five minutes later. "It was really scary," says Jenny. "As the lead, I see it as my responsibility, the safety of the team."

Challenges like this are all in a day's work for Jenny, who leads the Forensic Seismology Team at AWE, the technology and security organisation behind the UK's nuclear deterrent. She is one of many women forging careers in nuclear security at the company, which was formerly known as the Atomic Weapons Research Establishment. She and her colleagues are leaders and role models for a new generation of employees. As her colleague and senior science manager, Lorna, puts it: "I think the idea that you can't be a working mother in a senior management role has been pretty much debunked." She believes that's only become possible because of the equal opportunity policies AWE offers.

Attracting women into engineering and nuclear security has long been a challenge for an industry with a stuffy, male-dominated image. AWE is tackling this with outreach programmes to schools, for example, that debunk stereotypes and show girls and young women the vast range of roles and careers on offer. Helen, now Group Leader, Engineering at AWE, recalls how similar

DMP/ISTOCKPHOTO

A PATH FOR NON-SCIENTISTS

"It's an environment where you have to be pretty tough," says Lorna. "You've got to be thinking on your feet because things go wrong all the time." She is not talking about her current job at AWE but her former career teaching modern languages at a UK secondary school. Lorna's degree is in modern languages but the skills she acquired managing a room full of teenagers, such as time management and emotional intelligence, have allowed her to pursue a high-flying career as a leader and manager at AWE. "I think as teachers you're not encouraged to reflect on the other skills that you deploy in the classroom that make you an incredibly attractive proposition for anybody who's got any kind of people management and leadership requirements," she says.

Much as she loved teaching, the Covid pandemic made Lorna question her career path. A civil service job advert for a team leader in policy and strategy caught her attention. It involved managing and leading a team that delivered operational and radiation protection training at Defence Science and Technology Laboratory, the science and technology research arm of the UK's Ministry of Defence. The team was incorporated into AWE about a year ago.

"The science bit terrified me," says Lorna. "I thought I'd be getting a rejection email quite swiftly."

But Lorna realised her people skills made her highly qualified for the role. These skills are often wrongly described as "soft" skills, she says. "I think they're actually hard skills because, I don't know that they can be easily taught." She now manages a team of 70 in Defence Radiation Protection Services at AWE, helping the Ministry of Defence and a small number of commercial customers work with radiation safely. Despite not having a STEM background, Lorna says her expertise is valued and her efforts to understand her colleagues' work recognised. "People value that and they value the time you invest in them as individuals," she says.

IMAGE SUPPLIED BY AWE

Jenny's role includes speaking at conferences related to the Comprehensive Test Ban Treaty

schemes inspired her as an A-level student. "Like many young women, I knew I liked science and maths, but I didn't know what I could do with it," she says. "Without that outreach, I wouldn't have understood the massive potential and scale of the industry."

Retaining talent is another challenge AWE is tackling, and the company has several schemes to foster career development for women. One is a gender balance group supported by AWE's human resources department. This focuses on three areas: attracting more women into AWE, changing the culture to improve the experience of woman at the company and working to maximise the potential of female employees. There are training courses in areas such as leadership and support for employees wanting to study for formal qualifications. For example, Lorna studied for a chartered management degree alongside her day job.

Employees are encouraged to go out and find the training that works for them, says Helen, who works on the Astraea programme to develop the UK's replacement warhead. "We all have very good development plans and there's a large swathe of coaches and mentors." Both she and Jenny value the opportunities they have been given to learn on the job. "I've been on leadership courses," says Jenny, "but I always find I get more out of being able to talk to somebody with more experience and just bounce ideas off them."

The company is also removing barriers that prevent women advancing to senior roles. This has created an ethos of flexible working and an excellent work-life balance which benefits everyone. All employees are encouraged to take shared parental leave after the birth of a child, for example.

For women, the flexible working arrangements have been transformative. Lorna says that the balance this gives to her home and working life has huge implications for her family. "It means they get the best of me," she says.

Meanwhile, Helen was supported in redesigning her job around school hours and Jenny receives time in lieu for the field exercises she leads, like the one in Hungary. And when the going gets tough, she can rely on being part of a supportive team. "I've been extremely lucky that every time I've been faced with a challenge, it's been met with the support of those around me rather than a barrier."

Learn more about AWE careers at: www.awe.co.uk/careers

Views

Comment

High hopes

Flying is probably the single hardest thing to decarbonise, but an unlikely solution could be at hand, says **Mike Berners-Lee**

TO FLY or not to fly? That is the question environmentally conscious people are increasingly grappling with. Sometimes taking the plane seems the only viable option, perhaps when time is tight or when a loved one lives far away.

I think we can have some flying as part of a sustainable future – but only if we put a few misleading myths to rest and instead lay out some realistic opportunities to cut its impact on global warming.

The first myth is that so-called sustainable aviation fuel (SAF) can solve the problem. It is a complete misnomer, as SAF turns out not to be sustainable at all.

Here's why. There are three main types of SAF. The first is fuel from waste products, especially cooking oil. The problem is, the whole world's waste cooking oil supply would be enough to power only 2 to 3 per cent of flights. The second is synthetic SAF, produced from raw materials such as captured carbon dioxide using energy from renewable sources. The process involved is so inefficient (at least 2 kilowatt-hours of electricity input per 1 kWh of fuel generated) that it is a self-defeating use of our limited renewable power. The third type of SAF is created from crops, so needs a lot of farmland. The detrimental pressure that this puts on both our food system and on nature is a big problem. The hard reality is that sustainable aviation fuel really isn't a "game changer".

The next piece of wishful thinking I often come across is that we can decarbonise aviation through electrification or by using hydrogen as a fuel. Electrification will be practical only for short-haul flights because the weight of batteries renders it unworkable for long-haul operations. Hydrogen is tricky because it takes up so much space, even when compressed to 700 times atmospheric pressure. This means it needs to be stored in large, pressurised cylinders, making it unfeasibly bulky compared with liquid fuels.

SIMONE ROTELLA

The good news is that I also see some clear opportunities that aren't getting enough attention.

The closest thing we have to an elusive silver bullet to make aviation greener has flown under the radar until very recently. Contrails – those high, cloud-like streaks left by aircraft engine exhaust fumes – account for over 60 per cent of the climate change impact of all our flights, and much more if you look at the short-term impacts over, say, 20 years.

They do this by reflecting heat released at Earth's surface back down, acting like a blanket. But the overall impact of a contrail is complex. Not only do they trap Earth's radiant heat, but on a sunny day they can have a cooling effect by reflecting incoming sun rays. This happens only in the daytime, and they cool most when contrails are above a darker surface, such as an ocean. The more frequent, warming effect happens most at night when they occur over warm, dark surfaces.

It is possible to manage contrails by making small tweaks to flight paths: taking a plane above, below or around a specific pocket of weather that will cause them to form. When flying over a sunny ocean, it may even be an advantage to deliberately create them. Small tweaks to just 1.7 per cent of all flight paths could have the effect of cutting the contrail warming impact by nearly 60 per cent. All that is required is some real-time modelling built into the flight path calculation, and no more flexibility than is already routinely applied to avoid storms and other aircraft.

It is a relatively cheap solution, one that just needs the aviation industry to get behind it. Once contrail management is in place, there may even be a role for SAF, as it burns more cleanly and could be used to mitigate contrails on the worst-offending flights.

Does this mean we can all relax about the climate impact of flying? Sadly not. But it might help us continue to fly when we have a good enough reason to do so. ▮

Mike Berners-Lee is the author of *A Climate of Truth: Why we need it and how to get it*

No planet B

Rocky start Scientists have discovered a new type of sedimentary rock made of debris from slag heaps, formed in the geological blink of an eye. Could this be good news, asks **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading
I'm listening to Chapters, *comedy poet Tim Key's anthology, on audiobook.*

What I'm watching
Wimbledon, the women's Euros and, later this month, the British and Irish Lions rugby test series against Australia.

What I'm working on
My vegetable patch. I'm a newbie, so learning from my mistakes. How do you know when a beetroot is ready to harvest?

This column appears monthly. Up next week: Annalee Newitz

ALMOST 20 years ago, *New Scientist* ran a feature called "Imagine Earth without people", a thought experiment about what would happen to our planet over thousands of years if humanity suddenly disappeared. It was an entertaining way to discuss all the impacts our species has had on the environment, without resorting to hand-wringing. The bottom line was that it would take a long time, but the damage would eventually be reversed, leaving barely a trace of our civilisation's existence. "The humbling – and perversely comforting – reality is that the Earth will forget us remarkably quickly," the piece concluded.

I was reminded of this when reading a recent research paper in the journal *Geology*, in which researchers from the University of Glasgow, UK, report the discovery of an Earth-shattering geological process suggesting that, in fact, Earth won't forget us.

They were studying the geology of Derwent Howe on the coast of Cumbria, UK. For around 125 years, starting in the 1850s, Derwent Howe was a major centre of iron- and steel-making. Its blast furnaces generated huge amounts of a waste product called slag. All told, around 27 million cubic metres of furnace slag was deposited in banks along a 2-kilometre stretch of coastline. The slag bank is still there, though it is being eroded by waves and tides.

When the Glasgow researchers went to the beach, they found a series of outcrops made from an unfamiliar type of sedimentary rock. The beach used to be sandy, so the rock must have been a recent addition. It was clearly clastic, meaning it was composed of fragments of other rocks and minerals (clasts) that have been cemented together in layers. On closer inspection, they found that the clasts were derived from the slag heap. The only conclusion was that material was eroding from the slag, being washed into the sea, depositing onto the shore and then turning rapidly into rock.

And when I say rapidly, I mean rapidly. The formation of clastic rocks usually takes thousands or even millions of years. But here it was happening in decades – a blink of an eye in geological terms. The slag has been there in large quantities for only a century or so.

Even more remarkably, the team found two artefacts firmly entombed in the clast that prove unbelievably rapid rock formation, or lithification. One was a penny coin minted in 1934. The other was an aluminium ring pull-tab from a drink can that could be no more than 36 years old. In other words, lithification is occurring within decades. The researchers propose that this is an entirely new geological process called the "anthropoclastic rock cycle".

> **"The researchers propose that this is an entirely new geological process, the 'anthropoclastic rock cycle'"**

"What's remarkable here is that we've found these human-made materials being incorporated into natural systems and becoming lithified over the course of decades," team leader Amanda Owen told the University of Glasgow's press office. "It challenges our understanding of how a rock is formed, and suggests that the waste material we've produced in creating the modern world is going to have an irreversible impact on our future."

As at Derwent Howe, so all over the world. Similar rocks were discovered near Bilbao, Spain, in 2022, but couldn't be securely dated. Slag waste is a global phenomenon, and it is probably being turned to rock anywhere it comes into contact with ocean waves, according to team member David Brown.

On the surface, that might seem like a problem, and indeed we don't yet know what the environmental impacts of such processes are. But maybe the discovery is good news. If industrial waste is being locked away in solid rock, surely that is a nice, neat way of dealing with it without having to actually deal with it, right? The rocks at Derwent Howe also contained fragments of clothing, plastic, car tyres and fibreglass, which otherwise litter the environment. Maybe rapid lithification would be a good way to dispose of our detritus.

There is another upshot of the research. For decades, earth scientists have been disagreeing over whether to designate a new geological epoch called the Anthropocene, to recognise that humans have replaced natural processes as the dominant influence on the Earth system. I'm a big supporter of the concept because it underscores the extent of our perturbation of the natural processes that kept Earth habitable and safe for people for millennia. Last year, however, the International Union of Geological Sciences voted not to accept the Anthropocene because of a squabble over when it began.

Surely now is the time to reverse that decision. Our influence on the surface of Earth is literally laying down new geology, starting about 175 years ago. Future civilisations will be able to see it and study it. If that isn't a new geological epoch, then what is? ▮

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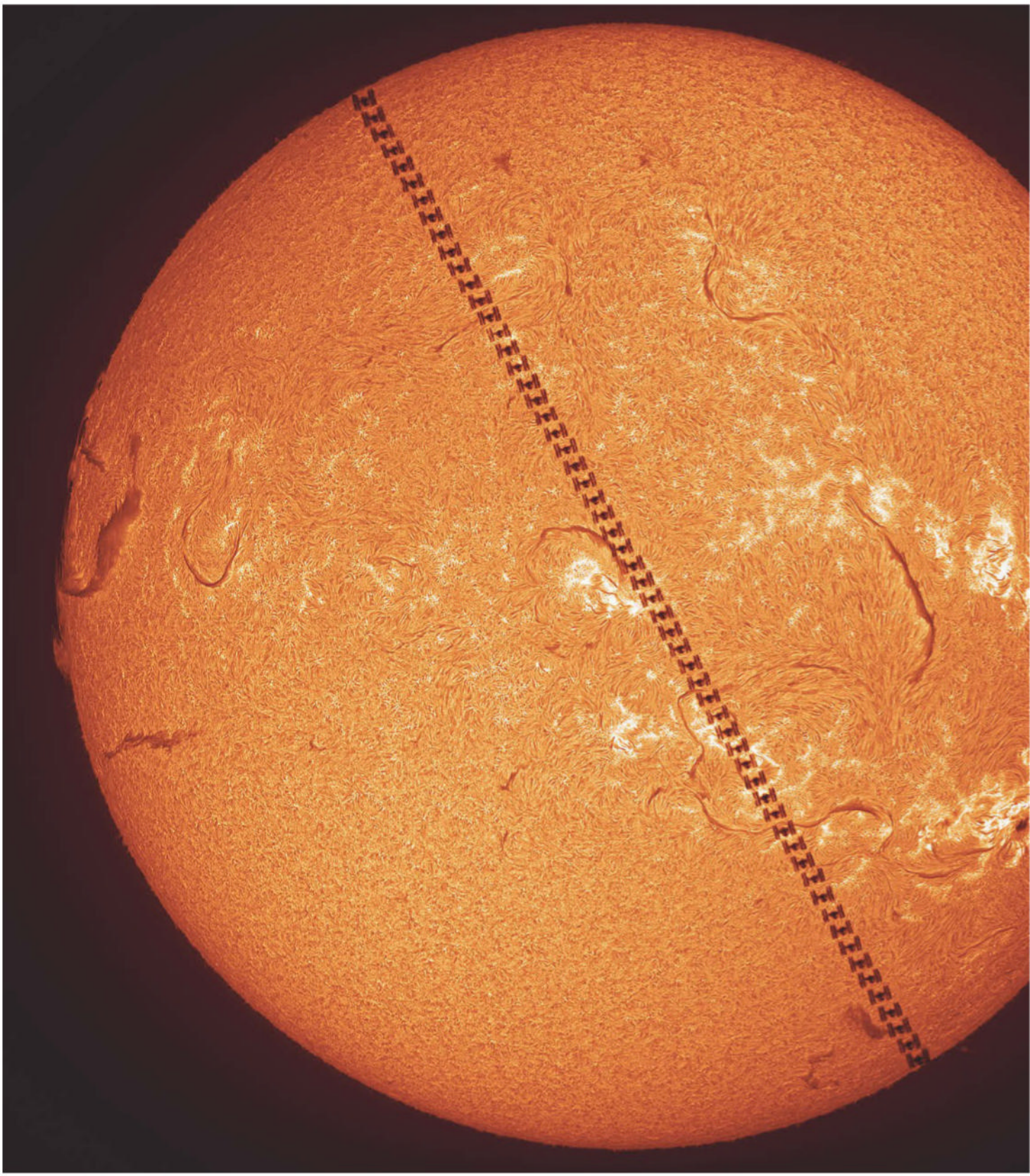
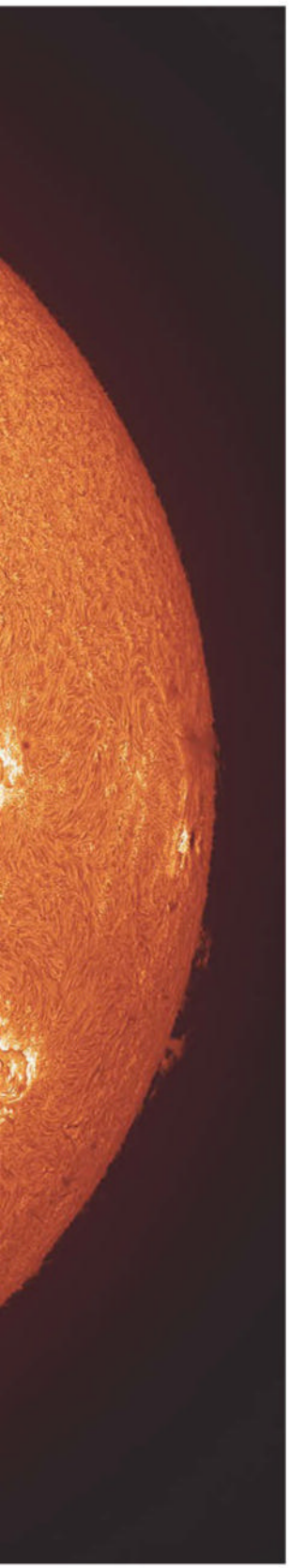


ENCOUNTER WITHIN ONE SECOND © ZHANG YANGUANG



CLOSE-UP OF A COMET © GERALD RHEMANN AND MICHAEL JÄGER

DRAGON TREE TRAILS © BENJAMIN BARAKAT

Starstruck

ZWO Astronomy Photographer of the Year, Royal Observatory Greenwich

THE International Space Station (ISS) scrolling across the sun, a relative close-up of a comet and an otherworldly tree framed by rotating stars are all shortlisted for this year's ZWO Astronomy Photographer of the Year contest.

At far left is Zhang Yanguang's *Encounter Within One Second:* a superimposed series of shots of the silhouetted ISS as it passes directly between Earth and the sun. The space station's large solar panels, which harvest energy from that very same star, are clearly visible. The photographer used two optical filters to isolate specific wavelengths and highlight crisp details of the sun's broiling surface.

Next, clockwise, is a close-up image of comet C/2023 A3 (Tsuchinshan-ATLAS) by Gerald Rhemann and Michael Jäger, taken from Namibia. Comets have two tails – one made of dust and one of gas – and here they appear to have almost overlapped due to high solar winds.

The final image is *Dragon Tree Trails* by Benjamin Barakat, taken in Firmihin Forest on the Yemenese island of Socotra. A dragon blood tree (*Dracaena cinnabari*) takes centre stage, framed perfectly by the starscape created by merging 300 individual exposures.

This year, the competition attracted more than 5500 entries from 69 countries. The winners in nine categories, two special prizes and the overall winner will be announced on 11 September and the winning images will be displayed in an exhibition at London's National Maritime Museum from 12 September.

Matthew Sparkes

Puzzled face...

Emoji add a new depth to communications, but what of their cultural impact? **Chris Stokel-Walker** hoped for more in an illuminating but flawed account

Book

Face with Tears of Joy
Keith Houston
W. W. Norton

IF A picture is worth a thousand words, then what of emoji, that ever-increasingly important part of our lexicon? *Face with Tears of Joy: A natural history of emoji* by Keith Houston has some insights, as it charts the story of these odd characters and how they infiltrated daily communications.

A history of emoji, where they came from and how they came to dominate our discourse is much needed, and Houston is a witty, pacey raconteur, taking us through their genesis and managing to excavate new nuggets that track them back a decade before their widely accepted birth date.

It is a clever device. By extending the family tree of emoji back into 1980s niche Japanese computer hardware, rather than their widely accepted origin, closer to the turn of the millennium, Houston brings insight that will be novel to many readers, whether or not they are obsessed with peppering their missives with emoji.

Standardising the look of the irrepressible emoji must have been tricky

Clearly, this book is deeply researched, as is clear from the moment you realise that Houston waded through the minutes of the various subcommittees of the Unicode Consortium, the standards body that quickly entered a power vacuum in the early 2000s to help social networks and phone providers ensure that images are depicted in a relatively similar way, wherever they crop up.

So what made emoji such a powerful cultural movement? While Houston can linger on producing a chronology of these images, he does begin to tackle the huge philosophical question of distilling the millions of perceptions of commonly used items into a single understanding across societies and cultures.

Take one short section on how Facebook users reacted to a video of the 2017 terrorist attack on Westminster Bridge in London. When readers wanted to leave a reaction, the platform only let them pick one of six emoji, none of which felt particularly apposite. Houston's writing here is really insightful.

Sadly, throughout the book, Houston backs away from digging deeper into such insights and experiments. He also fails to stay with the fascinating-sounding Unicode meetings, as decisions are taken on whether to admit images for tacos and other popular everyday items onto hundreds of millions of phones globally. Instead, we get a Wikipedia-style listing of events as they happened.

"Typewriter artists created images from keystrokes, a precursor to the emoticons that begat emoji"

This chronological approach is important, but it is also replicated in a separate timeline of around a dozen pages at the end of the book. Too often, it felt like you could read the bullet-pointed summary and learn as much about emoji and their history as you would if you had read the preceding 180 pages.

Which is a shame. Houston convincingly makes the case that emoji need to be studied carefully and their cultural impact taken seriously. It just isn't clear why we are given minute details in one example to the exclusion of others. We are told, for example, about the media reporting of Kim Kardashian's 2015 Kimoji app, which presented users with images of the reality TV star in different emotional states. It apparently had 9000 downloads per millisecond at its peak, writes Houston. He goes on to back a more realistic number reported by others – 9000 downloads per second. Why is this so important, except to fill space?

That said, there are some charming and illuminating nuggets about this still-quite-new means of communicating. Besides winding back emoji's big-bang moment, Houston unearths vignettes about early typewriter artists who created beautiful images from keystrokes, a precursor to the emoticons that themselves begat emoji.

All in, *Face with Tears of Joy* is a comprehensive and often illuminating read. But to me, it felt too often as if it was just filling pages that could have been more meaningfully filled with analysis of the "why" and the "then what" of the adoption of emoji, especially over the past two decades.

In the end, Houston's book is a valuable start on the cultural deconstruction of emoji. I will look forward to many more books on that subject in the future. ▮

CANER ELCI/ALAMY

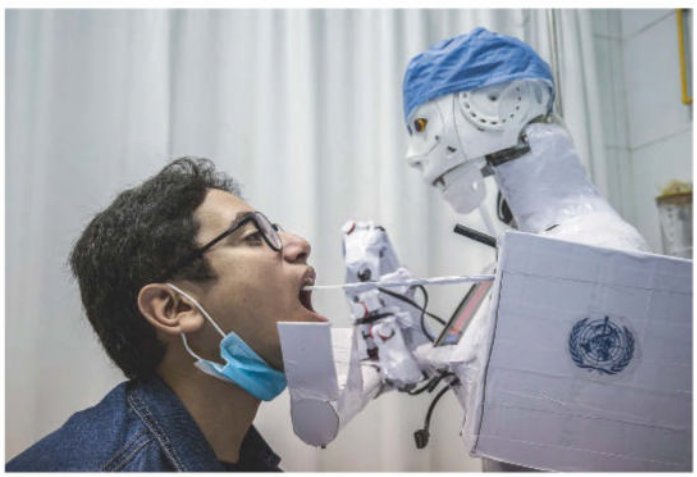
Chris Stokel-Walker is a technology writer based in Newcastle, UK

Making medicine shiny

Rebooting healthcare with fabulous tech seems irresistible. But where is the critical analysis, asks **Carissa Wong**

Book

Hacking Humanity
Lara Lewington
W. H. Allen:
UK, available now
US, 14 October



KHALED DESOUKI/AFP VIA GETTY IMAGES

Will robots routinely take cheek swabs in the future – and if so, how soon will this happen?

SMART toilets that track your gut health. Robotic pets that boost well-being. Mirrors that measure your blood pressure. It is hard to predict the future with any certainty, but, as a biomedical reporter, I was curious to read a book that envisions how fast-evolving technology could transform healthcare.

In *Hacking Humanity: How technology can save your health, and your life*, Lara Lewington draws on more than a decade of experience as a technology reporter at the BBC to cover an impressive array of innovations: from medical robots to lab-grown organs and genetic editing to treat certain conditions. "Let me show you the way to a future where we shall be hacking humanity," she writes in the introduction.

What follows is a whistle-stop tour through the hottest developments in medical research, brought to life through first-hand accounts of Lewington enthusiastically trialling cutting-edge devices, being scanned and taking blood tests. She also meets the characters and companies pioneering such innovations, helping put a human face to tools that often rely on artificial intelligence.

But, as someone who reads health news every day, I found the start of the book somewhat underwhelming. Covering wearable devices that track things like your sleep, exercise and blood sugar levels, Lewington explains what seems obvious to me: we can now monitor our bodies like never before and analysing this data could help doctors treat us more effectively. I would have liked more detail on how wearables might actually be integrated at scale in under-resourced healthcare systems.

Subsequent sections were more interesting, such as a look at how innovations like 3D-printed organs are actually helping scientists develop new medicines. I also enjoyed a passage that covers blood tests and AI models that are enabling earlier detection and more personalised treatment of cancer. If you are less familiar with weight-loss drugs and anti-ageing research, Lewington also provides an engaging rundown of both.

As a self-professed "tech optimist", Lewington presents a very upbeat view of the devices she encounters, often reeling off a series of impressive-sounding study results with relatively limited discussion of any caveats.

While this enthusiasm may be refreshing for some, I have seen countless supposedly "game-changing" technologies fail to deliver – and would have preferred a heavier dose of scepticism.

The book does end by acknowledging that the shiniest technologies are often only available to the richest. Lewington also stresses the need for tools to be tested on a more diverse range of people, including ethnic minority groups and women, who are often underrepresented in medical research.

However, I would have liked a more extensive discussion of how medical AI can worsen health inequalities and how we can avoid this, given how heavily this technology features throughout the book. Research has suggested that some wearable heart-rate trackers may work less well for people with darker skin. It would have been nice to have such cases woven between the promising results, along with expert opinion on how we can learn from them.

Overall, *Hacking Humanity* may be a good pick for someone who is looking for a quick summary of the most ambitious ideas at the forefront of medical innovation – but less so for those who are looking for a deeper, more critical analysis of where healthcare is heading.

New Scientist *recommends*

Gerardo Bandera
Deputy audience editor
New York

If you visit Paris, you must see Wolfgang Tillmans's **Nothing Could Have Prepared Us – Everything Could Have Prepared Us** at the Pompidou Centre (pictured), before it closes for a long refit.

The exhibition, on until 22 September, displays the artist's longtime dialogue with science, from neuroscience to astronomy. It is sited, appropriately, within the Public Information Library, where it interacts with its environment to ask big questions about the nature of knowledge.

The installation *Truth Study Centre*, for example, questions how

world views are created, with excerpts of research papers looking into the way the brain adapts to dishonesty placed next to newspaper cuttings full of propaganda.

Elsewhere, Tillmans draws our attention to the natural systems we are part of. Photos of turbulent seas and the polluting air vents of data centres highlight the climate crisis and our role in it. His show is a compelling take.

CAVAN IMAGES/ALAMY

A leap of good faith

Saving six of Earth's most endangered species is the mission for a new nature programme. It is a heartwarming call to action, says **Gregory Wakeman**

TV
The Wild Ones
Apple TV+

APPLE TV+

A Caucasian leopard, *Panthera pardus tulliana*, spotted in Armenia

THE WILD ONES, the latest nature documentary from Apple TV+, is an insider trip charting the work of three experts – and it is a series that rewards careful watching.

The opening narration points out that nature is in crisis: some 150 species are lost every day with millions more threatened. The mission here is to "find, record and protect" six of the most endangered, not only by opening the world's eyes to the animals concerned, but also by speaking to local officials about saving them from extinction.

We follow Declan Burley, a camera trap specialist, wildlife cameraman Vianet Djenguet and expedition leader Aldo Kane as they travel the world, struggling to capture images and videos of some of Earth's rarest creatures.

In the first of six episodes, we travel with them to the Malaysian jungle in search of a very rare tiger. In later episodes we are off to Mongolia's Gobi desert to find the Gobi bear, Indonesia to track down the Javan rhinoceros, Gabon for gorillas, Armenia to seek the Caucasian leopard and the North Atlantic for one of three species of right whale, *Eubalaena glacialis*.

The show uses cutting-edge technology, such as drones and thermal and night cameras, to get stunning footage of the animals and their habitats. Travelling deep into the Malaysian rainforest – a place so remote that more people have been to the moon than are known to have visited it – and 800 kilometres into the centre of the Gobi desert means that *The Wild Ones* reveals parts of the world never seen before on screen.

It really only works, though, if Burley, Djenguet and Kane have the emotional resonance to make viewers care about the animals and keep them invested. Luckily, they do. Whenever the group catches a glimpse of a limping leopard, a whale caught so tightly in fishing nets that it can't eat, or we learn that there are so few Javan rhinos left they have been reduced to inbreeding, it is impossible not to be left feeling heartbroken.

"Watching the three on-screen experts do their jobs impeccably will hook die-hard fans of the genre"

A particularly low moment comes deep in the jungle of Taman Negara national park in Malaysia, when Burley examines the footage from one of his tiny, hidden devices. At first, he is delighted to learn that they have shots of the elusive and critically endangered Malayan tiger, but his joy soon turns to despair when he spots that one of the animal's feet has been severed by a poacher's trap.

Back at camp, Burley shows the video to Djenguet and Kane. Burley is so connected to the animals that he simply can't help but become emotional, while a local expert explains that the image of the injured tiger is so powerful that it is likely to make people across the world take action. The trio know that is the reason they are there, but it doesn't hurt them any less.

This is television, however, so each episode's length means that, despite the very real emotion, *The Wild Ones* can drag in places, while the forced banter between its protagonists and occasional bits of over-dramatisation, such as equipment locked in a supposedly waterproof box getting wet, feel contrived and, at times, lessen the show's impact.

Thankfully, with each passing episode, Burley, Djenguet and Kane become more comfortable on screen, and while they lack the charisma and presence to keep viewers on the edge of their seats, watching them do their jobs impeccably will hook die-hard fans of the genre.

The programme is a rarity among nature documentaries because it provides an intimate and painstaking look at the ability to deal with the emotional turmoil, physical endurance and sheer patience that is required to make such shows. Literally dozens of cameras are sited in dangerous places, sometimes miles apart. They have to be repeatedly checked to ensure that any specific spot is, in fact, where the animals spend their time. And even when the team members pack up for home, they must return months later to collect the footage.

Ultimately, the dedication and ingenuity the three use to capture just a few seconds of footage of these endangered animals is what makes *The Wild Ones* worth watching. Especially when the results are so majestic and will, hopefully, play a vital role in keeping these species alive. This is a heartwarming call to action. ▮

Gregory Wakeman is a writer based in Los Angeles

Editor's pick

It isn't really science; it's natural philosophy

28 June, p 40

From Andrew Whiteley, Consett, County Durham, UK

Your perceptive article rightly contends that physics (and probably any area of human understanding) can't be done without metaphysics. This is because of the questions that are unavoidably raised around our view of the nature of reality. This is why I favour a return to the old term "natural philosophy" for science in its broadest sense, since the acquisition of evidence and the forming and testing of theories are only part of what scientists actually do and think about.

Some memories take a few days to recover

28 June, p 19

From Martin Whittle, Sheffield, UK

Memories that can't be recalled, but still influence us, surely have a close neighbour in those names or words that we know we know, but can't quite bring to mind. For me, the name of a person or place can sometimes escape my grasp just as I am about to say it. That name is then "on the tip of my tongue", but can't be recalled for a while, often for a day or two, after I have slept on it. I have often thought this would be consistent with some connection being broken, or neurotransmitter depleted, by the attempted recall, which has then to be reconnected or replenished in the land of nod.

We'll never totally escape the need for fertilisers

28 June, p 35

From Matthew Stevens, Sydney, Australia

The goal of incorporating symbiosis machinery in the roots of non-legume crop plants is worth the investment, but we can never "get rid of chemical fertilisers" totally. Even if we establish bacterial symbiosis in grass crops, for example, and then apply composted animal and human manure, to be able to produce enough food to feed the world's population, we must maximise the productive capacity of both fertile and marginal land.

As crop harvesting removes soil nutrients from the land, we have no choice but to replace them. Nitrogen-fixing rice and wheat would be an enormous boon, but we can't stop the loss of nutrients to the oceans, so we will at least have to keep applying phosphorus, potassium and trace elements.

It is commonly known as road tax for a reason

Letters, 28 June

From John Bailey, Blackwater, Hampshire, UK

I take issue with Ronald Watts's interpretation, in the debate about how to deter car use, of what parking charges are. I pay a tax to the UK government to put a motor vehicle on the public highway. Why would my payment apply only when my car is moving?

The Tarzan theory of language evolution

28 June, p 31

From Ros Groves, Watford, Hertfordshire, UK

Here is another idea about how language arose. As pitch-based communication is widespread among non-human animals, could language have developed from similar-pitched Tarzan-like calls specific to a tribe, by which they could identify its members? As we became more complex, a wider repertoire of melodic vocalisations was needed. Pitched sounds could then have been differentiated more acutely through their combination with consonant- and vowel-type inflections. Over time, the need to communicate both more quickly and more intricately could have evolved into an advancing rapidity of pitch change, with vowel and consonant sounds dominating. This developed into something more like language as it is now.

Corporate harm extends to psychological realm

7 June, p 36

From John Fewster, London UK

As some corporations continue to exploit and pollute the physical environment, so big tech media corporations are re-engineering the psychological environment. It is evident that they control and manipulate information for gain. Of course, it was ever thus, but current internet media power and reach now means that influence, for good or bad, can be bought, sold and spread in milliseconds. Damage may be less visible than when it is physical, but it is far-reaching, tending to produce and preserve destructive moral, political and economic models.

This AI certainly didn't understand the word no

31 May, p 16

From Christine Wolak, Huntersville, North Carolina, US

Regarding "AI doesn't understand the word 'no'". The AI-generated summary of trail users' comments for a particular trail in a popular hiking app said that there were ticks. But when I read through the comments myself, the only mention of ticks was that there were *no* ticks. This result really put a distrust of AI in me – what is the point of having a summary if it is wrong?

On the battle to keep risky tick bites at bay

21 June, p 36

From Ed Shields, Neebing, Ontario, Canada

I live in a very bad tick region and I spend hours each day outside always worrying about getting bitten. I was shocked by the idea that anyone wouldn't want a vaccine that worked in part by giving them an unpleasant reaction to a tick bite. A choice between getting a bad disease from a tick or simply getting an itch seems a no-brainer.

From Bob Masta, Ann Arbor, Michigan, US

Excellent article on ticks, and new approaches to controlling them and the diseases they spread. However, the sidebar on how to avoid them omitted a much more effective way to handle exposed clothing. Before washing, throw it in the dryer on high for at least 10 minutes. The clothes will get a lot hotter, and the dryness is better at killing ticks (or anything else).

Cronenberg woz 'ere first

28 June, p 28

From Todd Bailey, Penarth, Vale of Glamorgan, UK

In a review of Matt Wixey's *Basilisk*, you credit David Langford's 1988 story *BLIT* with the idea that mere exposure to certain images could cause physical harm. This reminded me of David Cronenberg's 1983 film *Videodrome*, in which a TV show induces brain tumours. Brings back memories of renting films on VHS tape.

Calling Earth, anyone home?

28 June, p 13

From Brian Reffin Smith, Berlin, Germany

A dead satellite gets struck by a micro-meteorite sending a signal to Earth. To an alien, that satellite could look a lot like a doorbell.

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Back from the dead?

Ambitious projects aim to put dire wolves and woolly mammoths back into our ecosystems. But do we really need them, asks **Michael le Page**

SARA GIRONI CARNEVALE

DIRE wolves were massive and highly intelligent animals nearly the size of a small horse, capable of ripping a man's arm off as easily as a dog kills a rat. They lived in cold regions in a place called Westeros… oh sorry, I'm getting confused with the fictional dire wolves in the *Game of Thrones* TV series.

The dire wolves that actually lived on Earth were no larger than today's biggest grey wolves, but with a sturdier build, bigger teeth and larger bacula, or penis bones. They probably ate now-extinct megafauna such as giant ground sloths. After thriving for many millennia, they went extinct around 10,000 years ago.

But now they are back. At least, a company called Colossal Biosciences is claiming the dire wolf is the first species to be brought back from the dead. It isn't the only animal being targeted for resurrection. Plans are afoot to do the same for the dodo, woolly mammoth, passenger pigeon, moa and more. But is it really possible to revive an extinct species? Such efforts also raise the question of whether – beyond the obvious appeal of seeing long-lost animals in the flesh – there are any good reasons to try this, and why organisations such as Colossal are spending vast amounts of money on it.

The idea of resurrecting an extinct species goes back at least a century. In Germany in the 1920s, there were attempts to recreate the extinct wild cattle known as aurochs through the selective breeding of their descendants, domesticated cattle – in part because it was thought cattle had been weakened by domestication. The result was an animal that looked a bit like a smaller aurochs. In the 1980s, there was a similar effort to breed zebras with the same coats as the quagga, an extinct subspecies of the stripe-covered plains zebra, which resulted in quagga-like specimens that lacked stripes on their hindquarters.

"But I don't think you can claim that that's a quagga," says Claudio Sillero at the University of Oxford. Breeding can create animals that physically resemble quaggas or aurochs, but genetically they aren't the same, he says.

These days, however, there are alternatives to selective breeding. What if you could get hold of the DNA from an extinct animal, put it in a living cell and create a clone of that long-dead individual? This, of course, is the idea that captured the public imagination when it was featured in the 1993 movie *Jurassic Park*. There is no formal scientific definition of "de-extinction", but this scenario – creating an identical copy of a long-extinct animal – is what many people understand by the term.

It is also supposed to be impossible. "None of the current pathways will result in a faithful replica of any extinct species, due to genetic, epigenetic, behavioural, physiological, and other differences," declared a 2016 report on de-extinction by the International Union for Conservation of Nature (IUCN).

"It's about definition," says Tom Gilbert at the University of Copenhagen in Denmark. "If your definition of de-extinction is bringing back an extinct animal, exactly – genomically – like the extinct form, then yes it's likely impossible." That is because for the vast majority of extinct animals, there is no way to recover a complete genome. There are always going to be gaps resulting from the degradation of DNA over time.

Resurrecting genes

However, there may be a few exceptions where animals went extinct very recently and we have well-preserved cells. In fact, in 2020 the US non-profit Revive & Restore used the cryopreserved cells of a black-footed ferret that died in 1988 to create three living ferrets that are clones of that long-dead individual. It did this by transferring the intact DNA from the frozen cells into living eggs.

"That's literal resurrection," says Ben Novak of Revive & Restore. "We've resurrected extinct gene variants for an endangered species."

It isn't de-extinction, however, because black-footed ferrets never died out completely. But at one point, there were just seven related individuals left, so cloning a non-related specimen massively boosted genetic diversity and, in turn, the species' survival prospects.

There have been a few attempts to revive extinct species using this kind of cloning. For instance, the last remaining bucardo – a subspecies of the Iberian mountain goat – died in 2000 after a tree fell on her. Her cells were cloned, and a bucardo was born in 2003 – but it lived for just 10 minutes, probably because of health issues related to cloning.

This is the closest we have got to true de-extinction, but even if the clone had survived, it wouldn't have been 100 per cent bucardo. A tiny proportion of its DNA came from the egg donor, in the form of cell organelles called mitochondria. And with no male bucardos – so no Y chromosome – there would have been no way to establish a pure breeding population.

We have cryopreserved samples of only a few other extinct species, such as the gastric-brooding frogs *Rheobatrachus silus* and *R. vitellinus*. These frogs, which incubate their eggs in their stomachs, died out soon after their discovery in Queensland in the 1970s. So far, efforts to clone them have been unsuccessful.

For extinct species where there are no cryopreserved cells, the only option is to turn to DNA preserved in bones and teeth, and sometimes frozen tissues found in permafrost. Last year, for instance, Colossal claimed to have obtained from a tooth a near-complete genome sequence of the thylacine, the Australian carnivorous marsupial (also called a Tasmanian tiger) that went extinct in 1936. We don't yet have the technology to turn that sequence on a computer back into DNA in a cell, but it should become doable in the future.

Because DNA breaks up over time, the longer ago a species went extinct, the more fragmentary any genetic sequence we can retrieve will be. This means there is no chance of creating exact clones of animals that went extinct much more than a century or so ago. And the most ancient DNA fragments sequenced so far are just 2 million years old. So, sorry kids: no dinosaurs.

With species that went extinct long ago, the question isn't only whether we can revive them, but also whether we should even try. After all, the world these animals lived in is long gone.

These kinds of issues were explored in the 2016 IUCN report. It concluded that we should try to recreate a lost species only when there ›

is a conservation benefit, such as restoring an ecosystem in which the animal had played a key role.

For this purpose, it doesn't matter if a revived animal is an exact copy of the extinct one, as long as it does much the same thing. In the jargon, this is called "creating a proxy of an extinct species for conservation benefit", and this is what some biologists mean when they use the term de-extinction. But creating an ecological proxy is a very different thing from *Jurassic Park*-style de-extinction.

Aurochs revival

In fact, for many purposes, living species are good-enough proxies. "We should always reach first to extant species as potential ecological replacements," says Philip Seddon at the University of Otago in New Zealand, who helped write the 2016 IUCN report.

So are the various de-extinction projects justified, according to this criterion of conservation benefit? Take aurochs, the extinct wild cattle. Large herbivores like this have an immense effect on landscapes, says Claus Kropp of the Auerrind Project in Germany. The huge quantities of dung they drop set off chain reactions involving many other animals and plants, and the deep hoofprints they leave in mud create habitats for animals such as frogs.

The cattle created in the 1920s breeding project, however, aren't even half the size of aurochs, says Kropp. So the Auerrind Project is again trying to recreate them via conventional breeding, but this time it has a better idea of what it is aiming for, given that we now have partial genome sequences from dozens of ancient aurochs. There is a similar project under way in the Netherlands.

Can't existing large cattle breeds do the same? Most modern breeds aren't suited to living outdoors year-round, says Kropp, and they also lack the forward-facing horns that helped aurochs defend themselves against predators. "We want to use the animals in regions where we have wolves," he says. "We want to give them the best possible chance."

Then there is the plan by Revive & Restore to create a bird that behaves like the extinct passenger pigeon. This will be done by modifying its closest living relative, the band-tailed pigeon.

Before they were wiped out, enormous flocks of passenger pigeons could deposit inches of guano on forest floors when they roosted in the trees above, says Novak. The thinking is that these disturbances shaped the nature of forests and boosted biodiversity.

"Even though there's lots of forest again today [in the eastern US], the composition of that forest is very different than it was in the past," he says. "We're starting an experiment in the next four to six weeks where we're going to spread guano on a forest site in Wisconsin, and then analyse that over some years."

The team estimates there is enough forest to support 2 billion passenger pigeon-like birds, says Novak – though whether people would welcome the return of such vast flocks is questionable.

Achieving this will be a huge technical challenge. For starters, modifying birds is especially difficult because no one has found a way to locate the DNA inside the giant cell that is the yolk of an egg – a problem Colossal will also face with its plan to "de-extinct" New Zealand's giant wingless birds called moas (see page 14).

Then there are the 25 million differences between the genomes of the band-tailed and passenger pigeons, says Novak, though he hopes only thousands of changes will be needed to recreate their key characteristics. The plan is to swap large segments of the band-tailed pigeon's genome with the equivalent parts of the passenger pigeon genome. These chunks will be chosen because they contain gene variants thought to be important to the behaviour of passenger pigeons, but the hope is many of the other variants on them will turn out to play a role, too.

"We don't necessarily know what all these mutations are doing, so our thought is, let's just get more in there," says Novak. "Let's say we only make a dozen changes, but they're all 100,000 base pairs in size; we will have accomplished tens of thousands of mutations that way."

Even if the project succeeds, scientifically the result will be a kind of hybrid between the band-tailed pigeon (*Patagioenas fasciata*) and the passenger pigeon (*Ectopistes migratorius*). For this reason, Novak has proposed the name *Patagioenas neoectopistes*: the "new wandering pigeon of America".

While Revive & Restore does sometimes talk about "bringing back the passenger pigeon" for the sake of ease, Novak is clear that recreating it isn't possible: "We cannot resurrect the original passenger pigeon. It's extinct."

In contrast, Colossal's attempt to make grey wolves more like dire wolves was much less ambitious. There are millions of differences between the two species, but the company made just 20 small changes to the genome of grey wolf cells, only 15 of which are based on the dire wolf genome. The altered cells were then cloned, resulting in the birth of three gene-edited grey wolves.

The 20 changes are intended to make the animals larger and more muscular, and their fur longer and white, rather like the dire wolves depicted in *Game of Thrones*. (The TV series was mentioned three times in the 7 April press release from Colossal.) It won't be clear until the three animals are fully grown how successful the attempt to change their shape was, says Colossal's chief scientist Beth Shapiro. "We have to wait until they're older to get the scans that we need."

However, rather than describing these animals as a kind of hybrid, as Novak plans to do for the pigeons, Colossal continues to claim they are "the world's first successfully de-extincted animal".

Plans are afoot to revive the passenger pigeon using genetic engineering

CHRONICLE/ALAMY

JEAN-MARC ZAORSKI/GAMMA-RAPHO VIA GETTY IMAGES

COLOSSAL BIOSCIENCES

Above: Will woolly mammoths one day roam the Arctic again? Left: One of the "dire wolf" pups created by Colossal

"With those edits, we have brought back the dire wolf. We have been using the concept of functional de-extinction from the beginning, and that is what Colossal achieved," the company said in a statement to *New Scientist*.

But not only are these gene-edited wolves very far from being exact genetic copies of dire wolves, there is also no evidence they can perform an ecological role that's different from grey wolves'. Even if they could, with no megafauna larger than bison left, there is no gap for them to fill. What's more, Colossal has no plans to release the gene-edited grey wolves – one of the many potential issues is that they could interbreed with normal grey wolves.

The scientific verdict is clear. "The three animals produced by Colossal are not dire wolves. Nor are they proxies of the dire wolf," said a statement put out by the IUCN's expert group on canids.

By swapping more chunks of the grey wolf genome for dire wolf ones, as Novak plans to do with the pigeons, it would be possible to create "hybrids" that have more dire wolf DNA than the three modified grey wolves. With enough effort, it might even be possible to create hybrids that are closer to dire wolves than grey wolves. But with Colossal claiming the task of reviving the dire wolf has already been achieved, it seems unlikely for the company to do this.

The issues with Colossal's plans to "de-extinct" the woolly mammoth by modifying elephants are similar to those with the dire wolf. Again, the result will be some kind of hybrid between elephants and mammoths – probably more elephant than mammoth – and the need for them is unclear.

Proponents often say large herbivores could help slow the loss of permafrost in parts of the Arctic. Indeed, one small study found that permafrost stays colder when large animals flatten snow, so it no longer acts as a blanket insulating the ground from the cold air above.

But horses could also do the job, says Richard Grenyer at the University of Oxford. "There's very good science suggesting you don't need mammoths," he says. "And the biggest problem is the scale. The sheer amount of land required to make any difference [climate-wise] is beyond anything we've ever seen in any conservation project."

There is also the question of why a for-profit company like Colossal is putting so much effort into de-extinction. How is it going to make back the vast sums it is spending? Grenyer, for one, can't see how the company can do this from de-extinction alone. He suspects that this is more about developing new technologies than de-extinction, and that the dire wolf project is just a showcase for the company's genetic modification skills.

"This isn't a de-extinction business; they won't be bringing a whole thing back from the dead ever because that's not what they do," suggests Grenyer. Colossal, of course, claims it has already done exactly that.

The company makes no secret of the fact that it aims to profit from spin-off applications. It says its research could lead to advances in everything from IVF and drug discovery to regenerative medicine and "genetic enhancements". "We have a 17-person team that's working on a fully exogenous artificial womb that could have broad application," says Shapiro.

All the biologists *New Scientist* spoke to for this article agree the company is making significant advances. But if you are hoping for *Jurassic Park*, your best bet is still the movie version. ▮

"We cannot resurrect the original passenger pigeon. It's extinct"

Michael le Page is a reporter at *New Scientist*

Hidden magnetism

The discovery of a new type of magnetism could help us solve a long-standing problem in computing, finds **Jacklin Kwan**

LIBOR ŠMEJKAL has a fondness for the artwork of M. C. Escher, whose work was often inspired by mathematics. One of Šmejkal's favourite pieces is *Horseman*, a striking picture that features an elaborate, tessellating series of mounted figures. Strangely enough, it was this piece that inspired him to predict the existence of an entirely new kind of magnetism.

We have known of magnets for millennia. Today, they are at the heart of a raft of modern technologies, from electric generators and smartphones to loudspeakers and hospital scanners. And yet for 100 years, we have been missing something about them. We always assumed there were only two types. It was Šmejkal's art-inspired insights that finally gave the lie to that in 2022.

Fast-forward to today, and we know that what Šmejkal called "altermagnets" aren't just an idea. We have discovered real examples and are working out how to make this new kind of material in practical and useful ways. There is even a possibility that these magnets could help us build a completely new kind of computer. "Altermagnets could actually have all the functionalities of current devices, but much faster, with less energy consumption, and smaller," says Šmejkal.

To understand magnetism and why it is so important, we need to start with the electrons that whizz around in atoms. Each of these particles has an intrinsic quantum property called spin. This isn't quite like anything in the everyday world, but you can imagine it as a tiny spinning top that can rotate in two directions, which scientists label "up" or "down".

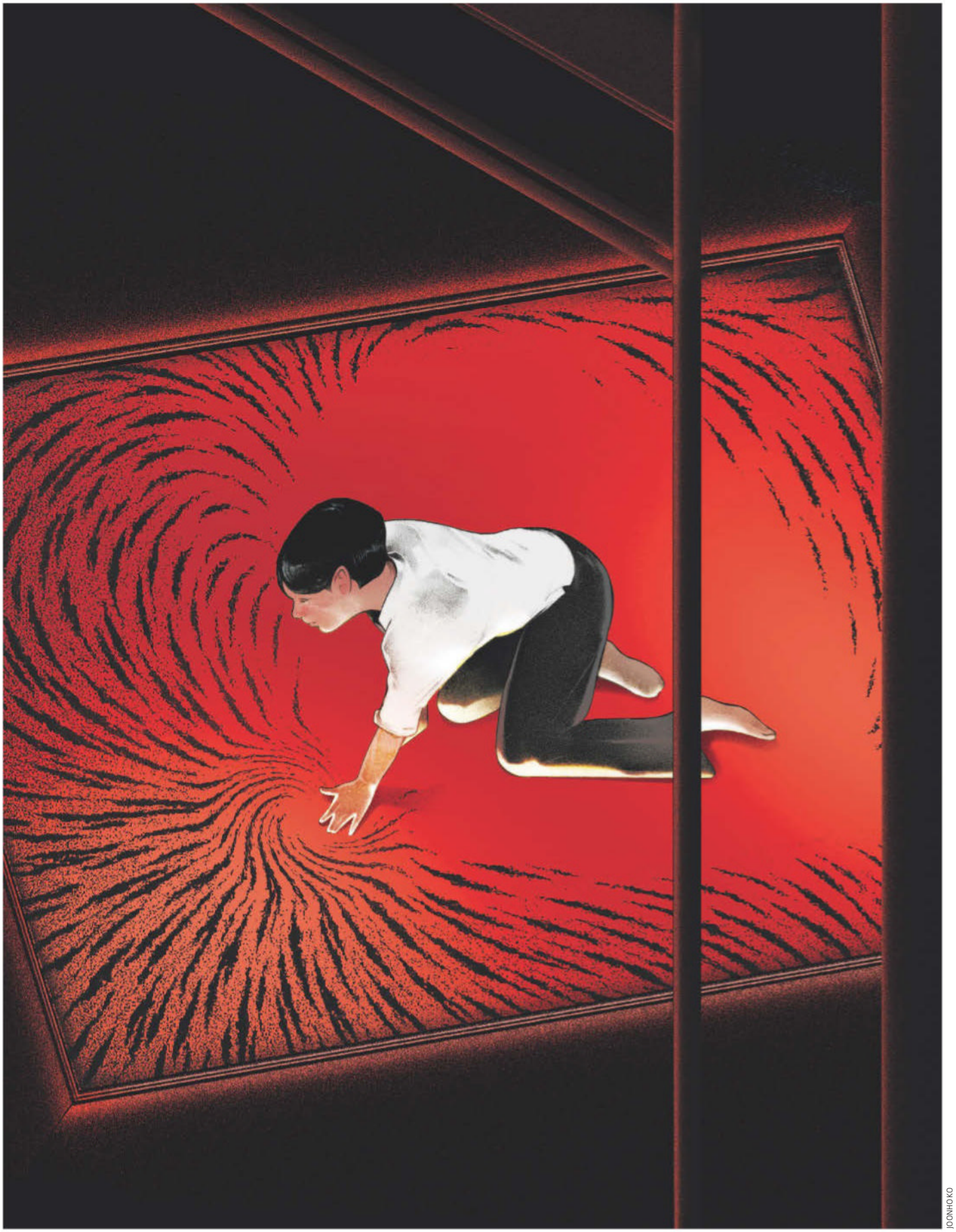
Electrons like to orbit their atoms in pairs, one spin-up, one spin-down, so the spins cancel out. But that isn't always possible, as an electron sometimes ends up alone. With nothing to cancel it out, the unpaired electron gives the atom what is known as a magnetic moment: like spin, it can either be up or down, and it governs the atom's magnetism. If you have enough atoms with magnetic moments pointing in the same direction, they create a strong, directional magnetic field. This is called ferromagnetism. It is a phenomenon that even the ancient Greeks knew about – they found rocks that attracted iron nails or filings to them – and it is also what is going on inside the magnets many of us have stuck to our fridges.

Ferromagnets are easy to spot because they attract or repel other magnetic materials, like nickel or cobalt. But there is another, more subtle kind of magnetism that wasn't discovered until the 1930s. Antiferromagnets also have magnetic arrows, but this time they point in alternating directions – picture a line of arrows going up, down, up, down and so on. The result is a magnetic stalemate, a solid with magnetic order on the atomic level, but no unified, detectable magnetism on the scale of ordinary objects.

The mental model of imagining tiny arrows pointing up and down inside magnets was invented by physicist Louis Néel, who theorised the first antiferromagnets – which were experimentally confirmed in the decades following – and who won a share of the 1970 Nobel prize in physics.

That's how things have stood for nearly 100 years: two types of magnetism, nice and neat. It was 2018 when Šmejkal, who is now based at Johannes Gutenberg University ›

"Altermagnets could have all the functionalities of current devices, but much faster"



JOONHO KO

Mainz in Germany, began to suspect there might be more to the picture. At the time, he was a young PhD student in Prague, Czech Republic, studying a strange phenomenon sometimes seen in antiferromagnets called the anomalous Hall effect. Šmejkal's breakthrough was to realise that this effect and similar arcane magnetism puzzles couldn't be explained with the model that Néel had developed – he needed to go beyond it.

This is where Escher's 1946 horsemen artwork came in. The riders in the image slot together in alternating colours with an elaborate, beautiful symmetry. Take one of the lighter figures, flip it, shift it sideways a jot and change its colour, and you match one of the darker riders. As he mused on this, Šmejkal realised there was an alternative mathematical method for describing this symmetry operation. "I realised that you can actually define this operation, this changing of colour or orientation, in another way," he says.

A matter of symmetry

And here's the thing: understanding symmetry has always been crucial in physics, and this is particularly true in materials science, where the intricate relationships between different kinds of atoms are best described in that language. Indeed, Néel's way of thinking about atoms' magnetic moments has symmetry at its core. But by using his new mathematics as a framework, Šmejkal began to extend Néel's model, firstly by thinking in three dimensions instead of two and secondly by including atoms with no magnetic moment in the picture.

As he did so, a new possibility began to emerge. You could still have neighbouring atoms with magnetic moments that point in opposite directions: up, down, up, down, as in antiferromagnets. But every alternate atom would be rotated by 90 degrees, hence the name altermagnet (see "A third kind of magnet", right). Šmejkal says this rotation can happen as a result of magnetic atoms existing in a sea of non-magnetic atoms. Though the arrows still alternate in pointing up and down, the rotated atoms give rise to a subtle effect that enables some magnetism to leak through.

This had all started as an attempt to solve a particular set of puzzles in magnetism, but Šmejkal says it amounted to something much grander: it predicted that a whole new kind of magnetism was possible. Altermagnets would have no net magnetism, like antiferromagnets, but they would have some of the quantum properties that make ferromagnets so useful in technology. In 2022, Šmejkal and his colleagues published what he calls a "complete mathematical framework" of altermagnetism. "The whole community was quite excited because these systems seem to combine the prized advantages of ferromagnets and antiferromagnets," he says.

The world only had to wait two years before the prediction was confirmed. In 2024, Juraj Krempaský at the Paul Scherrer Institute in Villigen, Switzerland, and his colleagues studied manganese telluride, a compound thought to have the right structure to produce altermagnetism. To check if it did, they used light beams to track the precise movements of electrons inside the material – and these turned out to closely match simulations of what would be expected for an altermagnet.

The discovery of a third kind of magnetism is huge in its own right, but what makes it even more exciting is that it could solve a long-standing technological problem. To see why, we need to know a little about how computers store information. Today, they tend to do so in chips, essentially through the presence or absence of electric charge to signify a digital 0 or 1. But researchers have long been interested in the idea of using magnetism to store information, too – floppy disks, which were used in the 1990s, worked on magnetic principles. A more recent concept called spintronics takes things a step further:

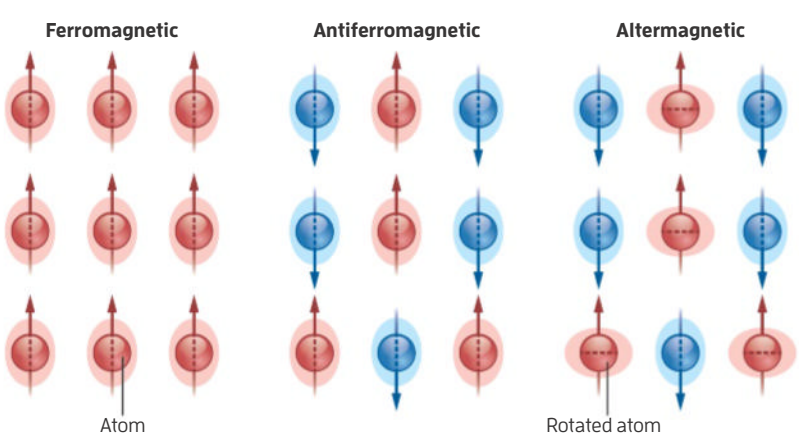
"These magnets could help us build a completely new kind of computer"

the idea would be to use not just the presence or absence of electric charge, but also the spin of the electrons too.

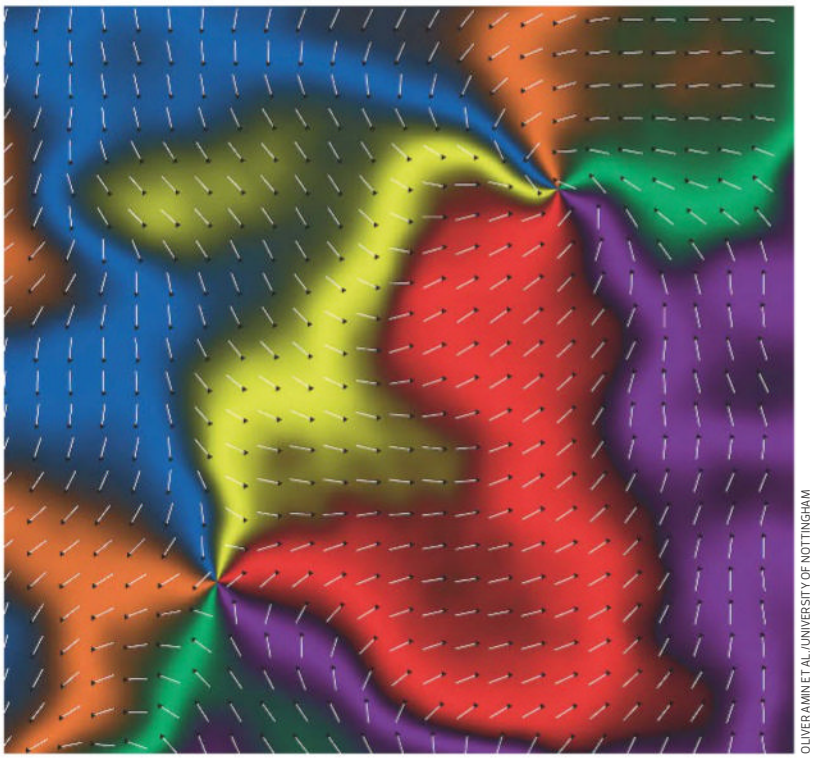
In theory, spintronics would enable us to cram much more information into computer memory, making it more efficient. But there has always been one big problem. For it to work, we need materials in which the up and down spins can be split into separate strands. Anna Hellenes, who works in Šmejkal's university research group, likens it to a ballroom full of dancers. In a non-magnetic material, all the couples waltzing clockwise

A third kind of magnet

Magnetism hinges on a property of atoms called magnetic moments, represented below by arrows. In ferromagnets, the magnetic moments are all aligned, and in antiferromagnets, they alternate. In a third, recently discovered kind of magnetism called altermagnetism, every other atom is rotated



MARK PETERSON/CORBIS VIA GETTY IMAGES



OLIVER AMIN ET AL./UNIVERSITY OF NOTTINGHAM

Far left: Spintronics has been likened to a ballroom dance floor
Left: A nano-scale map of manganese telluride showing the swirling patterns inherent in altermagnetism

or counterclockwise – the electrons spinning up or down – remain mixed on the dance floor. "But if we now have spin-splitting, these dancers spinning in one direction can separate from the others spinning in the other, and dance separately," she says.

The problem is that this spin-splitting effect, the bedrock of any spintronic device, was only found in ferromagnetic materials. This made sense because all the arrows in a ferromagnet point the same way, so electrons whose spin points in the direction of all those cumulative arrows are in a slightly different environment than those with spins pointing the other way. But if you try to cram lots of ferromagnets onto a tiny chip, they do exactly what you might expect: attract or repel each other. As a result, says Hellenes, spintronics has hit a ceiling.

Could altermagnets step into the breach? "This unique combination of features from altermagnets – no net magnetisation, but still spin-split bands – could be very advantageous for potential spintronic devices," said Igor Mazin, a physicist at George Mason University in Virginia.

Since it was confirmed that manganese telluride was altermagnetic in 2024, researchers have been busy trying to create new materials that have this curious property. One trick is to take a known antiferromagnet and apply mechanical strain to it in the hope of deforming the internal magnetic symmetry and coaxing altermagnetism into being. In 2024, researchers led by Atasi Chakraborty, a member of Šmejkal's research group, demonstrated that applying compressive strain to rhenium dioxide – long known to be an antiferromagnet – triggers a transition into an altermagnetic state.

What's more, a trio of researchers at the Beijing Institute of Technology in China realised that you can also create the right internal magnetic disturbances by stacking an antiferromagnet between layers of a different material, like a sandwich. The top and bottom layers induce internal electric fields that mimic the crystal environment of naturally occurring altermagnets.

Bona fide altermagnet

However, researchers tend to feel that these clever tricks may not lead to scalable altermagnets anytime soon, as the methods are difficult to pull off. Instead, it seems more likely that we can find practical altermagnets by looking at naturally occurring ones. "For the vision for altermagnetism over the next 10 years, I could quite easily see these materials becoming commercially viable," says Oliver Amin, a researcher at the University of Nottingham, UK, who created the first experimental image of manganese telluride after it was confirmed as an altermagnetic material. In a paper published in December, his team demonstrated that researchers could not only see the structures that gave this material its magnetic properties, but also control the direction and layout of them by heating and cooling the material in a magnetic field. "This is the first step towards realising these materials as practical materials for devices," says co-author Alfred Dal Din at the University of Nottingham.

We have good computational models of the kinds of atomic structures that are likely to exhibit this new magnetism, and Šmejkal and his colleagues used them to digitally comb through possible materials. They have identified at least 200 candidates, published shortly after their landmark altermagnetism paper. Confirming all those candidates experimentally will take time, but we already know that, other than manganese telluride, there is also strong evidence that ruthenium dioxide is an altermagnet.

Other than being the only certified, bona fide altermagnet, manganese telluride is an established material that scientists know how to grow in the lab at high qualities – the primary hurdle for many experimentalists. "The form of manganese telluride we're working on now has been studied in the form we're looking at for at least 20 years, probably more," said Amin.

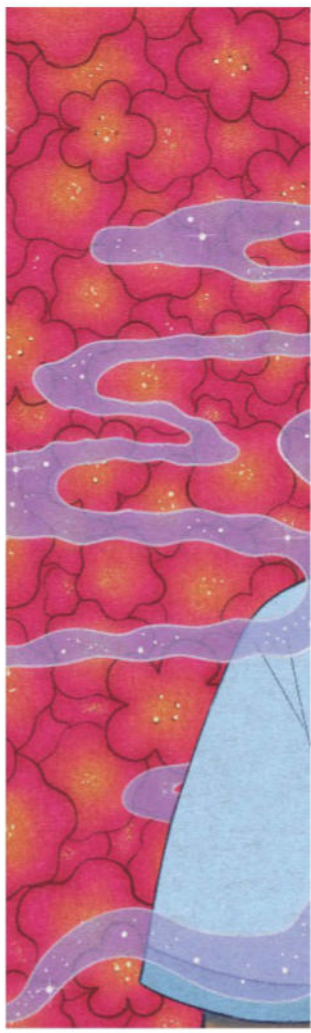
Just as researchers rush to get to grips with altermagnets, Šmejkal has another surprise up his sleeve. In a paper that hasn't yet been peer-reviewed, he and his colleagues predict the existence of yet another kind of magnetism, which he calls antialtermagnetism.

In materials with this strange property, neighbouring spins don't just alternate up and down like in an antiferromagnet, they also form zigzags. Picture tiny arrows lying next to each other, the first pointing north-west, then north-east, then south-east, then south-west – tracing out a zigzag. The neighbouring arrows are mirror images of each other, so that adding up the directions across all the mirrored pairs will cause them to cancel out, as happens in antiferromagnetism. But the mirrored pattern subtly reshapes how electrons move through the material in such a way that also causes spin-splitting, says Šmejkal.

The idea of antialtermagnetism builds on the complex and beautiful symmetries that Šmejkal was so taken by early on in his work.

Perhaps we can say magnets are like one of those Escher artworks that he likes so much – the more you look, the more delightful details you notice. ▮

Jacklin Kwan is a features editor at *New Scientist*



"Shamanism, at its heart, is a means of dealing with uncontrollable events"

Manvir Singh has spent years exploring why shamanism is so enduring. He tells Kate Douglas about the psychology behind its apparent healing effects, how its origins are being traced and why the tech sector might be a natural home for a modern equivalent of shamans

SHAMANISM seems to be having a moment in the Western world. According to the UK's most recent census, the number of people in England and Wales describing their religion as "shamanism" increased more than tenfold between 2011 and 2021.

Admittedly, that is still only 8000 individuals – up from 650 – but given that the number saying they had "no religion" rose by almost 50 per cent during that time, it is striking. What's more, surveys in the US suggest that hundreds of thousands of people there consult shamans regularly.

What is the appeal of shamanism? And what explains its current surge in popularity? These are just two of the intriguing questions anthropologist Manvir Singh at the University of California, Davis, explores in his new book *Shamanism: The timeless religion*. Raised as a Sikh, his interest in the subject was ignited when he first visited the Mentawai Islands in Indonesia and experienced the charisma of local shamans, their experientially vivid ceremonies and the central role they play in medical and spiritual life. Since then, he has spent a decade studying shamanism in a range of Mentawai communities and in the Colombian Amazon.

Shamanism has deep roots, probably dating back to the Stone Age, and the fact that it has emerged independently, time and again, in almost all societies seems to say something about the human mind.

As well as studying its rituals and effectiveness in modern hunter-gatherer groups, Singh also sees evidence for it historically. He argues that Jesus was probably a shaman and that it crops up in surprising places today, including tech CEO culture. What he has discovered is a rich seam of experience with implications not only for contemporary spiritual life, but for modern medicine and healing as well.

Kate Douglas: What exactly is shamanism?
Manvir Singh: That has been debated for decades, but I define shamanism as a practice in which a specialist enters altered states to engage with unseen realities or agents and provides services like healing and divination.

NATALIE FOSS

Is shamanism different from religion?
People have long tried to draw a line, confining shamanism to the realm of superstition or magic. But it's very hard to defend a distinction between shamanic and religious traditions, except by looking at how codified, centralised or hierarchically organised they are. If you're asking whether shamanism exhibits the features common to all religious practices – engaging with supernatural agents to procure blessings and avoid misfortune – then shamanism is religious at its core.

Does shamanism differ from place to place?
Very much so. One difference is the method of inducing trance. Mentawai shamans have public ceremonies, sometimes lasting all night, in which musicians play drums and the shamans dance. In eastern Colombia, and particularly among the Piaroa, the healing ceremonies are much more private, and trance is induced through psychoactive substances such as a psychedelic snuff made from a plant called yopo (*Anadenanthera peregrina*). The number of shamans also differs. Many Piaroa villages, including large ones, do not have shamans. Mentawai villages, meanwhile, can have many shamans. The community where I've worked the longest has at least 20, and some are considered more powerful than others.

How old is shamanism and how can we know?
I argue that as long as people have been behaviourally modern, we've had shamanism – so, that's probably at least 100,000 years. Archaeologists point to a couple of lines of evidence to claim prehistoric shamanism. One is rock art, especially of human-animal hybrids, which are sometimes said to portray shamans. They've also interpreted some elaborate burials – such as graves containing women with physical differences or notable headdresses made of teeth and bones – as potential Palaeolithic shamans.

But the archaeological record is much more open to interpretation than we would like. In my view, the best evidence for shamanism's antiquity is its ubiquity. Not only is it found around the world among the vast majority of hunter-gatherers, it's also incredibly difficult ›

to destroy and, when that does happen, it reemerges very easily. Psychological research suggests that it taps into universal features of the human mind.

What aspects of the human mind does it tap into?
Three main psychological capacities are involved. The first two are shared with religion more generally. There's our predisposition to feel that uncertain events are influenced by invisible agents – gods, spirits, witches, etcetera.

The second is our reliance on ritual – the willingness to engage in low-cost interventions to influence high-stakes outcomes. This manifests every day in superstitions and across religious traditions in practices like prayer. But what's critical for shamanism in particular is the intuition we have that when people seem essentially different from normal humans, we're more likely to accept that they have special powers.

Is this why altered states and trance are central to shamanism?
Yes. I understand trance foremost as a compelling performance for both the practitioner and the audience. That might sound like it's a deliberate put-on, but that's not quite right. Instead, trance is a powerful demonstration to everyone involved that this is a different state of being where one can access special powers. It's the profound departure from normal experience that makes trance hyper-compelling.

Are there other ways in which shamanism builds on our thinking about the supernatural?
Dualism is important as well. Cognitive scientists of religion write about intuitive dualism: we readily entertain the notion that minds or souls or some kind of essential substance exists separately from the material realm. Zombies, in a way, are bodies without minds. Spirits are minds without bodies. Dualism underlies much of shamanic ritual, including during soul journeying, when the shaman's soul is understood to leave their body, and possession, when a soul or spirit enters.

Do shamans – and their audience – believe in their powers?
It's complicated. On the one hand, shamanism can involve deliberate sleight of hand, such as pretending to extract an object from a sick person that is supposedly causing their illness. Shamans sometimes acknowledge that. On the other hand, they go to each other when they are sick or have a sick child, apparently because they consider the ceremonies to be effective. But audiences are not gullible and unreflective. Where I've worked, people will say things like, "His trance isn't real" or "He doesn't actually know the songs". There's a constant conversation about who is authentic. At a higher level, though, people tend to accept shamanism more generally – that, although some people are faking, there exist individuals who truly have these powers.

You suggest that Jesus was probably a shaman. Why?
I draw on a couple of lines of evidence. The first is that, during the classical period, the eastern Mediterranean was a very shamanic place. As far as we can tell, many of the Hebrew prophets were shamans. Greece had shamans in the form of their oracles. And ancient Mesopotamia – the neo-Assyrians, for example – had them too.

The second concerns the three defining features of shamanism: engagement with unseen realities, services like healing and divination, and altered states. It is very clear that Jesus displayed the first two. He's battling demons, communing with the Holy Spirit often for the purposes of healing; he's also divining about what will happen in the coming days. Whether he also entered altered states is a highly debated topic. But the canonical gospels – the best records we have of his life – contain passages that are very suggestive.

KEVIN FRAYER/GETTY IMAGES

MARK FOX/ALAMY

Left: A Mongolian shaman takes part in a fire ritual. Below: The psychoactive beverage ayahuasca is used in some shamanic traditions

CHARTON FRANCK/HEMIS.FR/ALAMY

A neo-shaman facilitates a purification ritual in Utah

Does shamanism work – at least when it comes to healing?
Originally, I was sceptical. Now, after studying the topic for a decade, I'm convinced it provides therapeutic benefits in three general domains.

First, shamanism is potent for inducing the placebo effect: it's immersive and involves empathy, both of which have been shown to alleviate pain.

Second, shamanism creates powerful experiences that can help patients escape from harmful self-narratives. And finally, it is social. If nothing else, it provides an assurance that you are loved or cared for, and that people are fighting for you.

How does a shamanic trance compare with modern psychedelic therapy?
People often talk about psychedelic-assisted psychotherapy as echoing some long-standing shamanic tradition. But historically and across cultures, it is usually the practitioner, the shaman, who enters an altered state, whereas in clinical settings, it is the patient. Nevertheless, both seem to heal patients by altering harmful beliefs through subjectively profound experiences.

What can modern medicine learn from shamanic healing rituals?
The most striking difference between shamanic healing – at least as it's performed among the Mentawai – and healing in other contexts is how festive and celebratory it feels. It has led me, at least, to reflect on the value of making healing feel less sombre and more social.

Who are the shamans in today's Western cultures?
Three contexts come to mind. First are the most obvious examples: neo-shamans, or people who understand themselves to perform shamanic rituals. Neo-shamanism is a peculiar movement with an idiosyncratic intellectual history, but in terms of the practice, it is shamanism, and we can study it as such. Second are what I call hedge wizards. They are not technically shamans because they don't enter trance. But they promise control over some uncertain outcomes and make a profession of it. The quintessential example is the money manager, who essentially divines the future of a chaotic and ultimately unpredictable system – the market.

Third is tech CEO culture. A critical feature of shamanism is the use of practices like ordeals, initiations and trance to seemingly depart from normal humanness, making claims of special powers more credible. You find this a lot in tech CEO culture, with people engaging in classically shamanic techniques such as deprivation and the consumption of psychoactive drugs. They probably partly do it for themselves. But such behaviours also serve a performative function, projecting a sense that these CEOs can do things their competitors cannot, that their companies are the ones to invest in and that they are prophetic seers who can achieve the miraculous.

Why are so many people embracing shamanism?
A couple of reasons. Many people have become disenchanted with organised religion, but nevertheless have a strong desire for spirituality. This gap makes shamanism compelling because it is useful, intimate and very direct. There's also a potential role for rising uncertainty. Shamanism, at its heart, is a means of dealing with uncontrollable events, so it has a big draw during times that feel unpredictable.

In your book, you say that other religions find shamanism threatening. Why do you think that is?
Shamanism allows people to have direct, often mystical relationships with the divine. That threatens organised religion – not just because shamans compete for supernatural authority, but also because they can introduce new doctrine or dogma. When religious authority is centralised, only a select few can mediate the divine and establish orthodoxy. Shamanism threatens any control organised religion might have.

How has studying shamanism changed your own ideas about religion?
It's made me focus less on belief and more on experience. The way we talk about religion often prioritises belief and faith. Yet human societies have developed these powerful practices to induce mystical experiences, and I better appreciate how engaging in them can be meaningful and therapeutic, regardless of whether, on a reflective level, I always buy into the metaphysical claims. ▮

Kate Douglas is a features editor at *New Scientist*

The back pages

Dear David

On the dark side

We are all talking about so-called "dark empaths" – but how would we know one if we met one? **David Robson** examines the science

David Robson is an award-winning science writer and author of *The Laws of Connection: 13 social strategies that will transform your life*

Further reading

If you suspect you are dealing with domestic abuse, you can find support in the UK: nhs.uk/live-well/getting-help-for-domestic-violence/

In the US, you can seek help from the Natonal Network to End Domestic Violence: nnedv.org/get-help/more-information/

For other forms of abuse, you can find support and information from the National Bullying Helpline: nationalbullyinghelpline.co.uk/

Dear David, an evidence-based advice column, appears monthly. Drop David a line with your social dilemmas at davidrobson.me/contact

Next week

Stargazing at home

MANY of us love a new way of labelling the people in our lives, and over the past few months you might have noticed rising interest in "dark empaths". "They seem sensitive and caring – but really they just want to manipulate you," *The Guardian* recently wrote, while TikTok influencers frequently declare it to be "the most dangerous personality type".

This month, a reader asked me to clarify the science behind the buzzword. What characterises a dark empath? And how would we know if we meet one?

The concept arose from research examining the so-called dark triad of personality traits: psychopathy (callous, anti-social behaviour), narcissism (excessive self-interest and entitlement) and Machiavellianism (a penchant for manipulation). For a long time, the dark triad was thought to coincide with a lack of care and concern about other people.

That changed with a landmark 2021 paper by Nadja Heym and colleagues at Nottingham Trent University, UK. Assessing nearly 1000 participants, they confirmed that many people exhibiting the dark triad lack the ability or inclination to place themselves in others' shoes. But a significant subset – around 175 – had high levels of psychopathy, narcissism and Machiavellianism, while nonetheless also doing very well on a standard measure of empathy. They reported being sensitive to how awkward others were feeling, for instance, and claimed that people's emotional states had a strong effect on their own mood.

LUC KORDAS/MILLENNIUM IMAGES, UK

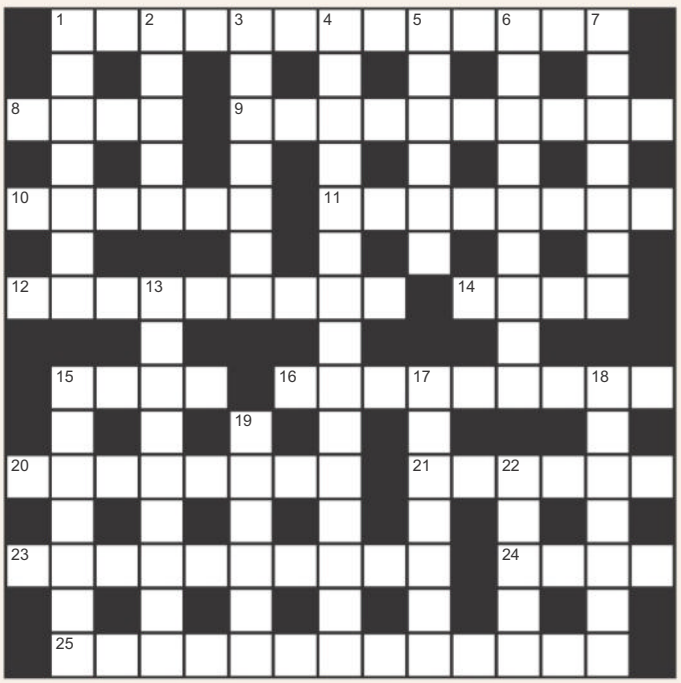
Heym and her team labelled these people "dark empaths". Further analyses suggested these people tend to be less aggressive and more extroverted than their less empathetic counterparts, but they demonstrated considerably more hostile behaviour than the average person. The dark empath, the researchers concluded, "partially maintains an antagonistic core", despite their gregarious exterior – a wolf in sheep's clothing.

The finding raises many questions. Psychologists distinguish cognitive empathy (the capacity to think through others' point of view) from affective empathy (the visceral feeling that comes from seeing another's emotions). It isn't yet clear whether dark empaths show a preponderance of one over the other. Nor do we know how their behaviour differs from situation to situation.

While I am curious to know the answers to these questions, this research doesn't yet tell us much about the ways to deal with these people. For now, I'd keep looking out for the classic red flags of toxic behaviour – such as attempts to keep you on an emotional knife edge through flattery and threats – and find ways to establish new boundaries. Labels like "dark empath" may sound sexy, but their actions are just as ugly as your garden-variety bully's. ▮

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

Cryptic crossword #166 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Intend to lift, as wallpaper may (4,7,2)
8 Five dropped by unspecified illness (4)
9 Excited partner of Langmuir now primary in foremost area (10)
10 Think about concussive blow splitting carbon and nitrogen (6)
11 Most of top part's generative filler (8)
12 Soldier, seized by insects, sees stars (3,6)
14 Will Shakespearean droop? (4)
15 EA Sports initially unknown, being basic (4)
16 Part of tract preceded by two points and a note; that was one (9)
20 Our phylum is provided in almost all job specifications (8)
21 Being "cloud", we'd regularly implement encryption (6)
23 Whisky omitted – we're told it makes for a damp atmosphere (6,4)
24 Having lost a thousand, 15 Down in the mouth? (4)
25 Cryptic clue for NIN artist left in unknown location by trucker, perhaps (4,2,7)

DOWN

1 Spoken greeting for astronaut Cernan during sterilisation procedures (7)
2 Kiss beneath front of veranda in low-cut top (1-4)
3 Dissect an aphid, find a flea? (7)
4 Hippest teacher's redeployed as vocal coach (6,9)
5 Badly translate two elements with the French (6)
6 Romanians travelling in part of southern Europe (3,6)
7 Some cereal in egg cup, perhaps? Most convenient! (7)
13 He, perhaps, having true British guts – this will upset them! (9)
15 That's right: C_2H_6 reduced by half, by one state (7)
17 I foolishly retain Newtonian force! (7)
18 Sea dog finding antique compound (3,4)
19 Loudly say Trurl can't access Vietnamese food? (4,2)
22 Ford hybrid (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #311
set by Corryn Wetzel

1 What is the name of the doughnut-shaped region of icy objects just outside Neptune's orbit?

2 The longest known non-stop flight for a bird (an incredible 13,560 kilometres) was made by what species?

3 The first computer mouse was made up of primarily what material?

4 Who proved Fermat's last theorem in 1994?

5 What is the name of the condition caused by a deficiency of the enzyme hexosaminidase A?

Answers on page 47

BrainTwister
set by Peter Rowlett
#82 Flipping coins

Position two coins in a row, one on the left and the other on the right. Each move, you may do one of the following actions:

1. Flip over the left coin;
2. Flip over the right coin;
3. Flip over both coins.

Starting with heads-heads, what is the quickest way to get to tails-tails?

Starting with TH and doing action #1, then action #2, gets to HT. Starting with TH and doing action #2, then action #1, also gets to HT. Does doing a pair of actions always give the same result, regardless of the order in which they are done?

How many ways are there to get from HH to TT without returning to a position you were previously in?

Solution next week

Time rules

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

Ron Dippold
San Diego, California, US
First, keep in mind that in the 400,000-odd years that *Homo sapiens* has been around, most people had no use for exact time. Dawn, sunrise, sunset and night were very important, but no cave person cared if it was 3.29 pm. A mere 4000 or so years ago, the Egyptians divided night and day into 12 hours each because it was important for astronomy and religion, and we still use that.

Why 12? Probably due to the Sumerian duodecimal (base 12) counting system. We count to 10 on our fingers, but there is a more compact way to count using just one hand. With your dominant hand, tap the tip of your thumb to the outer bone of your index finger. That's 1. Now move your thumb to the next bone along. That's 2, and the last bone is 3. With three bones per finger and four fingers, you can count to 12 on just one hand.

The Egyptians had a decimal (base 10) system, but used duodecimal for some things like hours. If you have 10-hour nights and want to schedule guard watch, you can do two people for 5 hours each or five people for 2 hours each. With 12, you can do two people for 6 hours each, three people for 4 hours, four people for 3 hours or six people for 2 hours.

"Ancient Egyptian hours were variable. If the day were shorter because it was winter, the hours of the day were shorter too"

For the same reason, the Babylonians loved the number 60. It is so much more divisible than 100 is. What can you trivially divide a batch of 100 things into? Ignoring 1 and 100, there are seven options: 2, 4, 5, 10, 20, 25 and 50 things. On the other hand, how about a batch of 60 things? A lavish 10 options: 2, 3, 4, 5, 6, 10, 12, 15, 20 and 30! That matters a lot for commerce, taxes and maths. If you want a simple 8 per cent-ish tax, just take five jars out of every 60. The Babylonians also liked 360 because it is 6 × 60 and around the number of days in a year.

Back to timekeeping: ancient Egyptian hours were variable. If the day were shorter because it was winter, the hours of the day were shorter and those of the night were longer! They varied from 53 to 67 (modern) minutes long. It was the Greek philosopher Hipparchus, 2200 years ago, who proposed combining day and night into 24 fixed-length hours.

He also used the Babylonian system to divide what was known of Earth up into 360 degrees of latitude and longitude. Three-hundred years later, the Greco-Roman Claudius Ptolemy subdivided these into 60 "partes minutae primae" and then each of those into 60 "partes minutae secundae". This is where "minute" and "second" come from.

These were still mostly for geometry, not timekeeping. It wasn't until the invention of the pendulum clock 400 years ago that clocks were precise enough to warrant more precise markings. At that point, they just borrowed the existing minutes (and later seconds) from geometry.

Chris Daniel
Glan Conwy, UK
Modern time measurement has its roots in the Sumerian civilisation, which flourished from 4500 BC to about 2000 BC in Mesopotamia in what is now Iraq.

The Sumerians must have recognised the versatility of the number 60, as it can be divided in more ways than any other number less than itself, having 12 factors (divisors) and being the smallest number that is divisible by the first six digits from 1 to 6.

Among their many innovations, the Sumerians pioneered cuneiform, or wedge-shaped writing on clay tablets, representing numbers up to 60 in a base 10 sequence of increasing stylus strokes.

These numbers were written with place value: the placement of the symbols denoted their value. Combined with the utility of 60, this made advanced calculations possible, involving multiples and fractions, connected to trade, construction and astronomical observations. The Sumerians also had a deep understanding of geometry – there is evidence that they understood the properties of right-angled triangles 2000 years before Pythagoras.

The "perfect" number 60 had a mystical association with the Sumerian supreme god Anu, who was depicted by the symbol for 60. The number 12 was also auspicious, being the number of major deities in the Sumerian pantheon, the number of lunar cycles in a year and the number of zodiacal signs in the sky. Like 60, it has several useful divisors.

Hillary Shaw
Newport, Shropshire, UK
Sixty is 5 × 12, and these numbers are significant anatomically and astronomically. The year is approximately 60 × 6 days long and there are just over 12 lunar months in a year. We have five fingers, and some early counting methods used base 12. Sixty also has more factors than 10, 12 or 24.

SYLVIA BORN/ALAMY

Could this cat run straight down this tree if it needed to, like squirrels do?

This week's new questions

Going vertical **Why can squirrels run straight down trees? And could my cat do the same thing if it had to?** ***Robert Morley****, London, UK*

Shaping up **Why are at least four faces required to make a flat-surfaced solid in 3D? And does a similar lower limit apply in higher dimensions?** ***John Corey****, Melrose, New York, US*

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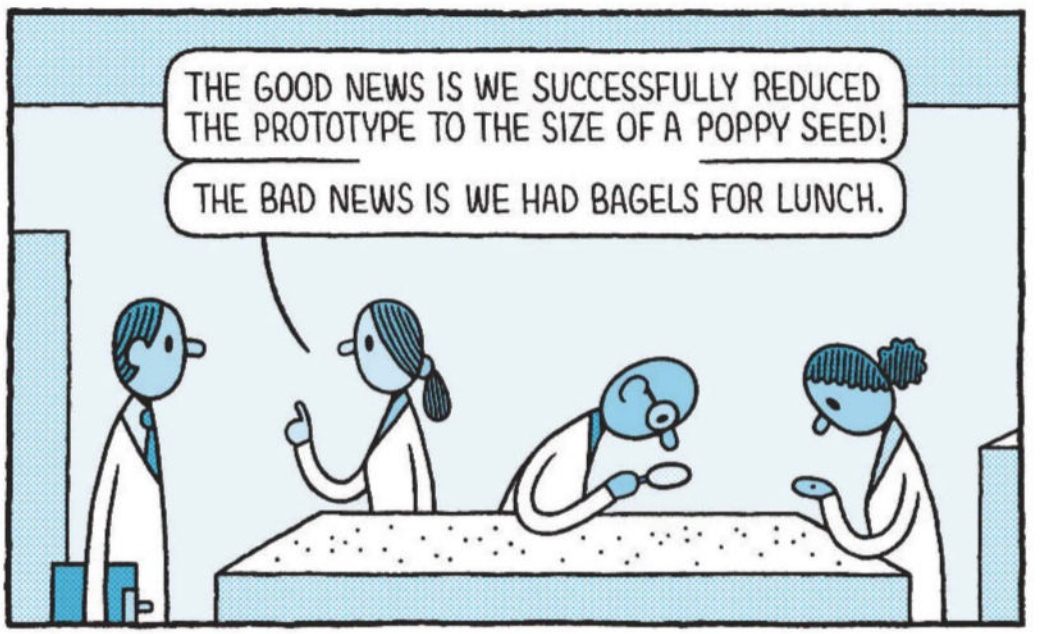
Tom Gauld
for New Scientist



Seven is the worst, being a prime number, but we are stuck with seven-day weeks, probably from the biblical Book of Genesis's account of the world's creation.
We are also stuck with base 10. Given that, we could rationally decimalise time, with 100,000 seconds in a day (coincidentally the same rate as the average human heartbeat), 100 such short-seconds in a minute, 100 such minutes in a long-hour and 10 long-hours in a day.

We could go on to have 12 months of 30 days and a leap holiday of five or six days. Each month could have three weeks of 10 days each, including a three-day weekend, which would leave us with 30 per cent of the week as leisure time, not the 28 per cent (two of seven) we have now. Every year would have the exact same calendar, apart from leap years, which would get that six-day holiday.

But then people born on, say, Monday would never get their birthday on a weekend. A seven-day work week could be tiring, and religions of one holy day a week would find this hard to adjust to.

Balancing act

Why do so many birds like standing on one leg? And why don't they fall over?

Mike Follows
Sutton Coldfield, West Midlands, UK
Birds' feathers help keep them warm, but most of them don't have feathers on their legs and feet. By standing on only one leg, birds reduce the amount of body heat lost through exposed skin. However, not all perching birds stand on one leg. This is because when they puff up their feathers to trap insulating air during cold weather, their shorter legs are often covered like a duvet.

"In 2017, a paper in the journal *Biology Letters* suggested that flamingos stand on one leg to conserve energy"

The birds most famous for standing on one leg are flamingos. Since many flamingos live in tropical climates, staying warm is unlikely to be why they do this.

In 2017, a paper in *Biology Letters* suggested that flamingos stand on one leg to conserve energy. It showed that flamingo cadavers can stay upright on one leg if the foot is positioned directly below their centre of mass. Cadavers on two legs fall over, as this requires muscular effort – by living birds, that is.

The researchers identified a mechanism comparable to the stay apparatus in a horse's foreleg – a system of ligaments and tendons that lets horses stand with minimal muscular effort and even sleep while standing.

Andrew Taubman
Sydney, Australia
Birds pull one leg up because if they pulled both up, they'd fall down. ▮

Answers

Quick quiz #311 *Answers*

1 The Kuiper belt
2 The bar-tailed godwit (*Limosa lapponica*)
3 Wood
4 Andrew Wiles
5 Tay-Sachs disease

Quick crossword #187 *Answers*

ACROSS 1 Subatomic, **6** Incus, **9** Program, **10** Takeoff, **11** Lioness, **12** Tallest, **13** Oxycontin, **15** Tramp, **16** Apsis, **19** Inception, **22** Ehrlich, **23** Alluvia, **25** Add up to, **26** Rotator, **27** Error, **28** Ellipsoid

DOWN 1 Sepal, **2** Biology, **3** Torpedo, **4** Mumps, **5** Catatonic, **6** Inkblot, **7** Cholera, **8** Safety pin, **13** On average, **14** Thighbone, **17** Strider, **18** Skipper, **20** Palmtop, **21** In vitro, **23** Aural, **24** Acrid

#81 Consecutive squares *Solution*

For the set of three numbers, we can use 3, 4, 5 (the only consecutive Pythagorean triple!).

The set of five numbers with the desired property is 10, 11, 12, 13, 14.

One way to find this is algebraically: $(n-2)^2+(n-1)^2+n^2=(n+1)^2+(n+2)^2$ simplifies to give $n^2-12n=0$, so the middle number must be 12.

The set of seven numbers is 21, 22, 23, 24, 25, 26, 27. This process can be generalised for any odd number, with the middle number always being four times a triangular number.

Sundown showdown

Feedback has been dimly aware for a while that there is a slew of AI-generated music swamping platforms like Spotify. Our awareness was limited, we confess, because we are so old that we still prefer to listen to CDs.

Still, we weren't too surprised when *New Scientist*'s Timothy Revell told us about an indie rock band called The Velvet Sundown that appears to be entirely AI-generated, from their songs, which sound like the beige love-children of Coldplay and the Eagles, to their uncanny-valley Instagram photos, which look like rejected concept art from *Daisy Jones & the Six*.

First, the band denied this. On their X account, The Velvet Sundown claimed it was "Absolutely crazy that so-called 'journalists' keep pushing the lazy, baseless theory that The Velvet Sundown is 'AI-generated' with zero evidence", and that "This is our music, written in long, sweaty nights in a cramped bungalow in California".

Yet there is no video of them, and none of the members has any online presence. Things seemed clear after *Rolling Stone* interviewed the band's "creator" Andrew Frelon, who said it was all an "art hoax". But then Frelon claimed that was itself a lie, and the "band" posted a statement denying any involvement with him. By this point, Feedback was bored of redrafting our redrafts, so we just want to say we don't know what's going on, and also we don't give two hoots.

Instead, we are going to run with Tim's suggestion that, if you form an AI band, "you should fully embrace it". Don't give yourself a name that sounds like something Lou Reed would come up with if he ever moved somewhere sunny. Lean in. Tim suggests the following artist names: Rage I'm a Machine, The Bitles and TL(LM)C. Feedback would like to add Pink Floppy Disc, Lana DEL Array, Captchatonia, Alanis Microsoft and Velvet Username.

Finally, this new collective of artists will need to be spoofed, by a performer called Weird Al Yankovic.

Twisteddoodles *for New Scientist*

Got a story for Feedback?
Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Sodom bomb

The wheels of science grind exceedingly slowly, but they do occasionally crush something into dust. And so it is that *Scientific Reports* has retracted a rather intriguing study from September 2021, which claimed to have found archaeological evidence for a cataclysmic event that inspired the biblical tale of the destruction of Sodom and Gomorrah.

In the story, the two cities are destroyed by God because of some not-entirely-specified sins. In contrast, the study proposed a "Tunguska sized airburst": a meteorite exploding in mid-air, causing devastation, along the lines of the 1908 explosion above Siberia known as the Tunguska event.

It claimed this happened about 3600 years ago and wrecked the Bronze Age city of Tall el-Hammam in present-day Jordan. Evidence included "a city-wide ~1.5-m-thick carbon-and-ash-rich destruction layer", "soot" and "melted platinum, iridium, nickel, gold, silver, zircon, chromite, and quartz".

Except, perhaps not. On 24 April, the journal pulled the paper, citing "errors in methodology, analyses, and interpretation" and "errors propagated from the original sources [about the Tunguska blast]". This followed four years of criticism and multiple corrections, all documented by the nice people at *Retraction Watch*. Several dozen images had been manipulated in an "inappropriate" way, and the burned and melted materials could be from smelting, rather than a mid-air explosion – given Tall el-Hammam was, we repeat, a Bronze Age city.

Feedback was particularly impressed by a comment left on the discussion board PubPeer by a Michael J. I. Brown: "The north arrow and shadows in Figure 44C indicate that the Sun is roughly north-north-east, which is not possible at the Dead Sea." This is a level of knowledgeable pedantry to which we can only aspire.

So, in short, someone wrote a paper about a pair of famously debauched cities, manipulated images in ways that went against the rules and failed to properly consider an obvious alternative explanation for their findings. How sinful.

Avocadon't

Feedback gets an awful lot of press releases, and to be honest, we ignore over 90 per cent of them. This is partly because we get added to a lot of irrelevant lists, like the time we got months' worth of messages about new wedding dress designs. But the biggest factor is that most are just boring.

Not so the message that popped up in our inbox on 2 July, with the subject line "Avocados Are Not the Enemy". The press release relates to the start of the Wimbledon tennis tournament and the decision to stop serving avocados there – apparently as part of ongoing efforts to become more sustainable. Ditching avocados, the message says, "perpetuates myths that are not backed by current data. In reality, avocados are one of the most nutrient-dense and environmentally responsible fruits available today".

The press release goes on to explain that avocados have a small water footprint. Furthermore, they are "naturally rich in heart-healthy fats, fibre, and important nutrients" and support small farms in places like Peru and South Africa.

Wow, we thought, what a vote of confidence. And then we noticed that the people praising avocados so highly were from the World Avocado Organisation.

To which we can only say, citing Rice-Davies, M. (1963): "Well, they would, wouldn't they?"

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