New Scientist

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WHY AREN'T YOUNG PEOPLE HAVING SEX ANY MORE?

REVEALING THE HIDDEN SOUNDTRACK OF ANCIENT CAVE ART

WHAT THE PROJECT TO ANALYSE HITLER'S DNA GOT SO WRONG

RETHINKING FAT

From metabolism to mood, the startling role of body fat in shaping our everyday health

PLUS
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Christopher Ward

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This week's issue

On the cover

28 Rethinking fat
From metabolism to mood, the startling role of body fat in shaping our everyday health

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Cover image: Matt Dartford

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"Without fat, we have issues with hormonal control, infection and immunity"

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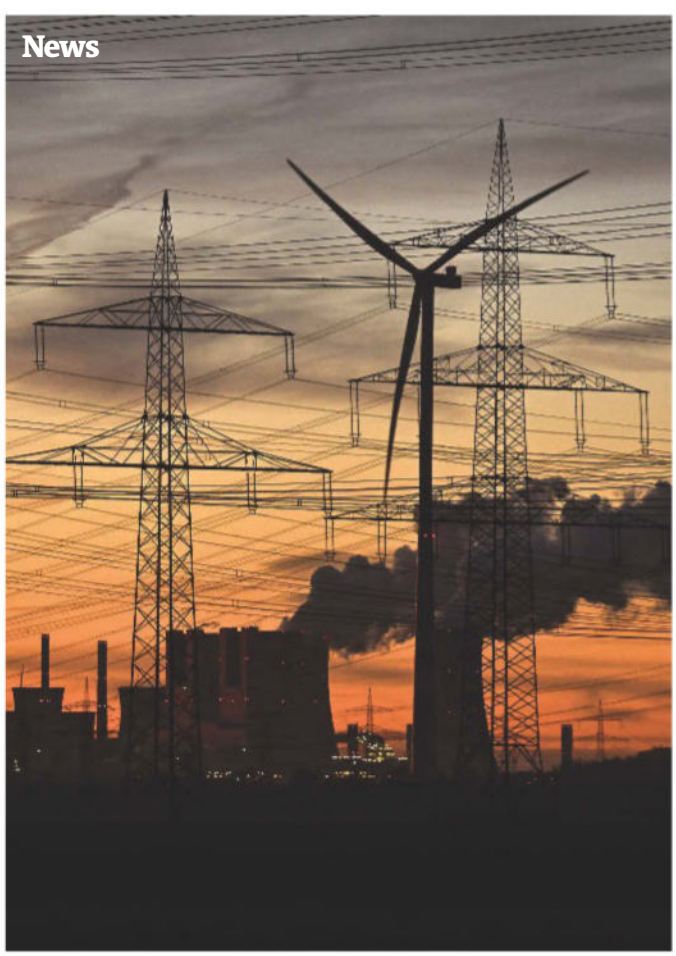

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Features

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The transfiguration of fat

Treating fat as an active organ can improve our approach to our bodies and obesity

JELLY belly. Thunder thighs. Muffin top. When it comes to our wobbly bits, we aren't short of derogatory terminology. Many societies tend to view fat as an inert padding that keeps us warm at best, if not a simple nuisance to be rid of. But it is time to reshape that thinking.

There is, of course, a serious downside to too much body fat. We know only too well that obesity is linked to numerous health conditions, including cancers, cardiovascular diseases and type 2 diabetes. Even so, many people who are obese don't experience these ill effects, a clue that something more complex is going on. It turns out that fat is far from passive, as we report in our cover story on page 28. Instead, it is a vital, dynamic body part, an organ in its own right that works with the brain, the bones and more to help keep us healthy.

This radical reframing of fat helps us better understand obesity – not as moral failure, but as organ failure. Doing so can shift the narrative away from fat-shaming and blaming towards developing better treatments for the condition. Indeed, efforts are now being directed towards new ways to "reprogram" malfunctioning fat cells to restore health and perhaps even transform "unhealthy" obesity into a more benign form.

"Fat is a vital, dynamic body part, an organ in its own right that works to keep us healthy"

Encouragingly, this may not require dramatic weight loss. Many of the benefits of today's weight-loss drugs seem to stem not from the kilograms they help shed, but rather from improving fat distribution and function.

Achieving this transformation would be revolutionary, not only in improving health but also in reframing what healthy body shapes look like. One downside of the runaway success of GLP-1 drugs is that they risk deflating the fat-positivity movement and reigniting the old moral judgements about body size and self-control.

But if fat could be reprogrammed, many more of us might live longer, healthier lives without obsessing over our size. A better understanding of fat's biology, and how it talks to the rest of the body, is a good place to start. ▮

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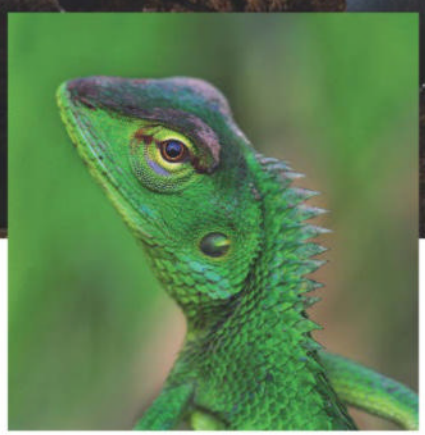

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13 March 2026 | 7 days

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News

MAURO PIMENTEL/AFP VIA GETTY IMAGES

Environment

Deforestation on the COP30 agenda

While delegates gathered for COP30 in Belém, Brazil, around 180 kilometres away, in Tomé-Açu, this truck transported wood from a deforested area of the Amazon. Deforestation was one of the items on the agenda at this year's UN Climate Conference, which was ongoing when *New Scientist* went to press. A study this year found that deforestation could bring more extreme heat and rainfall to the Amazon.

Palaeontology

The world's oldest ever RNA sample

RNA extracted from an exceptionally well-preserved woolly mammoth gives us a window into the gene activity of these ancient animals, reports **James Woodford**

A WOOLLY mammoth that was frozen in the Siberian permafrost for nearly 40,000 years has yielded the world's oldest RNA.

The specimen, found in 2010 and nicknamed Yuka, is regarded as the best-preserved woolly mammoth (*Mammuthus primigenius*) ever found by scientists. Yuka was originally thought to be a juvenile female who died, possibly after being attacked by cave lions, at between 6 and 8 years of age. But the new discovery turns part of this understanding on its head.

Scientists have already been able to retrieve the DNA from many woolly mammoths, including some that are more than a million years old. The reconstruction of their genomes has raised hopes that one day the species – or genetically engineered animals resembling mammoths – could be brought back to life through genetic engineering.

DNA encodes the genetic instructions for making proteins in all animals. When a particular gene is turned on, the code in DNA is transcribed into another molecule called RNA. RNA is much less stable than DNA, and usually degrades within a few hours after death.

Until now, the oldest RNA ever recovered came from a wolf that was preserved in Siberian permafrost over 14,000 years ago. Now, Love Dalén at Stockholm University in Sweden and his colleagues have managed to extract RNA from one of Yuka's legs – nearly tripling the previous record (*Cell*, doi.org/hbbnht).

The team used the same techniques employed to obtain RNA samples from fresh, modern specimens, but slightly modified them to retrieve much smaller, older molecules.

"Yuka is exceptionally well-preserved," says Dalén. "The specimen likely underwent rapid freezing and long-term burial in permafrost, as evidenced by the preservation of both the muscle tissue and the woolly fur. This greatly increases the chances of RNA to have been preserved."

However, working against the team was the fact that Yuka had been allowed to briefly thaw out during transportation from where the remains were discovered in north-east Siberia to Yakutsk. "Our assumption was that any truly ancient RNA still present in our samples would be degraded and fragmented in small pieces," says Dalén.

"RNA profiles from mammoths could tell us how traits, like hair, were controlled genetically"

The researchers had to take exceptional care to preserve all their samples from further deterioration and also prevent contamination. "We used liquid nitrogen to grind the samples, as well as sterile materials, a filtered air atmosphere, protective suits and a controlled laboratory environment to avoid any source of external modern contamination in our sequencing data," says Dalén.

RNA sequencing can give an indication of which genes were switched on at the time when the animal died. In the RNA isolated from Yuka's muscle and skin, the team found signs of gene activity related to muscle metabolism and cell stress – consistent with the idea that Yuka died in a cave lion attack.

One big surprise was that, through a combination of DNA and RNA analysis, the team is certain that Yuka was actually a male. "I have been around long enough to know that these things happen," says Dalén. "Yuka is well preserved for being 40,000 years old, but not completely intact, so it is not always easy to morphologically sex an individual."

The researchers also searched for any RNA viruses such as influenza and coronaviruses, but didn't find anything of interest. "But I think we will in the future see several studies on ice age RNA viruses," says Dalén. "There are, for example, some Pleistocene bird carcasses that would be really interesting to investigate with regards to bird influenza."

LOVE DALÉN

The team extracted the RNA from one of the mammoth's legs

Close to the limit

The RNA sequences recovered in the study aren't directly relevant for bringing about the de-extinction of mammoths, says Dalén, who is a scientific adviser to Colossal Biosciences, the company that earlier this year claimed to have brought the dire wolf back from extinction. But the study can give useful insights on which genes are important for the development of certain traits, he says. "RNA profiles from mammoths could in the future tell us how certain traits, like mammoth hair, were controlled genetically."

Merlin Crossley at the University of New South Wales in Sydney says obtaining such ancient RNA is a remarkable achievement, but the findings don't tell us much about the mammoth's biology. "It's a little bit like flying a light plane under the Sydney Harbour Bridge," he says. "It's an impressive technical feat, but I'm not sure what we learned from it."

Crossley believes that while older RNA samples may be found in the future, the team is close to the extreme limit of how long RNA can survive. He says it is also unlikely that useful information will be obtained from other mammoths because specimens like Yuka are so rare.

Climate change

Rapid melt from Antarctica could speed up the revival of crucial ocean current

Alec Luhn

WHILE the melting of the Greenland ice sheet is expected to slow or even collapse the Atlantic Ocean current that keeps Europe warm, meltwater from West Antarctica could preserve it.

But it won't be enough to prevent major changes in the climate. The Atlantic Meridional Overturning Circulation (AMOC) would still decline by 60 per cent, and its full recovery would take 3000 years.

"I would tend to say, don't be so quick to say that the AMOC is going to collapse," says Sacha Sinet at Utrecht University in the Netherlands. "But the things I show here do not change much what will happen for the next century."

The AMOC is a system of currents that brings warm surface water from the tropics towards northern Europe, where it cools and sinks before flowing south to Antarctica. The current carries 1.2 petawatts of heat that keeps Europe much warmer than Labrador in Canada or Siberia at the same latitude. But light, fresh meltwater from Greenland's ice is expected to hinder the sinking of salty, dense AMOC water, slowing down the current.

If the AMOC collapsed, winter cold snaps could reach almost -50°C (-58°F) in northern Europe. Sea levels would also be higher along the US east coast, and regions like West Africa could have more severe droughts.

Recent research concluded that even if we reach net zero by 2075 and then start removing carbon dioxide from the atmosphere, the risk of eventual AMOC collapse could still be 25 per cent.

Meanwhile, the melting of the West Antarctic ice sheet has been accelerating in recent decades, and some research suggests that it is likely to collapse completely. But the effect this will have on the AMOC is unclear.

According to simulations by Sinet and his colleagues, the timing is key. If a centuries-long pulse of Antarctic meltwater arrives at the same time as massive melt from Greenland, it will only speed up AMOC shutdown.

If the Antarctic water arrives about 1000 years before the peak of Greenland's melting, however, the AMOC would weaken for several hundred years, but then recover over the next 3000 years. While the AMOC eventually recovered in all scenarios, this early Antarctic melt prevented its total collapse and sped up its revival (*Science Advances*, doi.org/qdxv).

This may be because as light, fresh meltwater pools around Greenland, the sinking of dense, salty AMOC water shifts southward, and the current later regains strength as meltwater tapers off from Antarctica.

Although it is unlikely that West Antarctica would melt so early and Greenland so late, these findings reveal a greater connection between the AMOC and Antarctic melt, says Louise Sime at the British Antarctic Survey.

This link should be investigated with more complex models, as this study didn't include possible feedback effects like changing wind patterns, which could expand Antarctic sea ice, she adds. ▮

Melting in West Antarctica has accelerated in recent decades

COLIN N. PERKEL/ALAMY

Health

People with red hair may recover slower from wounds

CUTS and scrapes may be slower to heal in redheads. A study in mice shows a genetic variant that causes the hair colour seems to impede the rate at which lesions close up.

Our hair colour is influenced by a gene called *MC1R*, which encodes for a protein that controls the ratio of a black-brown pigment to a red-yellow one in hair follicles.

People with brown or black hair carry *MC1R* variants that encode for active forms of this protein. But nearly all red-haired people have less active or completely inactive forms due to mutations in *MC1R*.

The same protein is also in our skin, where it has anti-inflammatory effects. This led Jenna Cash at the University of Edinburgh, UK, to wonder whether it influences wound healing. This process requires a brief inflammatory response to clear out microbes and dead cells, but if it is prolonged, the healing is impaired.

"A genetic variant that causes red hair colour seems to impede the rate at which lesions close up"

To explore this, she and her colleagues surgically created small wounds on the backs of mice with black hair and red hair, the latter of which had a completely inactive form of the MC1R protein.

A week later, the wounds on the red-haired mice had shrunk by 73 per cent, on average, compared with 93 per cent in the black-haired mice.

The team wondered whether an experimental topical drug that raises the activity of active forms of the protein, but doesn't work on totally inactive versions, could aid healing.

The team then generated wounds in black-haired mice, some of which were treated with the drug. A week later, the treated mice's wounds had shrunk by 63 per cent, on average – more than double the rate of those of the control animals (*PNAS*, doi.org/qdxw). Further analyses found the drug works by reducing the number of inflammatory immune cells.

This approach holds promise for treating people, even redheads, most of whom have MC1R proteins with some activity, says Cash. ▮

Carissa Wong

For more on wound healing, see page 12

Space

A star-fuelled mystery

An isolated galaxy seems to be impossibly forming new stars

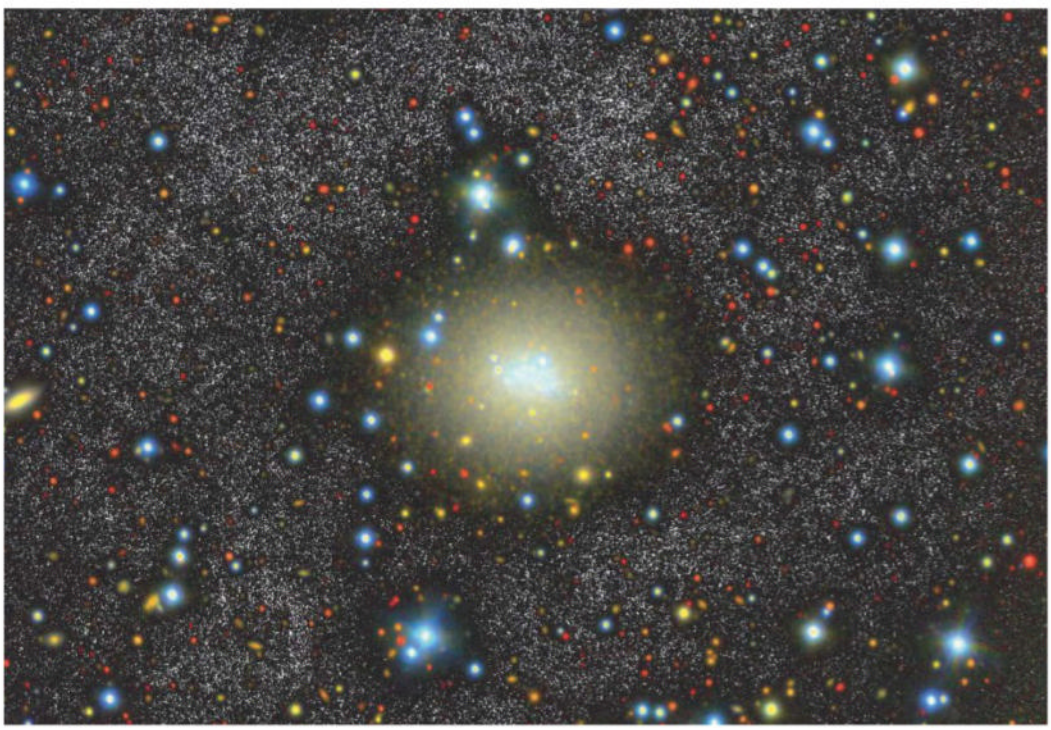
Leah Crane

ABOUT 12 million light years away lies the galaxy NGC 6789, located in the direction of the Draco constellation, in an area called the Local Void, so named because it is practically empty. Galaxies need gas to form new stars, and there is very little of that in the Local Void.

However, in the past 600 million years, NGC 6789 has formed about 100 million times the mass of the sun's worth of stars: about 4 per cent of its total stellar mass.

Ignacio Trujillo at the Institute of Astrophysics of the Canary Islands and his colleagues used the Two-meter Twin Telescope at Teide Observatory in Tenerife to take deeper images of the galaxy than we have had before, hoping to find evidence of an event that could have brought gas in (*Research Notes of the AAS*, doi.org/qdpm).

But the new images (one of which is pictured, right) found nothing, and the mystery remains unsolved. ▮



IGNACIO TRUJILLO ET AL 2025

Health

Ultrasound could clear the brain after a stroke

PULSING ultrasound waves through the brain could improve survival after a type of stroke by helping remove inflammatory dead blood cells.

Haemorrhagic strokes occur when a blood vessel in the brain ruptures, causing bleeding that disrupts the brain's oxygen supply and damages its cells, which leads to problems with movement and cognition.

Treatment often involves sealing the broken vessel with a small metal clip, then clearing out dead red blood cells – via a catheter, for instance – that would otherwise increase inflammation. But this is highly invasive and can lead to brain damage, says Raag Airan at Stanford University in California.

Airan wondered about the effect of ultrasound, administered in pulses outside the head, after he left such a device on for too long while using it to activate drugs in the brains of mice. "What I saw was that the spots of drug that I put in the brain were just like smeared out, like being transported further throughout the brain in a [cerebrospinal] fluid that usually clears gunk from the brain," he says.

30
percentage point increase in survival among treated mice

To find out more, he and his team collected blood from the tails of mice and injected it into their brains, mimicking a haemorrhagic stroke. Over the next three days, they pulsed ultrasound waves through the skulls of half the mice, for 10 minutes daily. The remaining animals received no treatment.

Next, all the mice completed a 3-minute test where they were placed in a tank with four corners, which allowed them to turn left or right. Healthy mice usually turn each way 50 per cent of the time. The mice in the ultrasound group turned left 39 per cent of the time, compared with 27 per cent in the control group (*Nature Biotechnology*, doi.org/g99xmr). This suggests the treated animals had less brain damage, which was later confirmed by analysing slices of their brains after death.

One week after blood was injected into the brain, about half the mice in the control group had died, compared with a fifth of those in the ultrasound group. "We increased survival by about 30 [percentage points] with just three 10-minute sessions of ultrasound," says Airan.

Further analysis revealed that the ultrasound pulses activated pressure-sensitive proteins on the animals' microglia, immune cells in the brain, enhancing their ability to clear away dead red blood cells. ▮

Carissa Wong

Virology

Strongest evidence yet that the Epstein-Barr virus causes lupus

Chris Simms

THE virus behind glandular fever, also known as mononucleosis or kissing disease, seems to infect and reprogram immune cells in the body, priming some people to develop the autoimmune condition lupus.

Lupus, or systemic lupus erythematosus, occurs when the immune system becomes hyperactive, with sustained activity of immune cells called B-cells and T-cells leading to attacks on healthy tissues. This causes a variety of symptoms, including painful muscles and joints, rashes and extreme tiredness. What causes lupus isn't well understood, but it probably involves an interplay of genetics, hormonal factors and environmental triggers, such as viruses and disturbances to our microbiome.

People with lupus – about 90 per cent of whom are women – tend to have relatively high numbers of antibodies against Epstein-Barr virus (EBV), which causes glandular fever. However, EBV infects most adults globally, usually without symptoms, while lupus affects around 5 million people worldwide.

To figure out how they might be linked, William Robinson at Stanford University in California and his colleagues developed a single-cell RNA-sequencing platform called EBV-seq to find which B-cells – which produce antibodies to neutralise pathogens – are infected by EBV in people with lupus, and work out what genes are being expressed by these cells to produce RNA.

In blood samples from 11 people with lupus, the researchers found that about 25 of every 10,000 sequenced B-cells were infected with EBV. In contrast, in 10 people without the condition, 0 to 3 of every 10,000 sequenced B-cells were infected with the virus (*Science Translational Medicine*, doi.org/g996kb).

Most of the infected cells were a type of B-cell called memory B-cells, which remember past pathogenic threats so they can trigger a faster response next time they crop up.

Robinson and his colleagues have shown that these infected memory B-cells express genes called *ZEB2* and *TBX21*, triggering a chain reaction that activates another type of immune cell, called helper T-cells, that recruit uninfected B-cells. This ramps up immune activity in a vicious cycle to a point at which it starts attacking the body.

95%

How many people worldwide are infected with Epstein-Barr, most asymptomatically

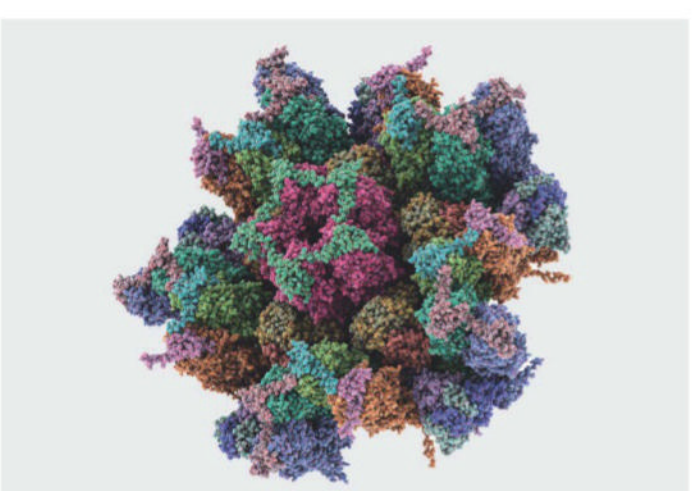
5 million

How many people worldwide are affected by lupus

Crucial to demonstrating EBV's causal role in lupus was the finding that the virus appeared to prime memory B-cells to act this way by producing a protein called EBNA2, which bound to the *ZEB2* and *TBX21* genes, boosting their activity. "Our discovery is the mechanism by which this very common virus that infects 95 per cent of us, Epstein-Barr virus, basically causes lupus," says Robinson.

As to why most people with EBV don't develop lupus, Robinson thinks some people's genetics predispose them to having B-cells that are more likely to mistakenly target healthy cells. "It's EBV infection in the context of the genetic and environmental milieu that predisposes one to lupus that together results in them getting lupus," he says.

"EBV isn't necessarily likely to play a part in every case of lupus, because the mechanisms that are involved in expression of lupus are very varied, but in distinct patients, I'm sure it's going to be a main contributor," says George Tsokos at Harvard Medical School, who reported that the virus induced unusual T-cell responses in people with lupus more than 40 years ago.



LAGUNA DESIGN/SCIENCE PHOTO LIBRARY

The Epstein-Barr virus infects cells in our immune system

A strong link was found between EBV and multiple sclerosis, another autoimmune condition, in 2022, and the new findings show how the virus could drive such disorders more broadly, says Robinson.

Finding a treatment

What's more, they could explain why some CAR T-cell therapies have shown impressive results in clinical trials for lupus. These treatments, which involve genetically engineering someone's T-cells to attack specific targets, were developed to treat blood cancers that arise when B-cells multiply out of control, and often deplete B-cells. "These CAR T-cell treatments seem to result in what we call long-term durable remission, where [lupus] patients are off all drugs, suggesting that they might even cure people. And we think it's possible that they might achieve this by getting rid [of] or depleting the EBV-infected B-cells," says Robinson.

But the jury is still out on the therapies' potential as a lupus treatment, says Tsokos, partly because, though levels of B-cells seem to drop in the blood of people given CAR T-cells, the cells often hide in bone marrow, and we don't yet have data to show that all of them are being removed.

The work also supports the development of a vaccine against Epstein-Barr virus, which is transmitted by saliva, for potentially preventing a range of autoimmune conditions. "A vaccine has the potential to prevent EBV infection and could thereby prevent lupus in the future," says Robinson, but he adds it wouldn't ward off the condition in people who are already infected with EBV, because the B-cell reprogramming seems to happen early after infection.

Comment Genetics

Analysing Hitler's DNA for a TV gimmick tells us nothing useful

To truly understand Adolf Hitler, we need to look at his personal life and the wider societal and historical context, says **Michael Le Page**

IF YOU resort to mentioning Adolf Hitler, some say, you have lost the argument. If you resort to sequencing Hitler's DNA to try to get more eyeballs for your TV channel, I would say you have just plain lost it.

And yet the UK's Channel 4 has done just that with *Hitler's DNA: Blueprint of a dictator*. I have forced myself to watch it, so you don't have to.

The DNA came from a blood-soaked piece of fabric cut from the sofa on which Hitler shot himself in 1945, which now resides in a US museum. The genome obtained has gaps due to the age of the sample, but the Y chromosome is said to match that of a male relative of Hitler, suggesting it is genuine.

If this had been done purely as an academic effort, to add a little to our knowledge by, for instance, revealing whether Hitler had a Jewish grandfather as rumoured (he didn't, according to the DNA), it would arguably be OK. Instead, we have a sensationalist, two-part documentary claiming this DNA evidence "will change the way we think about Hitler".

It's not in the genes

The trouble with this is that it implies genetic determinism – that Hitler was somehow destined to do the terrible things he did because of his genes. To be clear, the documentary doesn't make this specific claim, but it comes pretty close – what else could "Blueprint of a dictator" mean?

This is equivalent to arguing that if we made lots of Hitler clones, they would all end up killing millions, too. This isn't an experiment we can – or would ever want to – do, but there are plenty of clones in the world, in the form of identical twins, who share the same DNA. Twin studies have been used to estimate the extent to which all kinds of traits and conditions are due to genes rather than the environment.

Now, there are many issues with twin studies, not least that twins usually grow up in the same environment, so it is impossible to completely disentangle genetic and environmental influences. Even so, the highest twin-based estimates for the heritability of criminality – probably the closest we can get to being a genocidal dictator – are less than 50 per cent. So there is no reason to think most Hitler clones would be monsters.

Then there is the fact that our understanding of the human genome is very much still in its infancy. We can't yet predict simple traits such as eye colour with 100 per cent accuracy, let alone much more complex traits involving the interaction of the brain with the environment.

> "We can't yet predict eye colour with 100 per cent accuracy, let alone much more complex traits"

What we can do is look for genetic variants that have been statistically linked to a higher risk of conditions such as autism. People can then be given a "polygenic score" for each condition. The thing is, getting a very high polygenic score for autism doesn't necessarily mean an individual is definitely autistic. There are many reasons for this: environmental factors matter too, the association between trait and variant might be spurious, we haven't identified all the variants that matter, and so on.

According to the documentary, Hitler's genome scores very highly for autism, along with the mental health conditions schizophrenia, bipolar disorder and antisocial behaviour or psychopathy. It also has an above-average score for ADHD. But there is already a long history of claiming Hitler had these kinds of conditions on the basis of his behaviour. The genetic evidence doesn't prove anything and the diagnostic criteria for these conditions don't include genetic data.

But more to the point, so what if he had any of these conditions? As Simon Baron-Cohen at the University of Cambridge says in the documentary, the neglect and abuse Hitler experienced at the hands of his alcoholic father is "much more relevant to understanding why he grew up with hate and anger".

Later, we are told that schizophrenia-related traits can be linked to creativity and unconventional thinking, which might explain his political and military successes. Really? This is pure speculation.

To me, that is the issue with analysing Hitler's genome. You can make all these plausible-sounding connections with what we know about his personality and actions, but they could all be completely spurious. What's more, it risks worsening the stigma already associated with conditions like autism, schizophrenia and bipolar disorder.

This documentary gives the lie to its own claims, in that most of it simply rehashes what we already knew about Hitler. The only new thing is the claim that Hitler had Kallmann syndrome, which affects sexual development. But the physical effects of this condition vary widely and we already have documentary evidence stating that Hitler had an undescended testicle, so, again, history is more informative than genetics.

GETTYSBURG MUSEUM OF HISTORY

Hitler's DNA was sequenced from blood stains on a piece of fabric

There is also a wider issue that this documentary feeds into: the idea that Hitler was somehow uniquely evil and solely to blame for the second world war and the Holocaust.

Millions voted for Hitler, other politicians backed the laws that enabled him to seize power and many officials helped implement the racist laws that led to the Holocaust. There is no need to look to genes to explain why many individuals try to become dictators – the far more pressing question is why we let them. ▮

Michael Le Page is a reporter at *New Scientist* specialising in genetics

Technology

Forecast finds AI firms far off track to reach net zero goals

Chris Stokel-Walker

WITH the rapid expansion of the artificial intelligence industry, questions about the environmental impact of data centres are coming to the forefront – and a new forecast warns the industry is unlikely to meet net zero targets by 2030.

Fengqi You at Cornell University in New York state and his colleagues modelled how much energy, water and carbon today's leading AI servers could use by 2030, taking into account different growth scenarios and possible data centre locations within the US. They combined projected chip supply, server power usage and cooling efficiency with state-by-state electrical grid data to conduct their analysis. While not every AI company has set a net zero target, some larger tech firms that are active in AI, such as Google, Microsoft and Meta, have set goals with a deadline of 2030.

The team's estimates suggest US AI server buildout will require between 731 million and 1.125 billion additional cubic metres of water by 2030, while emitting the equivalent of between 24 million and 44 million tonnes of carbon dioxide a year (*Nature Sustainability*, doi.org/g99wk7). The forecast depends on how fast AI demand grows, how many high-end servers can actually be built and where new US data centres are located.

The team modelled five scenarios based on the speed of growth, and identified various ways to reduce the impact. "Number one is location, location, location," says You. Placing data centres in Midwestern states, where water is more available and the energy grid is powered by a higher proportion of renewables, can reduce the impact. This, along with decarbonising energy supplies and improving the efficiency of data centre computing and cooling processes, could cut the industry's emissions by 73 per cent and its water footprint by 86 per cent. ▮

Climate change

Fossil fuel emissions rise again, but China's are levelling off

Alec Luhn

WORLDWIDE fossil fuel emissions are set to rise 1.1 per cent in 2025, reaching another record high as humanity burns hydrocarbons at ever greater rates, according to the annual Global Carbon Budget report.

In a positive sign, emissions from China, the world's biggest emitter, have been flat, raising hopes that they may be reaching a peak and that global emissions might follow.

"We're not yet in a situation where the emissions go down as rapidly as they need to to tackle climate change," says Corinne Le Quéré at the University of East Anglia, UK, who worked on the report. "But at the same time there is a lot of positive evolution with China's and India's emissions growing less rapidly than before."

Humanity will put out 38.1 billion tonnes of fossil carbon dioxide emissions this year, the report says, the equivalent of 9 billion petrol cars being driven for an entire year (*Earth System Science Data*, doi.org/qdm9). While renewables are displacing hydrocarbons in many places, this isn't enough to offset the uptick in energy demand, much of which is being met by fossil fuels. The burning of coal, oil and natural gas has continued to increase this year.

1.1%

The increase in worldwide fossil fuel emissions in 2025

Earth has now heated 1.36°C since the pre-industrial era, according to the report. With emissions at the current level, keeping warming below the 1.5°C target of the Paris Agreement is virtually impossible, the report's authors say. Overshooting 1.5°C heightens the risk of catastrophic climate impacts, including irreversible tipping points such as the collapse of the ice sheets.

Last month, the United Nations secretary general António Guterres told world leaders gathered before the COP30 climate summit that exceeding 1.5°C is now inevitable, and humanity needs to slash emissions to keep this overshoot as small as possible.

If carbon absorption by ocean and land ecosystems is taken into account, global CO_2 emissions are actually down slightly in 2025. This is largely due, however, to the end of warm El Niño conditions, which had stifled photosynthesis in major sinks like tropical rainforests.

As the climate gets warmer, those sinks are absorbing less carbon, according to a separate study by the team behind the Global Carbon Budget report.

Nonetheless, total emissions have increased more slowly in this decade than in the previous one, says Pierre Friedlingstein of the University of Exeter, UK, one of the report's authors. "Things are looking better," he says. "If you look at the growth rate, it's much lower now."

The report estimated a 0.4 per cent increase in China's emissions in 2025. But an analysis by *Carbon Brief* found its emissions have been flat through the third quarter of the year.

Solar power has grown 46 per cent there year-on-year, compensating for increased electricity demand, it said.

The think tank Ember said in another report that thanks to the solar boom, fossil fuel power generation fell 1.1 per cent in China in the first three quarters of 2025, marking a "structural change in the country's electricity system." It declined by 3.3 per cent in India, which is also building record amounts of solar and wind power. ▮

Hydrocarbons are meeting growing energy demands

WHITMAN/NURPHOTO/SHUTTERSTOCK

Archaeology

Is this the earliest known image of cosmic creation?

Colin Barras

EBERHARD ZANGGER, LUWIAN STUDIES #5082

The flower-like circle on this ancient goblet may represent the sun

THE artwork on a 4300-year-old silver goblet unearthed in the Palestinian West Bank appears to show the universe forming – making it the oldest known visual representation of a creation myth.

"I think it's an ingenious design," says Eberhard Zangger at the Luwian Studies Foundation, a non-profit based in Switzerland. "With very few lines, it tells a very complex story."

The Ain Samiya goblet stands about 8 centimetres tall. It was found 55 years ago in an ancient tomb a few miles to the north-east of Ramallah at the western tip of the Fertile Crescent – a region where early civilisations flourished.

There appear to be two scenes depicted on the goblet. In the first, a large snake rears up and faces a chimera with a human torso and the legs of an animal, who stands over a small flower-like circle. In the second (pictured), a snake lies on the ground beneath a much larger flower-like circle with a smiling face. The circle is being held up, probably by two humanoid figures – although only one is visible today because the goblet is broken.

Archaeologists in the 1970s suggested the two scenes came from *Enūma Eliš*, a Babylonian creation myth in which Tiamut, a primordial entity, is defeated in battle by the god Marduk, who then turns Tiamat's body into the heavens and Earth. But, Zangger says, other researchers pointed out flaws with this idea. Not only is there no battle scene on the goblet, but it was also made about 1000 years before *Enūma Eliš* was first written down.

"I think it's an ingenious design. With very few lines, it tells a very complex story"

Alternative interpretations have been suggested – for instance, that the goblet is a symbolic representation of the birth of the new year and the death of the old one.

But Zangger and his colleagues, Daniel Sarlo, an independent researcher in Toronto, and Fabienne Haas Dantes at the University of Zurich, Switzerland, argue the scenes do show the formation of the world and cosmos, but come from a creation story far older than *Enūma Eliš*. Their work will be published in *JEOL – Journal of the Ancient Near Eastern Society "Ex Oriente Lux"*.

In the first scene, according to Zangger's team, there is chaos. The chimera represents a weak god, fused with the animals. Beneath its legs, the small flower-like circle represents a powerless sun. Ruling over all of this chaos is a monstrous snake. But in the second scene, order has emerged from the chaos. The gods have been separated from the animals, becoming powerful humanoid characters. They hold the equally powerful sun aloft in a "celestial boat", indicating the heavens have now been separated from Earth. The monstrous serpent of chaos, defeated, lies beneath the sun.

Zangger points out there are cuneiform texts from elsewhere in the Fertile Crescent that are similar in age to the goblet and describe how the gods separated the heavens from Earth. As such, we know the inhabitants of the region had developed stories about the creation of the world by the time the goblet was fashioned. "But the incredible thing about the goblet is that we now have a picture of what they imagined this creation to have looked like," he says.

Jan Lisman, an independent researcher in the Netherlands, is unconvinced. "What may be depicted is the daily movement of the sun," he says. "But definitely not 'origin' or 'chaos'." ▮

Health

Close contact could help our wounds heal faster

Chris Stokel-Walker

SEX, or even intimate touch, could speed up wound healing – but perhaps only if combined with a nasal oxytocin spray.

Often called the "love hormone", oxytocin has been associated with social bonding and sex. Previous research suggests it also speeds up the healing of oral ulcers, possibly due to its anti-inflammatory effect.

What's more, hostility between couples has been linked to the slower healing of blisters, which prompted Beate Ditzen at the University of Zurich in Switzerland and her colleagues to wonder if a lack of oxytocin during these interactions could be partly mediating this effect.

To learn more, they led a trial with 80 healthy heterosexual couples, whose average age was 27, who all received four small wounds on their forearms from a suction device.

The couples were split into four groups, all of which experienced different interventions over the following week. The first took a twice-daily oxytocin nasal spray and completed a 10-minute Partner Appreciation Task (PAT) – a structured discussion where they expressed gratitude for each other – up to three times a week.

The second took the oxytocin spray twice a day, with no PAT, while the third used a placebo spray and did the PAT, and the fourth used the placebo spray with no PAT.

Taking just the oxytocin spray, or doing the PAT with a placebo, didn't heal the wounds any faster than the no-spray, no-PAT group. Combining oxytocin and PAT helped a little, but the effects were most pronounced among couples who also reported touching or having any sexual activity with each other (*JAMA Psychiatry*, doi.org/qddf).

"Now we know we have a really strong indication that oxytocin seems to be an underlying mechanism mediating these effects of positive couple interaction," says Ditzen. ▮

Quantum computing

A boost for quantum computers

IBM has revealed two quantum computers, which connect qubits in newly intricate ways

Karmela Padavic-Callaghan

AS A contender in the race to build an error-free quantum supercomputer, IBM has been taking a different tack than its most direct competitors. Now, the firm has unveiled two new quantum computers, Nighthawk and Loon, that may validate its approach and could make the next generation of these devices truly useful.

IBM's quantum supercomputer design is modular and relies on developing new ways to connect superconducting qubits within and across different quantum computer units. When the firm first debuted it, some researchers questioned the practicality of these connections, says Jay Gambetta at IBM. He says it was as if people were saying to the IBM team: "You're in theory land, you cannot realise that." Now, IBM is going to show that to be wrong, he says.

Within Loon, each qubit is connected to six others and those connections can "break the plane", which means they don't just travel across a chip but can move vertically as well, a capability that no other superconducting quantum computer has had so far. Nighthawk, on the other hand, has four-way connectivity between qubits.

This increased connectivity may prove key for overcoming some of the biggest challenges faced by existing quantum computers – it could increase their computational power and eliminate their propensity to make errors. Gambetta says preliminary tests with Nighthawk show that it can run quantum computing programs that are 30 per cent more complex than those that run on the firm's currently most used quantum computer. Such increased complexity ought to lead to more applications for quantum computers, and IBM's past models have already begun to find uses in areas such as chemistry.

The ultimate goal of the industry, however, is finding ways to group qubits into so-called logical qubits, which are error-proof, and IBM has been championing a method that allows those groups to be smaller than in its competitors' approaches, such as the methods employed by Google. This could allow IBM to achieve error-free computations while sidestepping some of the costs and engineering challenges of needing to build millions of qubits. But it doesn't work without lots of connectivity between qubits – the kind that Gambetta says the team has achieved on Loon.

Stephen Bartlett at the University of Sydney in Australia says while more testing and benchmarking of the new devices is necessary, the increased qubit connectivity is exciting. "It's not a silver bullet that solves all of the problems of scaling up superconducting devices to the size needed for genuinely useful algorithms, but it is nonetheless a significant major step towards this."

In 2026, IBM plans to launch a modular quantum computer that will be able to both store and process information, which will be informed by upcoming tests of Loon and Nighthawk. ▮

IBM

IBM researchers hold a component of Nighthawk, one of its new quantum computers

Entomology

Parasitic ant plays a deadly trick on its relatives

A TYPE of parasitic ant takes over the colonies of a related species by inciting the workers to kill their own mother.

Around 230 species of ants are considered parasites – they lay their eggs in other species' colonies or steal their larvae and pupae. Some kill the host queens before laying their own eggs and convincing the workers to serve them instead.

Keizo Takasuka at Kyushu University in Fukuoka, Japan, and his colleagues noticed that, when a queen of the parasitic species *Lasius orientalis* was accidentally introduced into the nest of its relative, *Lasius flavus*, the *L. flavus* workers would then kill their own queen: their mother.

Many parasitic queens are killed by workers once they are discovered, but some get through the colony's defences, apparently by cloaking themselves in the scent of the colony.

To observe how the parasitic queens succeeded, the team assisted them by cloaking the female intruders with the scent of the worker ants before introducing them to the colony.

TAKU SHIMADA ET AL. 2025

A *Lasius flavus* ant queen is killed by her own workers

Once inside, the parasite sprays the rival queen with a chemical, thought to be formic acid, from an orifice at the tip of her abdomen.

The workers interpret this chemical as a danger to the colony and attack their queen. However, the process is slow, taking multiple sprays and many attacks from her workers before the queen is killed. Then the parasitic queen can lay her own eggs, which are tended to by the workers (*Current Biology*, DOI: 10.1016/j.cub.2025.09.037).

"If the parasitism succeeds, it allows the new queen to pass through the vulnerable founding phase far more safely than founding a colony alone," says Takasuka. "I suspect this strategy may be more widespread than we currently appreciate." ▮

James Woodford

Chemistry

Computer works like a living system

Reactions between enzymes and peptides create a constantly changing chemical network

Victoria Corless

A CHEMICAL computer made from a network of enzymes can perform a variety of tasks, like measuring temperatures or identifying substances, without needing to be rebuilt each time. This makes it more like an adaptive biological system than a digital circuit, and offers the promise of linking computers with biology.

Living organisms contain molecular networks that constantly integrate chemical and physical signals, such as when cells sense nutrients, hormones or temperature changes and adjust to stay alive. For decades, researchers have tried to mimic this in a variety of ways, such as building logic gates from DNA, but most of these artificial systems have been either too simple, too rigid or too difficult to scale.

Now, Wilhelm Huck at Radboud University in the Netherlands and his colleagues have taken a different approach. Instead of programming each chemical step, they built a system in which enzymes interact freely, creating complex behaviours that can

"We can think of the enzymes as hardware and the peptides as software"

learn to recognise patterns in chemical inputs (*Nature Chemistry*, doi.org/g995vs).

The team's computer uses seven different types of enzyme loaded onto tiny hydrogel beads packed inside a small tube. A liquid flows through this tube and can be injected with short chains of amino acids called peptides, which serve as the "input" for the computer. As the peptides pass the enzymes, each enzyme naturally tries to cut them at specific sites along the peptide chain. But once one enzyme makes a cut, the peptide's shape and available cutting sites change, which can either open or block opportunities for the other enzymes.

Because one reaction can feed into the next, the enzymes create a constantly changing chemical network, producing distinctive patterns that the system can interpret. "We can think of the enzymes as... hardware and the peptides as software [that] solves new problems depending on the inputs," says Dongyang Li at the California Institute of Technology.

For example, temperature affects how fast each enzyme works. At higher temperatures, some enzymes speed up more than others, shifting the mix of peptide fragments in the system's output. By analysing these peptide fragments using a machine-learning algorithm, the team could link these fragment patterns to specific temperatures.

Because different chemical reactions happen on various timescales, the system naturally retains a kind of "memory" of past signals, letting it recognise patterns that unfold over time. For instance, it could tell the difference between fast and slow light pulses, meaning it isn't just reacting to inputs, but tracking how they change.

Huck hopes a more advanced system could one day be used to translate optical or electrical signals directly into chemical ones, allowing it to respond in the way that living cells do. "We only used six or seven enzymes and six peptides," he says. "Imagine what you can do with a 100 enzymes." ▮

Health

Home hypnosis relieves menopausal hot flushes

THE frequency and severity of hot flushes during the menopause could be more than halved through the use of hypnotic audio recordings, which can be listened to at home.

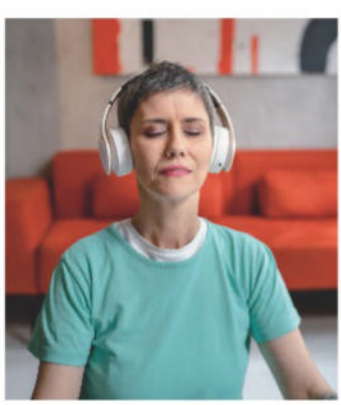
Up to 80 per cent of women experience menopausal hot flushes – sudden feelings of overheating that can cause excess sweating, discomfort, anxiety and sleep disturbances – due to the dramatic drop in oestrogen around this time. Dietary changes, hormone replacement therapy and cognitive behavioural therapy (CBT) can help, but don't work for everyone.

"Many people believe there's a mind-body connection, and that through mental processes, we can influence our bodies and our physiology," says Gary Elkins at Baylor University in Waco, Texas.

Hypnosis administered in a clinic has been shown to improve hot flush symptoms, surpassing the effect of CBT, but people need a more convenient option, says Elkins. Now, he and his colleagues have developed a six-week home programme that involves listening to 20-minute vocal recordings every day that aim to induce hypnotic relaxation and provoke images of coolness.

To put it to the test, they asked 250 postmenopausal women, average age 56, who experienced at least four hot flushes a day to complete either the hypnosis programme or a sham one that provides 20 minutes of white noise.

Six weeks later, those in the hypnosis group reported hot flush scores – a measure of their frequency and severity – that were 53 per cent lower, on average, than at the start (*JAMA Network Open*, doi.org/g993mf). Those in the sham group also benefited, but to a lesser extent, with a 41 per cent reduction. That is probably due to the placebo effect, says Elkins.



SHUTTERSTOCK/MILJAN ZIVKOVIC

Listening to hypnotic audio recordings can help people relax

After 12 weeks, when the intervention period had ended, both groups continued to experience improvements from their starting scores, with the hypnosis one reporting an overall improvement of 61 per cent. This is compared with an overall 44 per cent improvement in the sham group.

This supports the use of at-home hypnosis as a convenient, low-cost intervention for hot flushes around the time of the menopause, says Elkins. How exactly hypnosis works is unclear, but research suggests it enables the brain to modify its connections and rewire itself. This may explain why it is often effective for easing pain and anxiety. ▮

Christa Lesté-Lasserre

Space

Huge plasma cloud belched out by distant star

Matthew Sparkes

A CLOUD of plasma ejected by a star 130 light years away has been detected by a radio telescope on Earth, giving astronomers their first definitive observation of a coronal mass ejection (CME) from a star beyond our sun.

CMEs occur when storms on the surface of a star fling out bubbles of magnetised plasma into space. Such eruptions from our sun produce the auroras we see on Earth, but they can also be powerful enough to rip the atmosphere away from Venus, which is closer to the sun and isn't protected by a magnetic field.

Scientists have seen hints of CMEs on distant stars for decades, but have been unable to prove that material actually escaped the stars' gravitational and magnetic pull, rather than just leaping up from the surface before being drawn back in.

Now, Joseph Callingham at the Netherlands Institute for Radio Astronomy and his colleagues have used the Low Frequency Array (LOFAR) radio telescope in the Netherlands to pick up a burst, or radio waves, emitted by a CME as it travelled through space (*Nature*, doi.org/qdbk). These signals would be possible to detect only if the ejection had completely left the star StKM 1-1262, from which it originated.

They also used the space-based X-ray telescope XMM-Newton to determine the star's temperature, rotation and brightness.

Callingham says prior observations suggested that CMEs happened on distant stars, but this is the smoking gun that confirms it.

Anthony Yeates at Durham University, UK, says greater knowledge of CMEs from distant stars should be incorporated into models about the potential habitability of exoplanets. "If there was an exoplanet, it would have been quite catastrophic for any life on it," he says.

Climate change

Rift lakes drying up can cause earthquakes and eruptions

Alec Luhn

MARTIN HARVEY/ALAMY

Seismic activity has shaped the landscape of Lake Turkana in Kenya

A DRYING climate in East Africa reduced the amount of water in Kenya's Lake Turkana over thousands of years, which unleashed earthquakes and volcanoes from underneath it. This hazard of climate change could eventually affect other bodies of water around the world as rain and drought patterns shift.

Lake Turkana is often called the cradle of humanity, as fossils up to 4.2 million years old have been found there from at least half a dozen hominin species, some of which appear to have co-existed. As the lake shrank over recent millennia, those human ancestors would have had to contend not only with a drying climate, but also with greater seismic activity.

"We postulate that there would have been more frequent earthquakes and more frequent volcanic eruptions during these time intervals," says Christopher Scholz at Syracuse University in New York state.

Lake Turkana is located between Kenya and Ethiopia in the Great Rift valley, a place where the continental plate is slowly splitting and spreading apart. It is the largest desert lake in the world, a body of greenish, salty water ringed by sandy shrublands and windy outcrops. But nine millennia ago, the lake was even bigger and surrounded by lush grasslands and pockets of forest.

Between 4000 and 6000 years ago, the climate became drier and the water levels in the lake dropped by 100 to 150 metres. Lower water levels create less pressure on the lakebed below, which can impact seismic activity. To determine the effects of this climate change, Scholz and his colleagues identified certain sediment layers corresponding to different time periods in cores that had previously been taken from the lakebed.

> "It's almost like loosening the cork on a champagne bottle. The magma is more likely to rise up"

From a boat, they then performed sonar imaging at 27 faults on the lakebed to see how far the same sediment layers had been displaced from each other vertically on either side of each fault. They found as the climate dried, the sides of the faults began slipping past each other more quickly, increasing at an average rate of 0.17 millimetres per year (*Scientific Reports*, doi.org/g992ns).

"The main process is literally sort of clamping or unclamping this deformation zone, the zone of slip which results in earthquakes," says Scholz. "A drier system and lower lake load allows it to slip more readily."

Computer modelling suggested the reduced water mass also let more magma flow up from below the lake. One of the three volcanic islands in Lake Turkana erupted in 1888.

Scientists previously found lower sea levels increased volcanism at ocean ridges. But this is the first clear evidence of that happening around a lake, says Ken Macdonald at the University of California, Santa Barbara. "It's almost like loosening the cork on a champagne bottle," he says. "As you decrease that pressure, the magma is more likely to rise up in the crust and erupt."

While increased rainfall due to climate change is now raising water levels in Lake Turkana once again, it would take thousands of years for that to significantly suppress earthquakes and volcanoes.

But assessments of seismic hazards should start considering how the changing climate might affect water levels, according to the study authors.

Health

Why aren't young people having sex?

Sexual activity in young people is on the decline. Should we be worried about what this means for society, asks **Alexandra Thompson**

THE comedy film *No Sex Please – We're British* was released in 1973 with a largely youthful cast and one too many double entendres. Half a century later, that title seems more apt than ever, at least among the younger members of society. Over the past few decades, sex appears to have been on the decline among teenagers and young adults – but it's not just happening in Britain.

In the US in 2010, 12 per cent of 18-to-29-year-olds reported not having had sex in the past year, according to the General Social Survey, a long-running sociological survey. In 2024, that figure had doubled.

A similar decline in sexual activity among young people is occurring in high-income countries such as Australia and Germany. But it is most notable in Japan, with a recent review finding that around half of Japanese people remain sexually inexperienced through their mid-20s. This may explain why the number of deaths in Japan exceeded its births by almost 1 million in 2024, a "quiet emergency" according to the then-prime minister, Shigeru Ishiba. So, what is going on, and is it really an emergency?

Of course, the amount of sex people have has always fluctuated, says Kaye Wellings at the London School of Hygiene & Tropical Medicine. In the 1950s, the norm was to wait until you were married, she says, then when the contraceptive pill became available in the 1960s, "there was talk about a sort of free lunch, you could have sex without any consequences". The beginning of the AIDS epidemic in the 1980s made people much more restrained, she says. "But the 90s, I think is when the imperative changed and became one of encouraging sex."

DIMPLE PATEL/ALAMY

More people may now feel comfortable identifying as asexual

The current decline in sexual activity among young people doesn't have a single, clear explanation. Some say today's tough financial climate prevents them from being more independent. In 2023, for example, 18 per cent of 25-to-34-year-olds in the US lived in a parent's home – up from 9 per cent in 2000. "If you're living at home, it's not necessarily the most conducive environment to having lots of sex," says Luke Brunning at the University of Leeds, UK.

Youth unemployment is also high in countries such as the UK, which may partly explain why, on average, sexual inactivity seems to be slightly more pronounced among young men than young women – with the odds rising if they are out of work or have a low income. "It shouldn't be that a man's earning ability or financial status should be considered as attractive, but when you look at the research, it seems to be a universal pattern," says Peter Ueda at the Karolinska Institute in Sweden.

> **"Sex can be an intimidating experience. The less you do it, the less you feel comfortable with it"**

Rising sobriety might be another factor, if it makes young people more inhibited. A report by analytics company Gallup found that the proportion of 18-to-34-year-olds in the US who say they drink alcohol has fallen from 72 per cent to 62 per cent over the past two decades – but drinking has increased from 49 per cent to 59 per cent among people aged 55 and over. "You can pin it to 'generation sensible'," says Wellings. "That label has been given to young people who drink less, use less drugs [and] have less sex."

Then there are technological advances. The younger generation seems to have swapped in-person socialising for digital devices, but sexual encounters generally require physical contact. "Gen Z have been called the most connected but loneliest generation because they're really connected to each other, but they're mostly really connected with screens," says Natasha McKeever, also at the University of Leeds. "That can mean they're more nervous about in-person interaction."

Theoretically, dating apps have made it easier to connect than ever before, but their rollout since the early 2010s hasn't coincided with a rise in sexual encounters among young people. "These apps were not designed for people to actually have sexual intercourse, but to be hooked on the apps," says Andras Kolto at the University of Galway, Ireland. Users are now increasingly logging off, with some studies linking use of dating apps to depression and anxiety.

Reducing the stigma

Mental health issues may also be contributing towards the decline in sexual activity, with a report in *The Lancet Psychiatry* warning we have "entered a dangerous phase" with these problems among young people. "If people are not feeling great, they might not always be in the headspace to be engaged with sex," says Brunning. Anxiety can even become a self-perpetuating cycle. "Sex can be a very daunting, intimidating experience, and the less you do it, the less you feel comfortable with it," says McKeever. "So, if people aren't having sex for long periods of time, it might be that they get to a point where they really want to have sex, [but] they feel very anxious about it."

For some, this inactivity is a concern, given that sex has been linked to improved quality of life and overall health, and around half of women and two-thirds of men report wanting more of it. "When we see a decline in sex, the fundamental problem is we're seeing a failure of more and more people to live the lives they themselves say are meaningful and valuable and important," says Lyman Stone at the Institute for Family Studies in Virginia.

But not everyone agrees that young people are being negatively affected by this, providing they are content with their situation. For example, a study of heterosexual 18-to-39-year-olds in Japan found that around half of those who were single had no interest in romantic relationships. "There are more things for young people to do probably now than there were in the past," says McKeever. "There's a lot more opportunity for travel. There are more diverse careers open to people. Sex isn't the only good thing in life."

The shift could also be explained by reduced stigma around some young people not wanting to have sex, says McKeever, perhaps due to increased awareness around consent since the #MeToo movement or to young people now feeling more comfortable identifying as asexual. "When I was younger, I feel like a lot of people were having sex just because they thought that's what they had to do to be cool or it was a rite of passage, whereas now I think young people are more clued-up."

Of course, knowing exactly how sexual activity has changed among young people is limited by data issues. People may exaggerate or downplay their experiences depending on whether they are questioned about them face-to-face versus via an online survey, or according to the taboos of the time. "When the social climate is that taboos are very strong, you will under-report. At times when it's considered to be status conferring, you will over-report," says Wellings. Studies also vary in how they define sex or a young person.

Then there's the issue of volunteer bias – that certain types of people tend to put themselves forward for such studies, making the results less applicable to the general population. "Online populations tend to bias towards young, single, childless [people]," says Stone.

Exact numbers aside, researchers are unanimous that young people are having less sex than older generations did at their age. Similar to the situation in Japan, this has coincided with birth rates reaching record lows in the UK and US.

So is a lack of sex a societal emergency, as the number of children dwindle? No, says Kolto, who expects changing circumstances will eventually see numbers pick up again, as in previous decades. "The decline in adolescents' sexual activity will surely not be the end of [the] human race," he says.

"I don't think we have evidence that the situation [in the West] counts as a problem yet," says McKeever. But if politicians are worried about a lack of sex, there are some solutions. "Young people [having] less sex than some decades ago is a symptom of the pandemic of alienation [and] the cost of living and housing," says Kolto. "Politicians should take care of solving these issues, then sex will take care of itself." ▮

MICHAL CIZEK/AFP VIA GETTY IMAGES

Young people drinking less alcohol could be a factor in having less sex

9%
How many US 25-to-34-year-olds lived with their parents in 2000

18%
How many US 25-to-34-year-olds lived with their parents in 2023

24%
How many US 18-to-19-year-olds said they had no sex in the past year in 2024, double the figure in 2010

DAVID MAREUIL/ANADOLU AGENCY VIA GETTY IMAGES

In Japan, the drop in the birth rate has been called a "quiet emergency"

Technology

High-voltage 'wand' could defrost vehicles

Alex Wilkins

STATIC electricity can remove up to three-quarters of frost from a surface, which could save vast amounts of energy and millions of tonnes of antifreeze currently used to defrost vehicles.

In 2021, Jonathan Boreyko at Virginia Tech and his colleagues serendipitously discovered that frost becomes naturally charged as it forms. They used this natural electric field to charge a nearby film of water that could then, in turn, pluck ice crystals from the frost, acting as a natural de-icer. This effect, however, was minuscule and had little effect on the frost overall.

Now, Boreyko and his team have developed a more effective defrosting system by using an extremely high-voltage copper electrode suspended above frost-covered glass or copper. This system can remove half the frost from a surface in around 10 to 15 minutes, and 75 per cent of the frost if the surface is also highly water-repellent (*Small Methods*, doi.org/qc9q). "Instead of taking advantage of frost's pre-existing voltage, we're trying to turbo-boost the whole effect by applying our own voltage," says Boreyko.

Removing 50 per cent of the frost from a surface using their method required an electrode charged to 550 volts, more than double the voltage supplied by mains electricity in most countries. Unlike electrical sockets, though, the electrode has a tiny current, making it relatively safe. This small current also ensures it requires little energy, less than half the amount it would take to heat the frost directly, according to Boreyko.

As well as potentially being used in car windows and on roads, a fast and efficient defrosting method could also be helpful in the aviation industry.

"Instead of dousing hundreds of litres of antifreeze over an airplane wing to de-ice it when it's taxiing, instead you just have this machine that can drive around airport runways with an electric wand and, as you wave the high-voltage wand over the wing, it just pulls all of that ice and snow right off," says Boreyko. ▮

Defrosting an aeroplane can take hundreds of litres of antifreeze

JAROMIR CHALABALA/ALAMY

Views

Comment

Running out of road

Cars are getting bigger, which is bad for both us and for the planet. But we have ways to counter "carspreading", says **Anthony Laverty**

IF, LIKE me, you live in the UK, you have probably noticed something: there are more and more sport utility vehicles (SUVs) and similar types of large cars on the streets. These accounted for a huge 63 per cent of new car sales in the UK last year, up from 12 per cent in 2010.

Globally, the figure is about 48 per cent and shows no sign of coming down. Cars are getting bigger, and that is a problem. I work on the links between transport and health. This month, together with colleagues, I made a call in *The BMJ* for action to be taken – locally, nationally and internationally – to curb sales of these vehicles.

The main categories of health harms from cars are road danger, pollution and people driving instead of walking or cycling, which are better for their physical health. Larger and heavier cars are worse for all three of these risks.

ELAINE KNOX

It makes intuitive sense that larger cars are more dangerous if they run you over. Their fronts are blunter and taller than other cars' and this is bad news for cyclists and pedestrians if one of these cars hits you. I was involved in a review last year of all of the studies looking at what happened when an SUV hit a pedestrian or cyclist. We found that adults were 44 per cent more likely to die if hit by an SUV rather than a normal car. The review also estimated that in the US, 10 per cent of pedestrian and cyclist deaths and serious injuries would be averted if SUVs were replaced with smaller cars. This translates to about 1700 deaths and serious injuries each year.

Cars are also getting wider – a trend known as "carspreading". On average, new cars in Europe got half a centimetre wider each year from 2010 to 2024. There is only so much road space, and more of it being taken up by cars means there is less of it for people cycling or using other modes of transit. We know that if more people were walking and cycling, there would be big benefits to their health. So cars getting bigger means we are missing out on that upside, too.

The extra size of these cars also makes for more air pollution. The shift to more electric cars is obviously good news, as it means less emissions from exhausts. But even if SUVs are electric, fine particles from tyres and brakes are now major sources of pollution in urban air and are produced both by electric cars and fossil fuel-powered cars. As SUVs are heavier than other cars, they tend to produce more tyre and brake particles, so we don't see the same clean air benefits from electric SUVs as we do from smaller electric cars.

So what can we do to make fewer of these large, dangerous, high-emission SUVs? My colleagues and I have a few suggestions. There are now clean-air zones in some big cities, such as the Ultra Low Emission Zone in London. These stimulate people to think about pollution from older cars, although they aren't directed at vehicle size. This is changing in the UK, however, as Cardiff Council in October approved plans to charge the owners of SUVs and larger cars more for residential parking permits. This means the Welsh capital joins Paris, which famously tripled fees to park SUVs in its centre, as well as other cities in Germany and France, which charge more to park heavier or bigger vehicles.

As well as parking regulations, national governments could consider changes to vehicle taxes, for instance, to encourage smaller cars. Taxing large vehicles more would be commensurate with their cost to society through road danger and pollution.

Some people have reasons to need a larger car. But now that around half of new car sales are SUVs, we need to be clear about the dangers they bring to our health. If we are going to have safer streets and cleaner air, we need people to consider these issues when buying a car. We also need governments to do more to bring the costs of these cars into line with the extra danger and pollution they cause. ▮

Anthony Laverty is at the School of Public Health at Imperial College London

Future Chronicles

Escaping the Anslopocene

In the latest in our imagined history of inventions yet to come, **Rowan Hooper** reveals how an ingenious way to avoid AI slop was invented in the late 2020s

Rowan Hooper is *New Scientist*'s podcast editor and the author of *How to Spend a Trillion Dollars: The 10 global problems we can actually fix*. Follow him on Bluesky @rowhoop.bsky.social

In Future Chronicles, he explores an imagined history of inventions and developments yet to come.

This column appears monthly. Up next week: Chanda Prescod-Weinstein

BY THE mid-2020s, the world was becoming swamped with "AI slop". Whether images, video, music, emails, ads, speeches or TV shows, many people's interactions were with asinine content generated by artificial intelligence. Sometimes the experience was fun and relatively harmless, but often it was tedious and brain-sapping. At worst, it could be dangerously misleading. Even engagements with other people became suspect – who knew if the person on the phone was real or not? Many people found it nauseating and insulting, and wished they could escape the slop.

There was no "Butlerian jihad" – the fictional overthrow of all thinking machines in the *Dune* books, named for Samuel Butler's prescient 1863 letter on machine evolution, "Darwin among the machines". In fact, the solution, ironically enough, came through a clever use of AI.

Tech companies had developed a range of smart glasses that provided augmented reality (AR) displays with inbuilt cameras, mics and headphones. In 2028, engineers at the Reclaim Reality Foundation took the tech in smart glasses and used a custom AI to detect and then remove anything that was AI-generated. Wearing the unsmart glasses acted as a sort of negative AR, creating an entirely un-augmented reality.

Walking in a city wearing these DumbGlasses, which became known as X-ray spex as they saw through everything, was akin to paying for an ad-free TV show or podcast. The glasses removed banners and posters that had been made using AI and seamlessly replaced them with a natural background. Any speech and songs you heard, you could be confident they were made by a traditional analogue process. People used X-ray spex to relax, to calm themselves, to detox from the waves of AI slop they otherwise had to negotiate. Some wearers celebrated their status with T-shirts and badges bearing slogans such as "AI Vegan", "Real or Nothing" and "Slop-Free Zone".

As technology improved in the 2030s, it became possible to wear electronic contact lenses and miniature ear implants that performed the same function.

The online world was a different matter. There it was much harder to escape the clutches of AI and the constant algorithmic profiling.

> **"Engineers took the tech in smart glasses and used a custom AI to remove anything that was AI-generated"**

One method was to use a workaround to access search engines without triggering an AI summary. In the 2020s, one such option was startpage.com. Other hacks involved adding an expletive to your search prompt, which shut down AI-generated summaries. But workarounds didn't help avoid AI profiling and targeting when using social media networks. Escaping that was easier said than done when social media, the tools of online navigation and the online world itself were utterly dominated by tech giants. And few people wanted to renounce everything the internet revolution had given us. They still wanted a digital world to explore and a rich online experience.

The answer was the rise of a third kind of network. There was the regular internet, and there was the dark web, accessible only with specific browsers and passcodes.

Then there was the veriweb (from *veritas*, the Latin word for truth), made of content that was hallmarked as being AI-free. In collaboration with Reclaim Reality, artists, musicians and writers developed an unfakeable system – similar to the blockchain technology used to verify cryptocurrency transactions – that guaranteed the human provenance of any content. The veriweb, which was also known as the transparent web because you could see where the content came from, became the go-to place for guaranteed information and journalism. Wikipedia, plagued by AI-generated content for much of the 2020s, moved to the veriweb in 2029. News providers established outposts there and were soon followed by legacy news and media organisations keen to demonstrate their authenticity, trustworthiness and veracity. Moreover, on the veriweb, users weren't tracked, profiled and targeted by AI algorithms.

What was gained, as millions and then billions made the move, was a return to human-to-human connection and a rise in creativity. Most still used AI in a personal capacity – in medical diagnoses, for example – but the atrophy of the human brain that had been under way since the 2020s, when more and more actions were outsourced to AI, was checked.

What was lost, as people tried to navigate the vastness of cyberspace without the aid of algorithms to point them in helpful directions, was the feeling that your online experience was curated and personalised. Also lost was the unprecedented amount of intimate data harvested by those megacompanies, and the vast profits generated by the targeted exploitation of that data. Few mourned this loss. ▮

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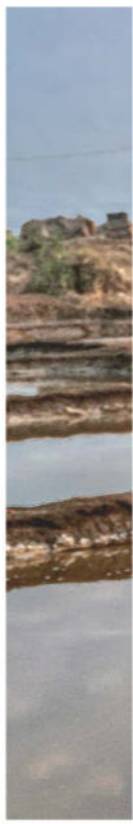

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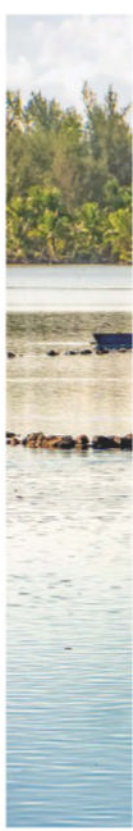


WASIM MUKLASHY

Water world

Taschen

ON EARTH, water predates us as an inhabitant and as a maker of structures, landscapes and lives. In this sense, it is our elder, our ancestor and, as Julia Watson writes in her new book *Lo-TEK Water*, our kin.

"Water is not a resource to be extracted or managed, but a living relative, a system of memory, intelligence, and reciprocity," the designer writes, introducing an exploration of how Indigenous understanding of water can inform a more sustainable, future-proof design for cities and other places that support our living.

TEK stands for "traditional ecological knowledge", and Watson writes within the framework of TEKnology, which combines such ancestral insights with more modern environmental, agricultural and architectural tools. This, she argues, provides a crucial lens for understanding some of the biggest current planetary crises, from droughts and floods to endangered marine species. "Can a city learn to live again by remembering how to work with water?" asks Watson.

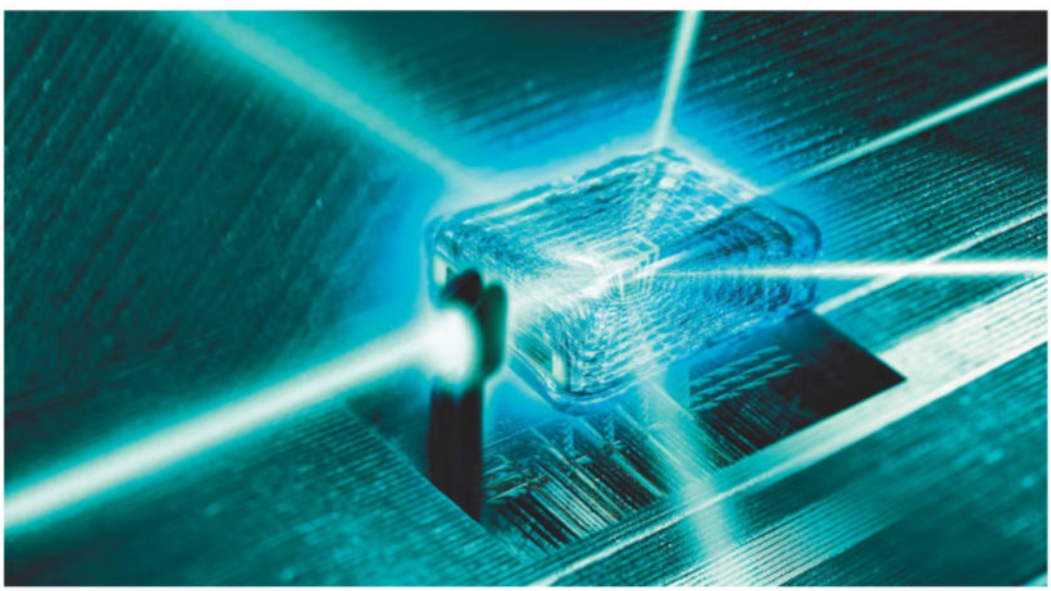
Lo-TEK Water overflows with images of places where water and humanity meet. The far-left image shows the vast Bay of Mont Saint-Michel in France, which contains a 300-square-kilometre forest of wood pylons used as scaffolding for mussel farming. At the top near-left is a single figure perfectly reflected in the still water of the salt pans of Goa, a traditional system where salt is produced from just saltwater and sunlight. The lagoons of French Polynesia are shown at the bottom near-left, revealing a 1000-year-old system for fishing that can both sustain families and preserve non-human life.

Karmela Padavic-Callaghan

Dazzled by the quantum realm

Attempts to describe quantum physics are rarely so ambitious or enjoyable, but this book's zeal sometimes steers too close to hype, finds **Karmela Padavic-Callaghan**

Book
Quantum 2.0
Paul Davies
Penguin (UK, out 27th November); University of Chicago Press (US, out February 2026)



RICHARD KAIL/SCIENCE PHOTO LIBRARY

***Quantum 2.0* visits the edges of our knowledge about the quantum world**

PHYSICIST Paul Davies's *Quantum 2.0: The past, present and future of quantum physics* ends on a beautiful note. "To be aware of the quantum world is to glimpse something of the majesty and elegance of the physical universe and our place within it," he writes on the book's last page.

This romantic and inviting view permeates the book. *Quantum 2.0* is a valiant effort to describe the quantum world and the very edges of our knowledge about it, and Davies is an informed and enthusiastic narrator. Yet his zeal, at times, comes dangerously close to hype, and his remarkable skill as a writer fills in gaps where a few more citations would have been more appropriate than a clever turn of phrase.

Davies's book is extremely readable, in spite of its ambitious aim of taking on nearly every facet of quantum physics. He discusses quantum technologies for computing, communication and sensing, touches on quantum biology and cosmology, and somehow has enough time left to run through many of the competing interpretations of quantum theory.

There are no equations in *Quantum 2.0*, and the few technical diagrams and schematics that are included are neither cumbersome nor slow down the reading experience.

As someone who writes about quantum physics myself, I took note of how clearly Davies breaks down experiments, as well as protocols from quantum information processing and cryptography – this isn't at all easy!

As a guide through the quantum world and all its eras, Davies is an inviting and friendly companion, and his own curiosity and excitement are undeniable. That excitement, however, isn't always as grounded as the nuances of contemporary quantum physics research call for. Unfortunately, excitement about most things quantum, in my experience, should always come with ample caveats.

"A reader not well versed in quantum research could mistake speculative claims for the truth"

For example, within the first 100 pages of the book, Davies twice claims that quantum computers could be used to advance climate modelling, which isn't the consensus opinion among computer scientists and mathematicians, especially when it comes to machines we will be using in the near term.

As another example, in a later chapter that deals with quantum sensors, he notes that manufacturers of certain sensors claim that they could help analyse conditions like epilepsy, schizophrenia and autism. I waited for Davies to qualify the claim or tell me what experts who don't sell such sensors think, but the follow-up discussion was sparse and uncritical.

As yet another caveat, I noticed that examples given during Davies's discussion of demonstrations of quantum computers' supremacy over their conventional counterparts were several years out of date.

A reader who isn't well versed in quantum research – who certainly wouldn't have a bad time reading this book – could easily mistake some of Davies's more speculative claims about quantum research as being closer to truth. This is only buttressed by weighty proclamations such as "It's safe to say that whoever controls Quantum 2.0 controls the world."

To be clear, I don't think Davies's sentiment is incorrect. Many of the devices that power our daily lives already rely on quantum physics, and our technological future stands a good chance of being even more quantum. I am personally rooting for that.

Advances in nascent fields like quantum biology or better integration of quantum theory and theories of the cosmos also seem imminent; just ask the myriad researchers hard at work trying to formulate, for instance, a quantum theory of gravity.

But when it comes to describing this future to someone for the first time, storytelling and writing skill simply have to be paired with rigour and nuance.

Otherwise, everyone is being set up for disappointment. ▮

Not for the squeamish

Exploring how we repair and replace body parts makes for a brilliant read – just beware the grisly details, warns **Carissa Wong**

Book

Replaceable You

Mary Roach

Oneworld Publications (UK); W. W. Norton (US)

OUR bodies are made of many squishy, hard and intricate parts. When these fail – or fall short of our expectations – what are we to do? Medicine offers some solutions, from dentures to skin, heart or hair transplants, but don't expect to buy a brand-new you anytime soon.

In *Replaceable You: Adventures in human anatomy*, popular science writer Mary Roach tours us through some of the most jaw-dropping efforts – past and present – to repair, replace or enhance our body parts.

These include fake teeth worn like mouth earrings, lab-grown anuses and gene-edited pig hearts, each presented with an infectious humour that had me chuckling, grimacing and holding my breath from one page to the next.

I have no doubt that Roach was, in her own words, drawn to the "human elements of the quest". She provides brilliantly entertaining accounts of travelling the world to meet the personalities – surgeons, scientists and patients – pioneering ways to tweak our bodies.

These encounters come alive thanks to her daring, sometimes mischievous, questions. For instance, when discussing intestine-derived vaginas with a surgeon over dinner, she points out that gut tissue usually contracts to move food along.

"That could be kind of fabulous for a partner with a penis, no?" she asks. "It's not that aggressive," the surgeon replies, between sips of Chianti.

Roach also indulges in some self-experimentation. At one point, she visits a surgeon who specialises in hair transplants. So enthralled is she by the process of hair follicles being plucked and planted from one body part to another, she persuades him to transfer some from her head to another part of her body. Her aim is to "marvel at the strangeness of a few strands of long, flowing head hair growing on, say, my leg." The transplant attempt fails, but there is hardly time to dwell as we move on to the trials and tribulations of growing hair from stem cells. Spoiler alert: we're not quite there yet.

One widely used innovation Roach covers is ostomy, where surgeons create an opening in the abdomen to divert bodily waste into an external pouch, or stoma bag. She meets people who have had stoma bags fitted because of conditions such as Crohn's disease and colitis, the symptoms of which can include gut inflammation and frequent bowel movements that make it hard to leave home. Roach discusses the need to reduce stigma around ostomy, while explaining the rather cool technology that makes it possible.

As I would expect of a book on replacing body parts, there is also a chapter on 3D-printed organs. Roach tackles the topic with appropriate caution. It isn't as simple as loading a printer with cells of your choice. Most organs are made of multiple cell types that must be laid down in highly specific patterns, and even then, printed tissue commonly lacks properties of the real deal – something researchers are often at a loss to explain.

I would highly recommend this book to anyone interested in the human body. But I will warn you that it features several vivid descriptions of surgical procedures. (Skip to the next paragraph if you'd rather not read them.) At one point, Roach describes a tube of fat and blood being extracted from a patient as "raspberry smoothie". Meanwhile, attaching a leg implant to a thigh bone makes "the sound of a tent stake going down".

Such sensory details certainly won't be for everyone, but for those willing to embrace the sloppy, sinewy and fragile nature of our bodies, the book serves as a wonderful reminder of how profoundly complex we really are. It certainly left me feeling grateful for all the working parts I have.

Scaffolds like these are used to give structure to 3D-printed organs

TRISTAN FEWINGS/GETTY IMAGES

New Scientist *recommends*

Penny Sarchet
Managing editor
London

I've long wanted to attend the Society of Wildlife Artists' annual **Natural Eye** exhibition, and a few weeks ago, I finally did. The art showcase ran at the Mall Galleries

in London in October, and it is available to browse online until 1 December.

Magazine editor Eleanor Parsons and I began by enthusing about each of the featured species. "Ooh widgeon! Curlew! Long-tailed tits!" Next, we played the "which-would-you-buy" game, only to discover that the piece I liked the most was the least practical: an astonishing found-object sculpture of a red underwing moth (above) by Dean Patman. At the time of writing, it is still available, if you share my appreciation of moths and have £1750 to spare.

In the UK, this is the season of winter migrants, when braving the winds at a muddy wetland rewards you with recently arrived ducks and waders galore. In lieu of an estuary, many of the artworks – in which wetland birds often starred – proved a calming substitute.

DEAN PATMAN

‘Dark matter music’

Brian Eno and Beatie Wolfe tell **Chelsea Whyte** about their new album – which is being transmitted into space by Nobel laureate Robert Wilson

Music
Liminal
Brian Eno and Beatie Wolfe
Verve Records

CECILY ENO

Beatie Wolfe (left) and Brian Eno preparing to launch their new album

ON A sunny day in October, I found myself standing in a field in New Jersey, craning my head up towards a massive metal cornucopia. I was at the Holmdel Horn Antenna for what I can confidently say is the strangest album release I have ever attended. Next to me stood Nobel prizewinner Robert Wilson, an astronomer who redefined the universe – in 1964, he and his colleague Arno Allan Penzias discovered the cosmic microwave background (CMB), the faint radiation spread throughout the universe that is strong evidence to support the big bang theory.

Joining that radiation out in the universe were tracks from *Liminal*, the third in a series of albums from ambient music pioneer Brian Eno and conceptual artist and musician Beatie Wolfe. Wolfe and Eno describe this album as “dark matter music”, a fitting phrase for the half-melodic songs and non-songs that mystify but also draw you in. “It’s invoking the invisible that’s all around us, that’s binding everything together,” says Wolfe. Eno adds: “It’s this idea that the universe is full of stuff that we can’t sense.”

Wilson and his colleague Greg Wright reverse-engineered the Holmdel Horn, making the 16-tonne antenna into a transmitter instead of a receiver. We leaned over a signal modulator to test it, straining to hear Wolfe’s low voice through the tinny device. “Beatie has that lovely rich bass in her voice, so it’ll be hard to hear,” says Wilson. But through the horn, the true recording would play out – even if it was silent from where I stood.

“The beam width is around 1 degree, so if you do the trigonometry, by the time the signal gets beyond Earth’s orbit, it will weaken,” says Wilson. He says the album’s signal will be strong enough to hear in low Earth orbit, but by the moon, it will be overwhelmed by the CMB.

Wright and Wilson turn the horn to the sky, ready to send *Liminal* to the stars. This album

“Brian Eno says the album is evoking the idea that the universe is full of stuff that we can’t sense”

paints a strange landscape, alternating between lush ambient tracks built from layers of synths and guitars, and songs that highlight Wolfe’s mournful vocals. Atmospheric is almost too small a word for how immersive it is. Listening brought on a feeling of endlessness, like slipping off the side of a boat into the ocean and drifting down, but in a freeing way.

After two album releases earlier this year, *Luminal* and *Lateral*, this instalment completes the trilogy. “There are many times we listen back to something and really had no idea how we made it,” says Wolfe. “Including who actually made the noises,” says Eno. “It’s like if you have an interesting conversation with somebody – it’s hard to remember how it evolved or developed; you can’t really reconstruct the flow.”

The album does feel conversational, drifting from a percussive and joyful urgency on a track called *Procession* to unsettling robotic lyrics spoken over a droning whirr on *Laundry Room*, and then to the immersive and deeply emotive *Little Boy* – Eno’s favourite track of the bunch.

“The biggest thing in music in the last 70 or 80 years is the ability to create new sonic spaces that couldn’t really exist, that are entirely fictional in a sense,” he says. “You can have reverbs that are a year long if you want, or create a space like an infinitely large building… I think what we’re interested in is exploring these new spaces and seeing what it’s like to be inside them.”

It is easy to describe ambient music as “other-worldly”, but *Liminal* isn’t quite that. The edges haven’t been sanded off so much that you don’t hear the humans – and the human imperfection – behind it. “It really mattered that you understand that another human being made these things,” says Eno. “Funnily enough, this is one of the reasons that I think AI doesn’t really work. It’s always really impressive when you see something made by AI; you think it looks amazing. But when you find out it’s a machine that made it, it has a kind of emptiness to it.”

When I ask them if they think anyone out there in the universe might hear their music after blasting it into space, they surprise me by saying they don’t much consider an audience when they are creating these pieces. “The nice thing about this music is we really weren’t thinking about anyone when we were making it. We made it because it was fun and exciting and felt new, these territories or feelings we were exploring,” says Wolfe.

Eno chimes in: “Play is part of science just as it’s part of art. All of the scientists I know do what they do because they’re fascinated by it. It’s the same motivation. The reason is because you feel that you’re learning something deeply important.”

I think back to Wilson, standing in the room where he revolutionised our understanding of the timeline of the universe, grinning over a laptop while we talk about where the music is now. It is past the moon, on the way to the constellation Corona Borealis, spreading out to join the rest of the dark matter. ▮

Editor's pick

A citizen-led approach to climate change

1 November, p 21

From Matthew Stevens, Sydney, Australia

Susannah Fisher's take on the COP30 negotiations in Brazil is hopeful, but I can't share her faith in relying on government or corporations to do anything meaningful. The common feature of most administrations is the setting of short-term goals, because democratic governments don't want to plan for a future for which they won't get credit, and autocratic governments work to stay in power for their own benefit, not that of the populace.

This leaves citizen-driven projects. Because we all focus on our immediate needs, if enough of us are motivated to overcome threats that affect us directly, we can achieve meaningful progress, particularly through shaping market demand. This creates a role for the more motivated among us to share ideas with which we can all engage. For this, we will have to bypass the gatekeepers of social media. An open-source, distributed-host, Wikipedia-like model for the exchange of ideas might work.

From enshittification to enlightenment

1 November, p 27

From Andrew Shead, Tulsa, Oklahoma, US

Cory Doctorow is correct about how algorithms end up ruining good services. However, I experience little to no enshittification, probably because I don't do so-called social media, and I pay to use encrypted services, enjoy a vast selection of open-source applications, use a phone with a replaceable battery and avoid the Google search engine. Just breaking free from "social" media will make you feel like an enlightened person in Nirvana.

Continuing adventures into human consciousness

25 October, p 36

From Peter White, Cardiff, UK

Robert Kuhn deserves praise for compiling a comprehensive catalogue of theories of consciousness. There is a problem, however. Science progresses by proposals of hypotheses that generate testable predictions. If the predictions generated by a hypothesis are disconfirmed, then that hypothesis is discarded and we can move on to better ones.

Theories of consciousness, however, don't seem to generate testable predictions. If there are 350 theories, at least 349 of them must be wrong. But it isn't clear what sort of evidence would show any of them to be wrong, so no progress is possible.

From Wolf Kirchmeir, Blind River, Ontario, Canada

It seems to me that consciousness isn't a state or quality, but something the brain does. Two observations that I think support this conclusion: one, we manipulate conscious experience by ingesting certain substances.

Two, anaesthetics reduce conscious experience to about as close to zero as is likely possible. The above implies that the proper question isn't "What is consciousness?" It's "How does the brain do conscious experience?" I suspect the awkward grammar of that question has a lot to do with why it's rarely asked.

From John Grant, Shelly Beach, Queensland, Australia

An excellent article, though it seems possible there may be difficulty providing detached judgement when it comes to asking ourselves about our own consciousness and what that means. To avoid bias, maybe a solution is to ask AI. Then there's the question of whether AI can attain consciousness and, by implication, think like a human. Based on its own observations of humanity, perhaps AI has already decided wisely that it doesn't want to.

Remembering our microbial friends

4 October, p 32

From Lindsay Wright, Rangiora, New Zealand

Graham Lawton's excellent article on fermented foods shows how human evolution has built a strong symbiotic relationship with Earth's vast biome. Thank you for reminding us how utterly scrumptious our microbial friends can be, and how to find them for our daily intake. Even that lightly rinsed tomato fresh from the garden offers much more than its simple chemical constituents. Perhaps that silly 5-second food-on-the-floor rule should be reversed?

Could we be more selective about what we hear?

Letters, 1 November

From Richard Black, Belchford, Lincolnshire, UK

In a letter responding to the article about how our brains "swivel" towards certain sounds, Bryn Glover mentions the problem of using hearing aids in the dining area of a pub. Although I don't use hearing aids, I have this problem of my brain focusing on the louder sounds behind me, or to one side, and wonder if hearing aids could be designed as binaural, forward-facing microphones. Could software not then pick up and selectively amplify sounds coming from the direction one is facing?

The case against biomass carbon capture

Letters, 8 November

From David Flint, London, UK

I am glad to have Eric Kvaalen's support for carbon capture, but his desire to rely on biomass for this is misplaced. The main, though not the only, problem is the vast area of land that would be needed for a capture programme that would significantly reduce atmospheric carbon dioxide. Research at Imperial College has shown that carbon capture from biomass can make only a limited contribution to meeting the need.

Sooner or later we will need to use heavy chemical engineering to capture CO_2 from the air. Happily we can exploit the falling cost of renewable energy but it will still be expensive.

A new way of looking at our family tree

8 November, p 40

From Nigel Yeatman, London, UK

When I did A-level biology, a species was a group of individuals whose members could interbreed to form fertile offspring. Since then it seems there has been meaning creep, especially in the hominins.

There is good evidence for hybridisation between all the "species" derived from *Homo erectus*. We are all *H. erectus*, with subspecies *H. e. erectus*, *H. e. neanderthalis*, *H. e. denisovensis*, and others, including *H. e. sapiens* (so called). This would emphasise that we could all have remote ancestors and genes from more than one, or all, of these groups. Unchain the subspecies taxon!

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THE BIG FAT TRUTH

Often regarded as a nuisance or a health hazard, we have overlooked the role of fat as a vital organ that shapes our health, finds **Linda Geddes**

IF YOU melted down the average UK adult, you would find around 22 kilograms (48.5 pounds) of creamy yellow fat – equivalent to around 88 blocks of lard, enough to fill two-thirds of a small suitcase or cast into 446 dinner candles. Melted, it would easily be enough to paint a large bedroom in a translucent, waxy sheen.

It's a queasy thought. For centuries, we have regarded body fat as an inert, lard-like substance. We carry it everywhere, and frequently despise it – yet this pale, oily tissue is undergoing a radical reassessment. Far from an inert nuisance, it is an organ – one that is alive and surprisingly communicative, has its own memory and is capable of influencing everything from appetite and metabolism to fertility, mood and immunity.

Fat, it turns out, isn't one thing. It comes in white, brown, beige and even pink forms – each with distinct functions and found in different locations – and contains a mix of immune cells, nerves and blood vessels that contribute to its powers.

"You wouldn't get pushback today if you claimed fat was an organ, in the same way your lungs or liver or spleen are organs," says Paul Cohen at The Rockefeller University in New York, who researches metabolic disease and cancer related to obesity. This shift in thinking is reshaping our view of body fat and our understanding of obesity. It challenges how we think about trying to get rid of fat, and is even prompting some scientists to explore how to reprogram it instead – not just to tackle obesity, but to improve our broader health.

MATT DARTFORD

Until relatively recently, body fat – also known as adipose tissue – was largely seen as a passive storage depot for excess calories, a layer of insulation against the cold and simple padding. These functions are clearly important: the evolution of body fat may have aided humans in moving out of Africa and surviving in colder climates. Even today, carrying a bit of excess weight reduces the likelihood of older people dying if they fall ill.

"I think the first thing that people fail to appreciate is what a valuable evolutionary step it was to be able to store fuel," says Randy Seeley, who researches energy balance and metabolism at the University of Michigan. "If you're not able to do that, you're a filter feeder: you have to swim in your food."

But while many organisms possess some form of body fat, in mammals, it has evolved into something much more complex than just a kind of meaty bubble wrap, says Seeley. "It also now becomes integrated into the overall regulation of blood glucose, body temperature and other physiological functions, including bone health."

The first clues that we were underestimating our body fat came in the 1990s with the discovery of leptin. This hormone, secreted by fat cells, acts on the brain to suppress appetite and boost energy expenditure. On the flip side, when people quickly lose fat, leptin levels drop, which the brain interprets as a sign that energy stores might be running low. It responds by ramping up hunger signals and reducing energy expenditure to help you regain that lost fat.

The discovery of leptin cracked open a hidden communications network between fat and the rest of the body. Since then, we have discovered that fat cells release many more hormones and other signalling molecules, some of which communicate with tissues nearby, while some travel much further afield. Together, they are known as adipokines.

What's more, this communication isn't only chemical – it is also electrical. We now have evidence for networks of nerve fibres extending deep inside adipose tissues, forming a direct, two-way line of communication between the brain and our fat.

Immune organ

"The nerve supply in adipose tissue enables a bidirectional and fast communication route with the brain," says Kristy Townsend, a neuroscientist at The Ohio State University who studies fat. As well as sending messages about energy and metabolism, nerves allow fat to quickly communicate its health status, for instance, whether it is injured or inflamed.

Immune cells may also join these conversations, relaying information about inflammation or injury and releasing molecules that help nerves survive and grow. "If you look at the tissue in between all the adipocytes, there's pretty much every immune cell you can imagine – so fat is also an immune organ," says Townsend.

In short, fat doesn't just store energy; it speaks. And together, these adipokines, immune cells and nerve fibres form the vocabulary of an unexpectedly sophisticated organ.

The far-reaching impacts of fat are only now coming to light. Its best-documented role is in energy balance (see "Your unappreciated organ", page 32), telling the brain when reserves are full or depleted. But fat's communication with the brain also seems to extend to our moods. While mood disorders such as depression or anxiety are complex, and stigma or poor body image may also ›

contribute to this, evidence is increasingly linking obesity – particularly metabolically unhealthy obesity – to these conditions.

While the mechanisms are still under investigation, the leading idea is that inflammation within adipose tissue triggers brain inflammation, which in turn alters the balance of neurotransmitters and triggers behavioural changes. Altered levels of leptin may also influence brain reward circuits and mood regulation.

And our fat plays a crucial role in fertility, too. Without a minimum level of body fat, for example, menstruation won't start or will stop, which makes sense, because entering pregnancy without sufficient energy to sustain a developing fetus could be catastrophic for both mother and child.

"In mammals, fat has evolved into something more complex than a kind of meaty bubble wrap"

"People forget that fat is metabolically really important. Without fat, we have issues with hormonal control, infection [and] immunity," says Louise Thomas, a professor of metabolic imaging at the University of Westminster in London.

So if fat is such a crucial factor in our health, why does it get such a bad rap? The first issue is its location. White fat makes up more than 95 per cent of our total stores and is found both under the skin (subcutaneous fat) and wrapped around internal organs (visceral fat). "Our organs are often sitting in a sea of fat," says Thomas.

That internal sea can turn toxic. Excess visceral fat is linked to a higher risk of type 2 diabetes, high blood pressure, heart attacks and certain cancers. Growing evidence also

THE YO-YO EFFECT

Losing weight is hard – but keeping it off is even harder. Even with blockbuster GLP-1 drugs like Wegovy, Ozempic and Mounjaro, the pounds often creep back on once treatment stops, hinting that fat may have a stubborn memory of its own.

This makes evolutionary sense. "In an environment where there's not enough food, it probably helps the body to remain hungry if you lose fat," says Ferdinand von Meyenn, at ETH Zurich in Switzerland.

Until very recently, obesity and the health complications that often accompany it were rare, so there hasn't been strong evolutionary pressure to develop a counter-strategy to protect against the negative consequences of excessive food availability.

Von Meyenn and his colleagues have been investigating the molecular basis for the problematic so-called yo-yo effect often seen with dieting. They suspect that chemical, or "epigenetic", markers on the genes of fat cells may hold the key.

Some of these insights came from studying fat samples taken from people undergoing bariatric surgery for weight loss. When they compared these samples with those from lean individuals, they found differences in the activity of various genes, which persisted even after people lost substantial amounts of weight.

Further experiments on mice that gained and then shed weight revealed a similar pattern. Next, von Meyenn and his colleagues looked at their epigenomes – the chemical markers that sit on genes and influence how they are switched on or off. Here, too, they found that obesity left a distinct and lasting influence.

Mice with these epigenetic patterns also gained weight more quickly when re-exposed to a high-fat diet, and when their fat cells were grown outside the body, they appeared primed to store more fat and glucose in their fat cells.

Fat may have a "memory", which could explain weight gain after a diet

PETER CRIPPS/ALAMY

Von Meyenn warns that these epigenetic changes haven't definitively been proven to cause the yo-yo effect. Even if they do, it is possible that other organs, including the brain, might similarly store memories of obesity.

It is also unclear how long fat cells might retain such memories.

Experiments so far suggest that these epigenetic changes last for up to six months, but nobody has looked beyond this yet. "We also see that the longer animals remain obese, the more pronounced the effects on the epigenome are," says von Meyenn.

If epigenetic memory is part of the problem, he thinks that finding a way to erase these marks might eventually help prevent weight regain: "It probably wouldn't prevent people from becoming obese again if they really wanted to, but it might take away the urge to overeat that many people experience."

suggests it may affect brain function and contribute to conditions such as Alzheimer's disease.

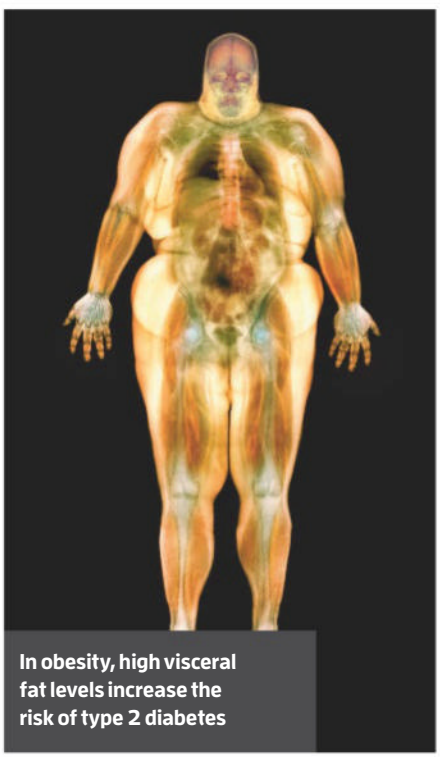
What triggers this shift from cooperative organ to rogue state is a major focus of research. While white fat cells in both subcutaneous and visceral deposits can expand and contract depending on the body's storage needs, those surrounding internal organs appear especially vulnerable to the harmful effects of excess fat.

In obesity, these fat cells enlarge and are prone to dying once they reach a critical size. Part of the problem is that their blood supply can't keep up with their growth. Stressed and suffocating, they release inflammatory molecules as distress signals, attracting immune cells to clear dead or dying cells.

These immune cells intensify the inflammation, with effects reaching far beyond the fat itself. The chemical signals interfere with insulin – the hormone that regulates blood sugar – raising the risk of type 2 diabetes. They are also linked to cognitive changes seen in obesity, such as memory and attention problems, and may create conditions that foster tumour growth. Obesity is a risk factor for many kinds of cancer, and often people who are obese tend to have worse outcomes.

Dying or overstuffed fat cells also release fatty acids, or lipids, into their surroundings – and in excess, these can be toxic to surrounding cells. Over time, this lipotoxic stress can damage the network of nerves threaded through fat, a condition known as adipose neuropathy. Obesity, type 2 diabetes and ageing are all linked to this loss of peripheral nerves, which further disrupts metabolism by impairing communication between the brain and fat.

Misfiring fat signals can also play havoc with our bones. Most of the time, oestrogen produced by adipose tissue can help protect against excessive bone resorption – where old bone tissue is broken down faster, then new bone can replace it. However, growing evidence suggests that excess fat, particularly visceral fat and fat accumulation within bone marrow, can impair bone quality and increase fracture risk. This is partly because inflammatory cytokines released by adipose tissue can stimulate osteoclasts, the cells responsible for bone resorption, which, in turn, promotes bone loss.



In obesity, high visceral fat levels increase the risk of type 2 diabetes

GUSTOIMAGES/SCIENCE PHOTO LIBRARY

"Without fat, we have issues with hormonal control, infection and immunity"

Despite the downsides of dysfunctional fat, adipose itself isn't the enemy – we need it. And efforts to get rid of it can backfire. Studies of liposuction, a cosmetic procedure that removes targeted fat, suggest that the extracted fat may simply reappear elsewhere. "You may want to remove fat from some locations, but you may like even less where you get it afterwards," says Seeley, who has been involved in some of this research. "If you remove subcutaneous fat, you're probably going to end up with more visceral fat in the long run, and that probably leaves you in a worse place than where you were before."

Not all fat is equal

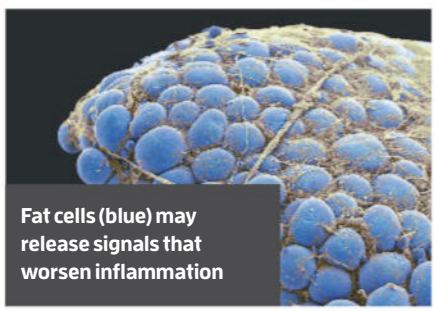
Not everyone with obesity is unhealthy, either. Between 10 and 30 per cent of people classified as obese based on body mass index seem to escape the usual health effects, such as insulin resistance, high blood pressure and unhealthy cholesterol levels – at least in the short term. This so-called metabolically healthy obesity has intrigued researchers like Matthias Blüher at the University of Leipzig in Germany.

About 15 years ago, Blüher and his colleagues began comparing fat tissue from people with obesity who developed insulin resistance – often a precursor to the development of type 2 diabetes – and those who didn't. They found that where excess fat sits and how it behaves are both crucial: people with more visceral and liver fat tended to be metabolically less healthy, while those whose adipose tissue contained smaller fat cells, fewer immune cells and a healthier secretion pattern of adipokines appeared to be more protected.

More recently, the researchers have taken this investigation down to the cellular level, analysing which genes are active in different fat deposits across dozens of people with healthy and unhealthy obesity. Their results, published earlier this year, reinforce that not all visceral fat is equal. "Even within the visceral cavity, it makes a difference where the fat is located," says Blüher. The highest risk is associated with fat that sits outside of the intestine, although, for now, they aren't sure why this is the case.

The fat also looks different in people with ›

healthy obesity: their fat cells are more metabolically flexible – able to switch efficiently between storing and burning energy – pump out fewer inflammatory signals and host fewer immune cells. Their visceral fat also contains mesothelial cells, which can transform into other cell types, perhaps enabling their fat to expand more smoothly without triggering excessive inflammation. Why some people have more of these metabolically healthy cells is probably down to genetics, although lifestyle factors such as diet and exercise may play a role.



Fat cells (blue) may release signals that worsen inflammation

STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

Either way, Blüher thinks that these insights could help doctors identify which people with obesity are at the highest risk of complications, and then tailor treatment accordingly.

His longer-term dream is to find a way to restore fat's healthy function – perhaps even transform "unhealthy" obesity into a permanently more benign form. Encouragingly, this may not require dramatic weight loss. Many of the benefits of modern weight-loss drugs and bariatric surgery seem to stem not from the amount of weight lost, but from improving fat distribution and function, says Blüher. "In bariatric surgery, even if people don't lose a lot of weight, the health benefits start almost immediately."

Achieving this would be revolutionary, not least because it would prompt a rethink of what a healthy body shape looks like.

And if fat could be reprogrammed to behave more healthily – or the cellular memories of its bloated heyday erased (see "The yo-yo effect", page 30) – many more of us might live longer, healthier lives without obsessing over size.

Whether obesity begins in the adipose tissue or the brain is still debated, but it is clear that when communication between the two falters, the whole system drifts off-kilter.

Seeley likens the situation to an orchestra: "All of these organ systems – your liver, pancreas, adipose tissue, muscle and gastrointestinal tract – are all talking to your brain, and your brain is talking to all of them. If your symphony conductor isn't doing a good job, then even if all your instruments are OK, it won't sound great."

In other words, fat isn't necessarily the problem; it's an instrument playing slightly out of tune in a misdirected symphony. Many of us have been conditioned to try to shrink, remove or hide our body fat. But the real task is to understand it – to coax this creamy, talkative organ back into harmony with the rest of the orchestra. Because when it plays well, it helps keep the whole body in tune. ▮

Linda Geddes is a journalist specialising in biology, medicine and technology

YOUR UNAPPRECIATED ORGAN

Not all fat is created equal. Most of what we carry is white fat, which is predominantly made up of white adipocytes – large, round cells, each containing a single droplet of fat that takes up most of their volume.

White fat is the body's main energy store – stashing excess calories away as triglycerides and releasing them as fatty acids for fuel – but it also plays a signalling role and provides insulation and cushioning, protecting internal organs from mechanical shock.

Tucked around our neck and shoulders and in a few other places are smaller, darker deposits of brown fat, packed with cellular energy factories called mitochondria that burn through fatty acids to generate heat. When activated, brown fat can burn through hundreds of times more heat per gram than any other tissue in the body.

Both kinds of fat may have shaped the course of human history, says Aaron Cypess at the US National Institutes of Health, who studies brown fat. "White adipose tissue is one of the main contributors to the establishment of civilisation, because if you don't have to spend all your time eating, you're freed up to do something else," says Cypess. "Brown fat helped in a different way, because it allows us to stay warm. We can therefore adapt to many different environments."

Fat comes in other hues, too. Beige fat cells, sprinkled through white fat, can adopt brown-like characteristics after exercise or prolonged exposure to cold, shifting from quiet storehouses into tiny furnaces that burn energy. During pregnancy and lactation, meanwhile, white fat cells in the breasts transform into pink fat, supporting milk production.

Saverio Cinti at Marche Polytechnic University in Ancona, Italy, who has dissected the entire "adipose organ", all the interconnected lobes and pads of fat, in mice and humans, argues that this rainbow-hued network of lobes and pads – which connect at the base of the neck and pelvis – forms a single, integrated system.

"The old concept of adipose tissue as a connective tissue is absolutely obsolete," he says. "No one questions that the stomach is an organ: it's a well-defined, anatomically dissectible structure, made of different tissues cooperating for digestion."

The adipose organ is similar, says Cinti: "It is a unified structure, composed of two tissue types – white and brown adipose – that cooperate to manage the body's energy, balancing storage and heat production according to the organism's needs."

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Songs from the caves

Ancient rock art was meant to be heard as well as seen, and we are now starting to bring those sounds back to life, discovers **Benjamin Taub**

DEEP underground, thousands of years of silence are abruptly broken by a researcher singing. His voice seems to awaken the walls of the cavern as the intimate space comes alive with the sound of our ancestors. Then he follows the cave's resonant response, until the beam of his headlamp falls upon a panel of ancient paintings.

This crude experiment, performed decades ago, led to a remarkable discovery: that prehistoric rock art, created from 40,000 to 3000 years ago, was meant to be heard as well as seen. "The oldest painted sites have this low, strange resonance, where if you sing, suddenly the cave sings back to you," says Rupert Till at the University of Huddersfield, UK.

Getting solid scientific evidence to support this idea hasn't been easy. Now, however, a seven-year study into the acoustic properties of rock art sites around the globe has provided it. The Artsoundscapes project leaves little doubt that prehistoric artists deliberately painted in places where echoes, resonance and sound transmission created otherworldly sonic effects. "I was completely amazed," says archaeologist and project leader Margarita Díaz-Andreu at the University of Barcelona, Spain, recalling her experiments at Valltorta gorge in eastern Spain. "Before the paintings, there was barely any reverberation, but as soon as we reached the paintings, the sound changed immediately."

And that's just the start. By studying the peculiar soundscapes in which ancient artworks are embedded, Díaz-Andreu, Till and other archaeoacoustic researchers are beginning to reconstruct the ways in which these ancient, multisensory illustrations amplified the potency of prehistoric rituals, storytelling and shamanic musical performance – and, perhaps, even altered listeners' states of consciousness.

That first researcher who used song to bring a new dimension to our understanding of Stone Age people was a French musicologist called Iégor Reznikoff, now a professor emeritus at Paris Nanterre University. He spent years vocalising inside palaeolithic caves in use from 18,000 to 11,000 years ago in his homeland before documenting his findings in the late 1980s. Counting the seconds between echoes,

PATRICK AVENTURIER/GETTY IMAGES

he noted a relationship between the placement of rock art and acoustic phenomena. "Iégor can go into a cave and make noises and guide you to rock art by listening for echoes," says Till. "I've been into these caves with him."

Reznikoff's methods of talking to the walls lacked rigour, and his conclusions were largely ignored by archaeologists. But his ideas reverberated around the fringes of academia, where the emerging field of archaeoacoustics was struggling for recognition. Among the first to expand upon his findings was Steve Waller at the American Rock Art Research Association, who recorded echoes of up to 31 decibels at some decorated spots in deep caves in France, while unpainted walls in the same caverns were acoustically dead.

"In deep caves, the echoes blur together like thunder, and it gives you this vision of a stampede of hoofed animals," says Waller. Writing in *Nature* in 1993, he pointed out that more than 90 per cent of European rock art depicts hoofed mammals like horses and bison, and suggested that echoing caves might have been interpreted as the homes of the thunder gods, who were embodied by these stampeding beasts.

Two decades later, with archaeoacoustics still largely overlooked as a legitimate field, Till launched the Songs of the Caves project to study the acoustics of painted caverns in northern Spain. Rather than just timing the delay between echoes, he and his colleagues took a measurement called the impulse response, which entails quantifying the movement of sound waves through a space when a short, sharp sound is played to give a so-called sonic fingerprint. "We did 250-odd acoustic samples in the caves, both next to rock art and where there was no rock art," says Till. "And we showed that there was a statistical relationship between the likelihood of there being a piece of rock art and an 'unusual' acoustic phenomenon that was associated with it."

Around the same time, Díaz-Andreu began investigating the soundscapes at Stone Age sites across Europe, providing more nuanced insights into these acoustic relationships. In Spain's Sierra de San Serván, for instance, she noted that art was predominantly found in rock shelters with "augmented audibility". ›

WORLD HISTORY ARCHIVE/ALAMY

N. SANTOS DA ROSA

Measuring the acoustics inside Cuevas de la Araña in Spain showed rock art was placed where the sounds effects were biggest

"This means that the places that had been chosen to be painted were those from which you could acoustically control the landscape," she says. To give a sense of what this might mean, she recounts being able to hear a distant dog-walker's phone conversation with astonishing clarity while standing at one of the decorated spots.

Although these findings helped to advance the field of archaeoacoustics, many scholars continued to regard it as a fringe discipline. So, in 2018, Díaz-Andreu initiated Artsoundscapes, which introduced cutting-edge methods to systematically measure sonic phenomena at painted sites across the world. Among the techniques pioneered by her team was the use of a dodecahedron featuring 12 loudspeakers to create a dynamic, omnidirectional impulse response. The researchers also used computerised models like geographic information systems to map the connections between rock art and acoustic effects.

Since wrapping up the project earlier this year, the team has published a series of studies from sites across four continents. They reveal that prehistoric cultures around the world used sound in strikingly different ways. In Siberia's Altai mountains, for example, amplification and unusually high clarity of sound were detected at potential gathering spots, where rituals and offerings involving music may once have taken place. In Mexico's Santa Teresa canyon, there are rock art at sites where pre-Hispanic cultures are thought to have held ritual dances. And at Spain's Cuevas de la Araña, the researchers report finding paintings primarily where the caves' acoustics "could have intensified the sensory effect and emotional impact of ceremonies likely performed with musical accompaniment".

The team also visited White River Narrows, a canyon in Nevada where Waller had previously noted an unusual sonic connection between

"The echoes blur together like thunder, giving you this vision of a stampede of hoofed animals"

painted rock faces. "Some of the rock art sites can actually communicate with each other, so if you're at one, you can hear the echoing coming to you from another," he says. Building on this, the Artsoundscapes researchers discovered that certain painted spaces outside the canyon lack reverberation but possess exceptional sound transmission, reproducing sounds with great clarity and amplification. Therefore, they concluded, these sites would have been more suitable for storytelling than shamanic rituals.

Auditory illusions

Only in South Africa's Maloti-Drakensberg mountains – which are famous for their San rock art – did the team fail to find a connection between paintings and sound. "We were expecting fantastic results – something new and exciting," says Díaz-Andreu. "We didn't find them."

Although there is no universal pattern, there is a growing consensus that painted sites worldwide were often chosen for their extraordinary acoustic properties and the impact these would have had on people's consciousness. In Finland's lake district, for example, prehistoric hunter-gatherers were inspired to leave their mark on cliffs that produced a disorienting sonic reflection. "The [wall] repeats, or doubles, every sound that you make in front of it, so that you experience a kind of doubled reality that is not normal," says Riitta Rainio at the University of Helsinki in Finland. "It's not a long echo like in caves, but a single reflection that's very short, sharp and strong."

Rainio and her colleagues have conducted psychoacoustic experiments to measure the subjective response of modern listeners to this auditory illusion. They found that people tend to perceive a "presence" at these painted sites. In one recent paper, they wrote that the sounds seem to "emanate from invisible sources behind the paintings" and that "a prehistoric visitor, who marvelled at the voices, music, and noises emanating from the rock, would have recognised them as coming from a human-like source, perhaps some kind of apparition or living person inside the rock". Speaking of her own experiences at the lakeside rock faces, Rainio says: "I was often quite scared, because I really thought that there was someone else there. There's this phenomenon where it seems like someone is approaching you as you approach the cliff."

Similarly, the Artsoundscapes team has investigated the psychoacoustic impact of rock art sites in both Siberia and the Mediterranean. Using the impulse response data from decorated caves in the Altai mountains, the team created "auralizations" of natural sounds – including animal calls, weather phenomena and the crackling of a bonfire – as if heard from within these spaces. In laboratory tests, participants reported that these digitised soundscapes evoked feelings

of "presence", "closeness" and "tension".

Teaming up with neuroscientists at the University of Barcelona's Brainlab, Díaz-Andreu's group also used electroencephalography (EEG) to study the ways in which certain sounds influence human brain activity. Their findings suggest that our brainwaves tend to synchronise with music that has a tempo of 99 beats per minute, potentially triggering altered states of consciousness. How this discovery relates to ancient shamanic rituals at rock art sites is a matter of conjecture, however. "We don't know for sure what the meaning of those sites was, but they are generally regarded as sacred, religious or ritual places," says Rainio. "And ritual usually means some kind of sound-making, which is often music." Tellingly, some of the paintings in Finland depict people playing drums.

Another clue about the sorts of sounds prehistoric people made at these decorated rock faces comes from the painted Isturitz cave in France, where 35,000-year-old flutes made from vulture bones have been found. By playing replicas of these prehistoric instruments inside the caverns where they were discovered, Till became the first person since the Stone Age to experience their ritual potential. "Previously, I'd only ever heard these bone flutes in classrooms or in concert halls, where they have quite a polite sound, a small sound," he says. "But then you take them into the cave and they produce this enormous, soaring sound, which transforms the cave into a space that sings."

Similar experiments have been conducted by archaeologist Fernando Coimbra at the Portuguese Centre for Geohistory and Prehistory, who played replicas of ancient bone flutes at a palaeolithic rock art site called Escoural cave. "When I played songs outside the cave, the sound vanished, but inside, the cave acts as an amplifier," he says.

In addition, archaeoacoustics researchers are moving beyond the sphere of rock art to reveal the many ways in which music may have shaped ancient ritual experiences. At the 5000-year-old Neolithic tomb of Ħal Saflieni in Malta, for instance, experiments by both Till and Coimbra have identified unusual resonant frequencies within a chamber called the oracle room. "If you play a large drum in there, the bass frequencies sustain for about 35 seconds, which is just remarkable", says Till. "So, you have to think of Ħal Saflieni not as a place where music was played, but as a musical instrument in itself, because the resonances are so strong that if you play anything in there, the building rings."

Altered consciousness

Inspired by similar, earlier findings, neuroscientists at the University of California, Los Angeles, used EEG to measure how these acoustic resonances affect human brain activity. Intriguingly, they discovered that frequencies close to 110 hertz – characteristic of a low baritone voice – tend to deactivate the brain's language centres and may boost emotional processing within the prefrontal cortex. This supports the idea that ritual chanting at places like Ħal Saflieni may have altered the consciousness of people within the space.

Nevertheless, not everyone is convinced that these sites were deliberately engineered to produce such acoustic effects. A 3000-year-old temple in Peru, for instance, creates acoustic resonances at the same frequency as those produced by conch shell horns – or pututus – excavated at the site. "I don't believe, personally, that the Chavín architecture was built simply to work with these conch shells," says archaeoacoustic researcher Miriam Kolar at Stanford University in California. "But I'm convinced by the evidence that the relationship did not go unnoticed. It's impossible to perform a pututu blast in any of the spaces of Chavín without getting some sort of strong sensory effect."

We don't know exactly what went on at the site, but Kolar says the "whole body response" triggered by these extraordinary acoustics may have provided a basis for ritual activities by creating a powerful shared experience. Likewise, Till's archaeoacoustic research at Stonehenge in the UK suggests that the rhythmic sound of percussion would have "made the whole space resonate like a wine glass", potentially synchronising the emotional experiences of thousands of participants during solstice rituals some 5000 years ago.

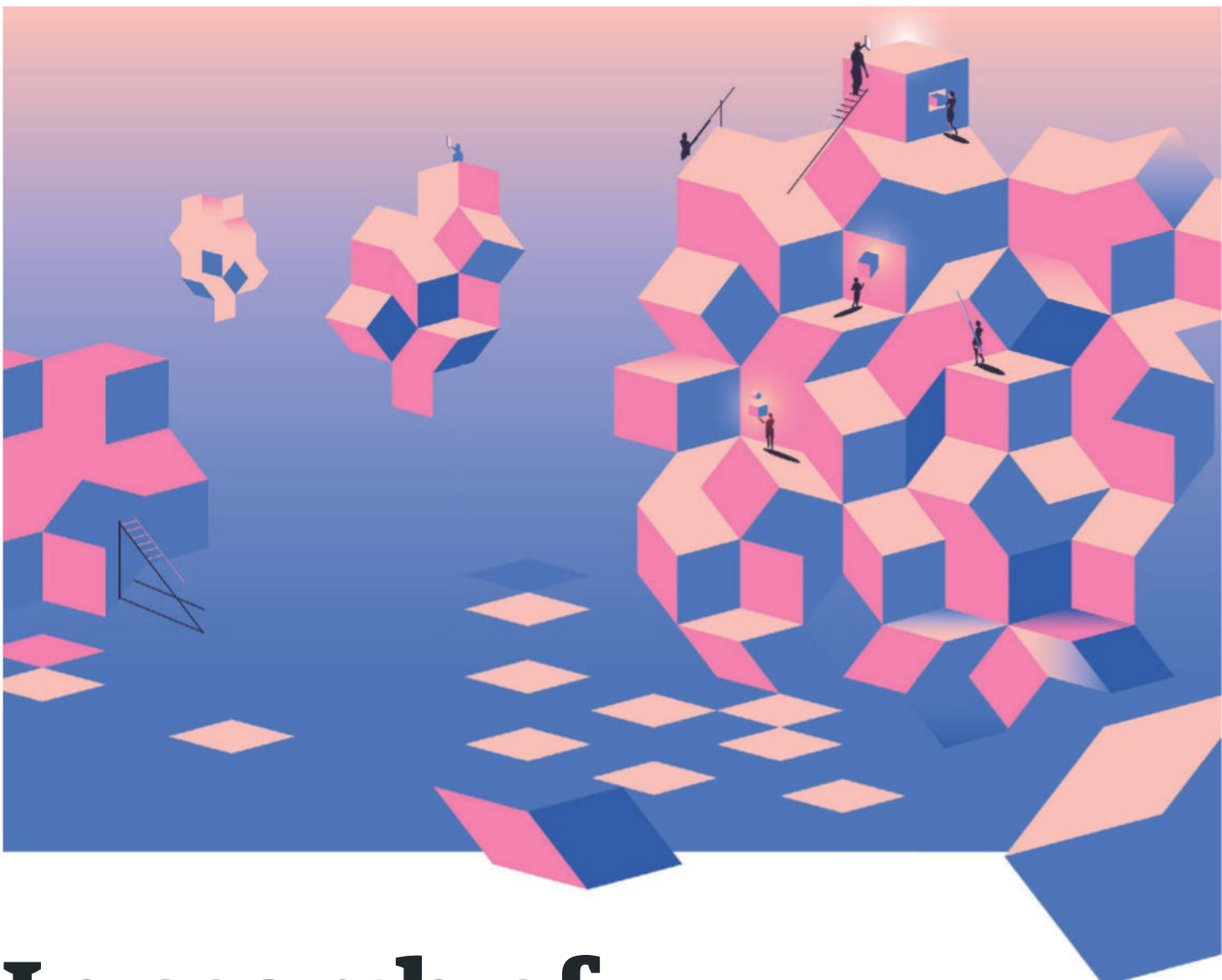
Bringing the story full circle, Till thinks that these Neolithic monuments may have served to perpetuate the ritual function of Palaeolithic rock art sites. "We used to have caves where the spirits lived, and we knew the spirits lived there because we could hear their reverberation," he says. "But when we left the caves to occupy the open spaces and the plains, we needed a place where the ancestors could be." Stonehenge, Ħal Saflieni and other similar monuments may therefore have been built as new homes for the dead, where the voices of the spirits could again be heard and consulted through sonic rituals.

This body of work is finally bringing archaeoacoustics into the fold of mainstream academia. More broadly, these findings underscore the importance of incorporating sound into archaeology, both in terms of enhancing our understanding of ancient ritual experiences and the conservation of prehistoric material culture. Waller points out that at famous rock art sites around the world, visitors are encouraged to exercise decorum and hush, yet until we reintroduce sound to these spaces, we won't know what it is we are trying to protect. "I'm advocating for the preservation of the sound, because there are examples where they've built a visitor centre right in the middle of the canyon or they've put the restroom right in front of the rock art panel, and they're unintentionally ruining the acoustics," he says. "I'm trying to spread the word, to preserve the soundscapes." ▮

DAVID RYAN/ALAMY

Conch shells were used in an ancient Peruvian temple to create sensory effects

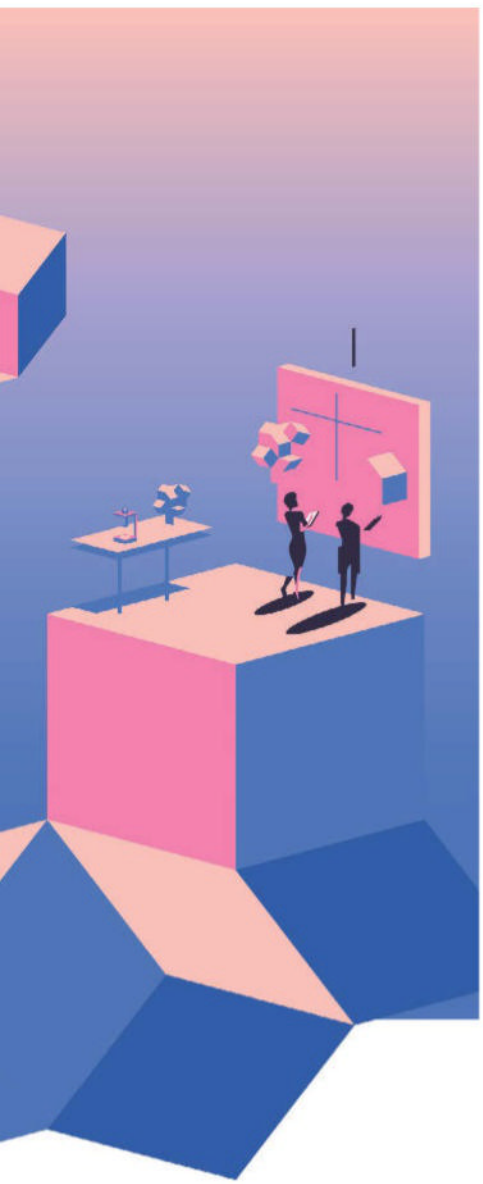
Benjamin Taub is a science journalist who reports on areas including anthropology



MARCUS MARRITT

In search of the impossible

A strange form of matter was thought to exist only in the lab – until it started showing up in the world's most extreme environments, finds **Elise Cutts**



IN AUTUMN 1945, Lincoln LaPaz crouched over a patch of scorched ground in the Jornada del Muerto desert of New Mexico. LaPaz, an astronomer, was out hunting for meteorites. He had spotted something in the dust: a strange, glittering crust of blood-red glass. This was no meteorite, but it was striking enough that he held onto it.

It wasn't until decades later that anyone would realise quite how special LaPaz's chance find was. For, embedded in one of those shards was a particularly unusual kind of material – a quasicrystal.

Quasicrystals were long assumed to be entirely theoretical, due to their supposedly impossible atomic geometry. It wasn't until 1982 that they were shown to exist at all – and even then, they were only seen in strictly controlled lab conditions. But LaPaz's now-recognised discovery is one of a growing number proving that these materials can form outside the lab, and that they are far more common than anyone suspected. They might even turn out to be a new window on the turbulent history of Earth and the solar system as a whole.

"There aren't that many people searching for natural quasicrystals," says physicist Paul Steinhardt at Princeton University. "We could be walking across them every day and wouldn't know it."

We used to think quasicrystals were impossible. All familiar crystals – from table salt to diamond – are made of motifs, arrangements of atoms that tile in a perfectly repeating pattern in three-dimensional space. By the 19th century, mathematicians believed they had catalogued every possible geometry for repeating patterns. The final tally: 230 crystal structures, each formed by shifting, rotating or reflecting a single atomic template.

Notably absent from this list were crystals with "forbidden symmetries", like the fivefold rotational symmetry of pentagons and starfish.

It was thought that fivefold symmetries, alongside sevenfold, eightfold and higher rotational symmetries, were all impossible. Motifs with these symmetries can't fit together into a crystal without overlapping or leaving gaps.

"All the [orderly] materials ever discovered by humans – whether in the lab, in nature or in space – were confined to this restricted list, up until the 1980s," says Steinhardt. He and his then-student Dov Levine were the first to theorise the existence of quasicrystals, solids whose atomic patterns never repeat exactly, in 1983. "They're a kind of disharmony in space," says Steinhardt. This makes mathematical room for forbidden geometry, like fivefold symmetry.

Just a year later, materials scientist Daniel Schechtman at Technion Israel Institute of Technology in Haifa published a study about a strange, lab-grown alloy with a fivefold symmetry, vindicating Steinhardt and Levine.

Suddenly, quasicrystals were no longer mere mathematical musings. They were real materials. But many scientists insisted they couldn't survive for long without the repeating atomic scaffolds that lend true crystals their stability. Even after Schechtman eventually won a Nobel prize in chemistry in 2011, many still assumed that quasicrystals were aberrations – unstable, unnatural materials confined to the laboratory.

Quasicrystal quest

Steinhardt wasn't convinced. Teaming up with Luca Bindi at the University of Florence in Italy, a geologist with a knack for identifying new minerals, they set out to find quasicrystals in the wild.

Bindi rifled through the rocks held by his university's museum, looking for anything made of aluminium and copper – the composition of Schechtman's lab-grown quasicrystals. He came across a meteorite labeled simply as khatyrkite. It was a hit: aluminium-rich grains in the mottled grey space rock contained the first natural quasicrystal ever identified.

The find sent the researchers on their first quasicrystal chase. To prove that the sample truly did come from a meteorite, they traced it back to Khatyrka, a remote region in north-east Russia. The scientists travelled four days into the tundra on snowcats, then sifted through around 1.4 tonnes of clay looking for bits of rock that might be meteorite. It was worth it: in the less than 0.1 grams of meteorite they recovered, they identified a further two tiny grains containing quasicrystals.

The hunt never truly stopped. Since ›

> We could be walking across quasicrystals every day and wouldn't know it

The Trinity nuclear weapon test (below) formed quasicrystals in a mineral called trinitite (above)

SCOTT CAMAZINE/ALAMY, ABOVE: PAUL J. STEINHARDT ET AL. (2022)

Khatyrka, Steinhardt, Bindi and their colleagues have recovered even more quasicrystals from the rough and tumble world beyond the lab – the latest in 2023.

The quasicrystals in the Khatyrka meteorite came embedded in tiny globs of an unusual aluminium-copper alloy, ringed by stishovite – a dense kind of quartz that only forms under extreme pressure. That detail caught Bindi and Steinhardt's attention. Perhaps, they thought, the creation of quasicrystals wasn't the delicate, fussy process scientists thought it was. Maybe all it took was an impact.

That would be a sharp break from the known quasicrystal recipe. In the lab, they are made by carefully melting, mixing and cooling precise ratios of different elements. To test if rougher methods would also work, they teamed up with Paul Asimow, a geologist at the California Institute of Technology.

Asimow's technique was crude but straightforward. He simply gathered the building blocks of quasicrystals – metals like aluminium and copper – and blasted away. "You find the materials, put them in a chamber, bolt it to a gun and pull the trigger," he says.

It worked on the first try. "It's really easy," says Asimow. "Almost every time, we can find a quasicrystal. That's the most surprising thing." The method produced new quasicrystals with fivefold rotational symmetries and chemical compositions unlike anything reported before.

Encouraged, Steinhardt and Bindi started considering what other natural and not-so-natural events create extreme pressures, from asteroid impacts to nuclear explosions. This is what led them to LaPaz's radioactive, blood-red glass.

This glass has gained a cult status among collectors because it was discovered to be a remnant of the first atomic bomb test, Trinity – hence its nickname "trinitite". A few months before LaPaz went meteorite hunting around the Manhattan Project test site, the bomb had blasted the desert sand into glass, and where that glass mingled with copper from a transmission line, it glittered blood red.

The samples LaPaz collected were dispersed into university collections, museum archives and private hands. It was in one such collection, curated by trinitite enthusiast William Kolb, that Bindi and Steinhardt made their next big discovery.

In 2021, they confirmed that tiny metal globs within the trinitite contained what might be the first human-made quasicrystal.

Two years later, they found another "wild" quasicrystal – this time in a sample of fulgurite, a kind of material also known as fossilised lightning, which had formed when a lightning bolt struck sand and metal from a downed power line in Nebraska.

Together, these findings show that quasicrystals form readily in the chaos of an explosion, impact or electric discharge – not just in a pristine lab. They aren't mere mineralogical exotica. And, in the form of meteorites, they can quite literally fall from the sky.

Earlier this year, Steinhardt, Bindi and their colleagues thought they had found another quasicrystal in a micrometeorite collected in Italy. Every year, thousands of tonnes of these fall to Earth as dust. They are shed by space rocks of all kinds, but mostly they derive from ancient asteroids left behind from the earliest days of the solar system – chondrites, the same class the Khatyrka meteorite belongs to.

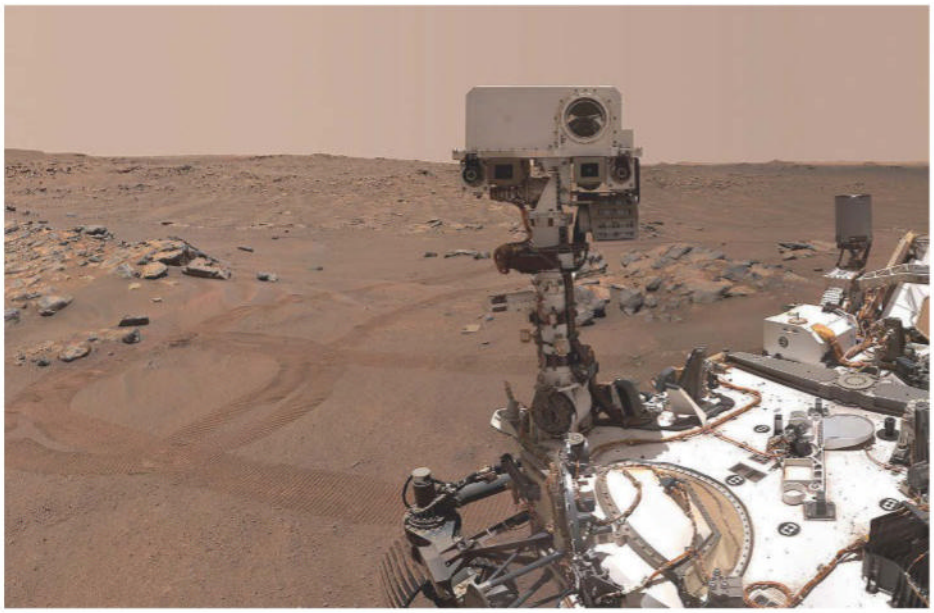
Forbidden materials

In 2024, Steinhardt and Bindi joined forces with Jon Larsen, a mineralogist at the University of Oslo in Norway who pioneered ways to isolate micrometeorites from rooftop dust. They sifted through 5500 samples looking for quasicrystals. "We found two [candidates] – not a quasicrystal yet – but with aluminium and copper," says Steinhardt.

Still, this quasicrystal approximant – a structure that mimics the pattern up close, but repeats over longer scales – was remarkable. Aluminium-copper alloys like those in the Khatyrka sample are vanishingly rare on Earth. But finding these forbidden materials in meteorites suggests they might be a lot more common in space.

The team is also chasing another lead. In April, Bindi and his colleagues found a quasicrystal approximant – a mix of palladium, nickel and tellurium with 12-fold rotational symmetry – in a rock from Australia, a tantalising sign that "earthborn" quasicrystals might exist, formed by dynamic processes deep within the planet.

With each new discovery, Bindi and



NASA/JPL-CALTECH/MSSS

Meteor-battered worlds like Mars could be home to quasicrystals

Steinhardt seem to re-emphasise that quasicrystals can form out there "in the wild". So why go to such lengths to recover more? Bindi's answer is simple: nature can surprise us.

In fact, it already has. One of the three quasicrystals found in the Khatyrka meteorite had a structure no one had ever predicted – neither in simulations nor based on experiments. The one found in the debris of the Trinity nuclear test was perhaps even more surprising. It was the first silicon-rich quasicrystal ever discovered, proof that even ordinary minerals can snap into forbidden patterns given the right kind of shock.

"We can hypothesise why," says Asimow. Perhaps quasicrystals are stable at high temperatures, and a sudden shock cools them fast enough to freeze that geometry in place. Or maybe the turbulent flows that follow shock waves mechanically push atoms into the quasicrystalline structure.

For years, theorists assumed quasicrystals were doomed to eventually crumble into conventional crystal structures, and the go-to tool for analysing material stability, known as density functional modelling, couldn't prove otherwise. It relies on analysing the properties of a single repeating unit and scaling up, a fruitless approach for a structure that, by definition, doesn't repeat.

But research here is also catching up. This year, a group led by Wenhao Sun at the University of Michigan found a workaround: instead of scaling up a repeating motif, the researchers modelled increasingly large "scoops" of quasicrystal and used the results to extrapolate to the stability of an infinitely large scoop. They discovered that some quasicrystals could be genuinely stable, meaning that no matter how long you waited, they would never spontaneously break down into another material.

> "Quasicrystals form in the chaos of an explosion, impact or electric discharge

If correct, the result lends theoretical weight to something the quasicrystal hunters have known for some time: these materials can survive for millions and perhaps even billions of years in nature. This could make them valuable witnesses of the violent shocks that create them.

That prospect is what keeps Asimow at his experiments. He is now in the middle of tests that will track the atomic structure of nascent quasicrystals in real time during shock compression. If researchers could learn to match particular quasicrystal types to distinct pressure-temperature conditions, they may be able to read the history of the celestial bodies they originate from.

This would mean quasicrystals could serve as markers of cosmic impacts during planet formation, as well as tell us more about meteor-battered worlds like Mars and the moon. Steinhardt and Bindi have tried to get access to Apollo mission samples to look for signs of quasicrystals. So far, no luck, but they haven't given up.

And although the Australian quasicrystal approximant isn't exactly a quasicrystal, it does suggest that exotic processes in the deep Earth can bake up forbidden symmetries, too, making natural quasicrystals a potential new window on the hidden geological dramas playing out below our feet.

Steinhardt and Bindi haven't found a quasicrystal by sifting through micrometeorites or Earth rocks just yet. But the approximants are a promising clue. Bindi is hopeful about looking for quasicrystals in the tiny droplets of metal sometimes encased in volcanic glass. And Steinhardt thinks the micrometeorite hunting could have better results in Antarctica or Greenland, where space dust steadily accumulates in ice. "I'd like to get to 100,000 [samples] if we could," he says. ▮

Elise Cutts is a science journalist who covers physical science, maths and fundamental biology

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The closing date for application is **09:30 am on Monday 12 January 2026.**

Interviews will be held in London on **Monday 2 March 2026.**

The back pages

Debunking gardening myths

Thank you for the music

Botanist **James Wong** is constantly asked if he plays music to his army of plants. Time to put this notion to the test...

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

DO YOU play music to your plants? As a botanist obsessed with collecting houseplants, I get asked this question all the time. This New Age notion first entered popular culture back in the 1960s, complete with psychedelic "music for plants" albums that are once again being popularised online. But what has the latest research into this evergreen question shown?

First, the obvious: plants have neither ears nor brains, so they can't appreciate music as we do. However, thanks to a series of recent studies, we now know that they can not only detect vibrations in their environment, but actually alter their behaviour based on the information they are receiving. In one study, mouse-ear cress exposed to the sound of caterpillars chewing produced higher levels of bitter toxins, which they use as defence. Remarkably, these plants even seemed able to distinguish the vibrations of leaf munchers from those of wind or insect mating calls, even when these were a similar frequency, activating defences only when faced with a threat.

Plants also respond to sounds of opportunity. Some flowers – like those of tomatoes, blueberries and kiwis – release pollen only when vibrated by the buzz of their specific pollinating bee species, ignoring the sounds of other bees. This can happen pretty quickly, too. Within as little as 3 minutes of being played the sound of a bee flying, the nectar in evening primrose flowers has been shown to become richer in sugary reward. Researchers have even reported that pea plants are capable of directing their root growth towards the sound of running water.

MICHELE CORNELIUS/ALAMY

Still, as anyone who has heard a 7-year-old with a recorder will know, there is a big difference between noise and "music", and experiments designed to test the effect of the latter on plant growth have shown more mixed results. A recent study found that some music tracks were associated with significantly improved lettuce growth, but had no effect on alfalfa.

On the noise front, another study found that sage and marigold plants exposed to 16 hours of continuous traffic noise each day showed significantly poorer growth. Could such background noise be interfering with their ability to detect important sonic cues? Right now, we simply aren't sure.

The moral of the story? Thanks to recent research, we know that plants, far from being oblivious to sound, can be significantly affected by it. But because so much of this is still a mystery, we don't know enough to be able to reliably predict exactly which sounds, at what frequency, volume or even duration, will lead to the outcomes we desire. So before you feel the need to blast Katy Perry at your plants 24 hours a day, remember they won't necessarily thank you for it, nor will your neighbours. ▮

Debunking gardening myths appears monthly

Next week
The science of exercise

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Kate Shaw, experimental particle physicist, working on the ATLAS experiment at CERN and the Deep Underground Neutrino Experiment (DUNE) at Fermilab

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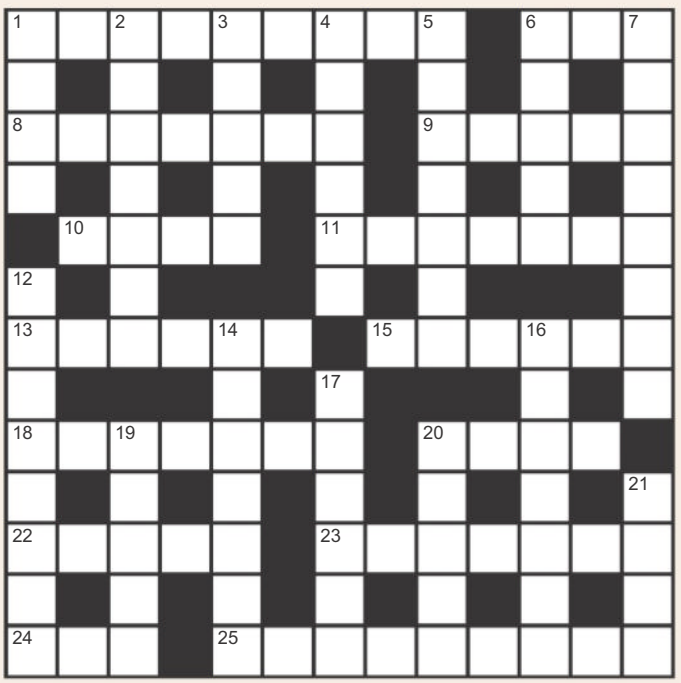
Cryptic crossword #175 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Trade includes some unopened Torricelli invention (9)
6 Step-parent keeps reversing phone download (3)
8 TikTok offering rent break in Chamonix, maybe (3,4)
9 Guy engages very skilled builder (5)
10 Joint formerly named after Kelvin (4)
11 A friend starting to master ASCII, for one (7)
13 Root is penetrating hard ground (6)
15 Astronomer recalled bad smell surrounding place (6)
18 Observed following his horses around: creature with a distinctive snout (7)
20 Search company storage unit (4)
22 Bark's said to be something like felt (5)
23 Lovelace collaborator, big-headed one, making CB (7)
24 Remove knight from handy location for an anvil (3)
25 Accidents scattered substance in "DO NOT EAT" packets (9)

DOWN

1 Enjoy the warmth of some Pyrenean people in the audience (4)
2 Wrong green ID was predominant (7)
3 Guitar string in only "Come Together" (5)
4 Fancy accessory meant for acid measurement much appreciated in retrospect (3,3)
5 Guilty feeling about code developer (7)
6 *The Far Side* cartoonist never initiated crime (5)
7 Centre of Petra becomes deadened, partially shadowed zone (8)
12 English setter rests on bleachers (one-third complete, non-permanent) (8)
14 Send interns bonus allowance (7)
16 Wavelength symbol outside a dance (7)
17 The most exemplary unfinished ancient city (6)
19 Sound of fan had been heard (5)
20 Copper-bismuth catalyst's primary crystal structure (5)
21 Fast plane carrying second kid (4)

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Quick quiz #329
set by Tom Leslie

1 Analysis of a famous fossil appears to have ended a debate over the existence of a tiny relative of *T. rex*. The fossil also contained the remains of which other species?

2 A 300-year-old mummy found in an Italian villa and recently analysed by researchers is distinctive for what reason?

3 A new bulletproof fabric developed by researchers in China is composed of fibres called aramids and what other material, often touted for its strength?

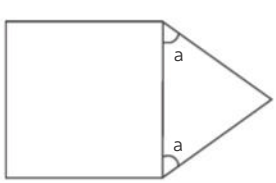
4 The term "julu" in the name of the proposed ancient hominin *Homo juluensis* means what?

5 A recent Harvard study found that walking how many steps per day caused a significant improvement in Alzheimer's-related decline?

Answers on page 47

BrainTwister
set by Peter Rowlett
#100 Tricky angles

A square has a triangle on one edge. Two angles of the triangle are the same, marked *a*.



If the angles marked *a* are 45 degrees and the area of the square is 400, what is the area of the triangle?

If the angles marked *a* are 60 degrees and the area of the square is 400/√3, what is the area of the triangle?

If the angles marked *a* are 30 degrees and the area of the triangle is 25/√3, what is the area of the square?

Answers next week

Spinning around

If a very large disc on a frictionless, horizontal spindle were gradually rotated faster and faster, what would happen as the rim approached the speed of light?

Mel Earp
Macclesfield, Cheshire, UK
I am always drawn to the Large Hadron Collider when considering questions like this. The LHC has a diameter of about 8.5 kilometres. When operating, it uses the equivalent of about a third of the energy required by the nearby city of Geneva. This is mostly consumed by the many large magnets needed to keep the beams, usually protons, in a circle.

There can be about 300 trillion protons in the collider at any time. This gives a mass of about 5×10^{-13} kilograms, which is tiny and yet requires so much energy to constrain.

No known material has the tensile strength to match. As a result, the rim of a spinning disc would detach long before approaching the speed of light. If acceleration were to continue, so would the disintegration.

However, imagine there were such a material. Then we get into the deep waters of special relativity, where the circumference experiences length contraction from the perspective of a stationary observer, but the radius doesn't, seemingly breaking the geometrical relationship between the radius and the circumference.

"The rim of a spinning disc would detach long before the speed of light. If acceleration continued, so would the disintegration"

Let's just be content that it isn't possible to construct this disc!

Ian Roselman
Leighton Buzzard, Bedfordshire, UK
Many years ago, when I was a research student in the physics department at the University of Cambridge, I was shown a room with bits of metal embedded in the walls. I was told that this was where a steel ball had been spun inside a glass vacuum jar at ever increasing speed, controlled by magnetic forces. Long before the peripheral speed of the ball came anywhere near the speed of light, the ball burst, shattered the jar and peppered the walls with metal.

Fortunately, the walls were thick and nobody was in the room at the time. This disintegration happened because the centrifugal force felt by the outer layers of atoms in the ball finally overcame the cohesive force of the metal. Similarly, I have calculated that a wheeled vehicle can't travel much faster than 1600 kilometres per hour before the wheels succumb to this effect.

Richard Waspe
Norwich, Norfolk, UK
Under increasing force, the disc's edge would distort more and more with ever faster rotation, eventually assuming a circumference not related to pi and not conforming to Euclidean geometry. In the real world, the disc would disintegrate long before this. However, if you were sitting on the disc – and not getting ill or squashed – your own part of the disc would appear unchanged. It's all relative...

Dave Neale
Bedford, UK
It can't. The frictionless spindle is irrelevant. Centrifugal force will tear apart any spinning object at a tiny fraction of the speed of light.

SHUTTERSTOCK/YURIY KULIK

This week's new questions

Caffeine conundrum **I am in an arid desert with a flask of caffeinated coffee. Should I drink it, or will its diuretic effects speed my demise?** ***Adrian Moore****, Maidenhead, Berkshire, UK*

Music in the wild **Animals seem to respond to music when it is played to them, but what do they hear?** ***John Grant****, Caloundra, Queensland, Australia*

What good is caffeinated coffee, which has diuretic effects, in an arid climate?

Push it to the limit

Can eagles have sharper eyes? Or cheetahs run even faster? Or must the evolution of any adapted trait in nature reach a limit? (continued)

Pat French
Longdon-upon-Tern, Shropshire, UK
Evolution isn't the pursuit of some ultimate superpower; it tends towards the optimal.

A cheetah lives in balance with the prey population in its environment. Any development that increased speed would come with a cost. Its musculoskeletal system is a balance between mass and energy delivery. More muscle would require increased bone mass to support it, both developments requiring more food input, more hunts and more prey. This would require a bigger territory to support each animal, which would reduce the potential cheetah population in a given area.

An eagle could possibly develop finer eyesight, a spider could possibly develop a stronger web system. But until their environment exerts a pressure for change, why should they do so?

Mike Follows
Sutton Coldfield, West Midlands, UK
It would be unusual for a species to become overdesigned – for instance, by evolving visual acuity far exceeding what is required for survival and reproduction.

Evolution operates through trade-offs, not towards perfection. This is why organisms can appear to be optimally engineered when, in fact, their traits represent compromises shaped by competing selective pressures.

An individual born with a heritable variation that confers even a slight advantage will tend to pass it on to its offspring – unless chance intervenes. Yet

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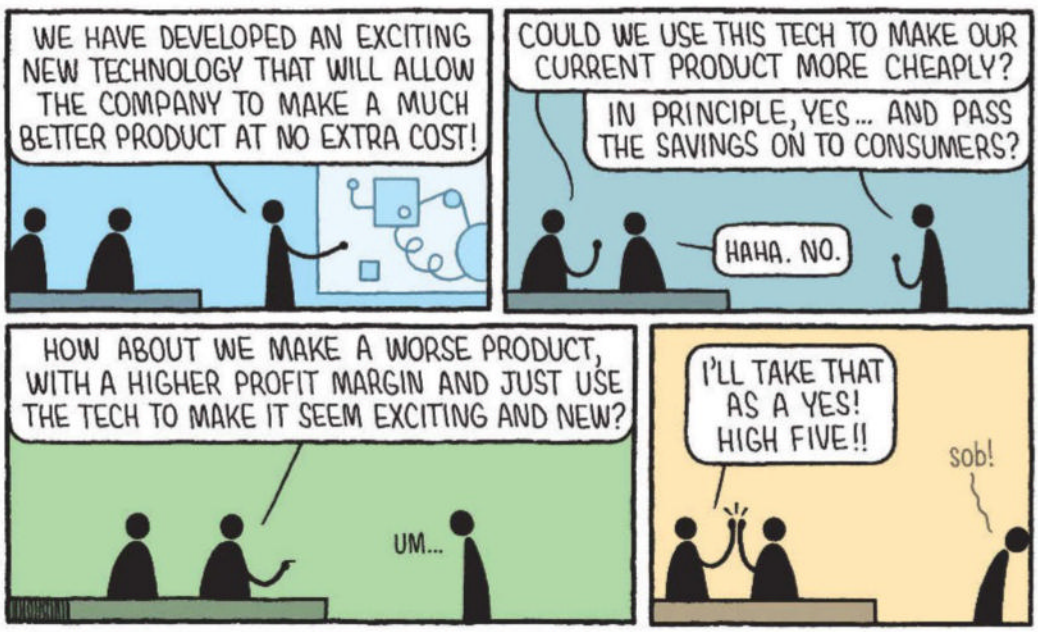

the metabolic and developmental costs of an enhancement, such as a more sophisticated eye, may outweigh its benefits. The same energy might be better spent on something else – for example, more elastic ligaments that enable a cheetah to change direction rapidly without injury.

Bone tissue exemplifies such compromises. It is exceptionally strong under compression and tension, but relatively weak under torsion and shear. In practical terms, a twisting force is more likely to cause a fracture than a comparable compressive load. To resist torsion more effectively, bones would need to be thicker or differently structured, increasing their mass. Birds with such bones would be too heavy to fly efficiently, and land animals would sacrifice speed and agility – a clear disadvantage for both predator and prey.

Simon McLeish
Lechlade, Gloucestershire, UK

Wild animals don't live in a vacuum: they are part of the environment, forming an ecosystem. At any moment, that ecosystem is a pattern of tensions around the abilities of the animals within it, which means changing one aspect may have an effect on the whole ecosystem.

"It would be unusual for a species to become overdesigned. Evolution operates via trade-offs, not towards perfection"

So, looking at the cheetah, if it ran faster, it may become exhausted more quickly in the chase, be more prone to overheating or be less able to turn sharply to follow a fleeing animal as it dodges to get away.

Evolution is driven by chance mutations. Some may result in a slightly different muscle protein, or some other difference, but any increased pressure on the antelopes the cheetah eats would change the whole ecosystem. One of the antelope species in the area may have recessive genes that allow it to turn more sharply, say. Individuals with that trait may become the dominant type and, potentially, a new species will arise. This is why human intervention in the environment can be catastrophic for animals: the change is often so rapid that the ecosystem becomes unviable, and extinction is the result.

What's the matter?

If an antimatter comet or meteor came into our solar system, how would we know? What if it hit Earth? (continued)

John Davies
Lancaster, UK

We would certainly know it was coming. As it approached the sun, it would collide with the contents of the solar wind. Those subatomic particles would annihilate with their antimatter counterparts in the comet, releasing pure energy. The result would be a comet that blazed across the sky, emitting electromagnetic radiation right across the spectrum. ▮

Answers

Quick quiz #329 *Answer*

1 Triceratops
2 It was turned completely green by copper
3 Carbon nanotubes
4 Big head
5 3000

Quick crossword #196 *Answers*

ACROSS 1 Workshop, **5** Air bag, **9** Retrofit, **10** Sprain, **12** Lucas, **13** Rocketeer, **14** Olefin, **16** Thiamin, **19** Mimicry, **21** Beetle, **23** Andromeda, **25** Sonar, **26** Trifid, **27** Akinesia, **28** Day-Glo, **29** Atheists

DOWN 1 Wordle, **2** Reticulum, **4** Omicron, **6** Imprecise, **7/3** Brake shoes, **8** Gangrene, **11** Scut, **15** Factorial, **17** Melanosis, **18** Impacted, **20** Ylem, **21** Bracket, **22** Organs, **24** Daisy, **25** Sense

#99 Hat trick *Solution*

Since the total of all 27 balls is 45, the third hat must have a total of 23.

After taking two sets of balls from each hat, the balls remaining in the hats are 7, 4 and 9.

For the second set of numbers, the balls are 6, 7 and 9 in the first hat; 1, 3 and 4 in the second hat; and 2, 5 and 8 in the third hat.

In the third case, the balls are 3, 8 and 9 in the first hat; 1, 4 and 5 in the second hat; and 2, 6 and 7 in the third hat.

No laughing matter

Feedback had a birthday within the past 12 months, and Feedback Jr gave us a card that read: "My ambition in life is to be as funny as you think you are."

Still, we persist with our dad jokes, if only because our offspring's exasperated reactions are so much fun. So we were delighted to learn that two psychologists, Paul Silvia and Meriel Burnett, have taken a scholarly interest in dad jokes. They have written an entire paper on the topic.

It's called "What's brown and sticky? Peering into the ineluctable comedic mystery of dad humor with a handful of machine learning models, hundreds of humans, and tens of thousands of dad jokes". The abstract begins, if you hadn't guessed, "A stick, of course."

The authors collated more than 32,000 jokes from the r/dadjokes community on Reddit. This dataset is available alongside the paper, so Feedback naturally downloaded the whole thing. It includes such gems as "How can you find out how old a boat is? Look at its berth certificate."

However, this isn't just an excuse to trot out puns: this is serious research. The psychologists gathered data on how popular the jokes had been on the site, and showed some to volunteers. This allowed them to pose the key question: "who finds these quirky jokes funny?" For this, panel members were asked questions about their personalities, political views and so forth. It turns out that people who are what the paper calls "culturally conventional" – for instance, "more educated" or "more religious" – found the jokes funnier.

A key factor, identified as "the most intellectually profound question on the survey", was whether people identified as cat people or dog people. Both groups found the jokes funnier, as did those who liked both animals, than those who didn't like either type of pet. Which tracks. As the researchers say: "One does wonder what people who don't like kittens and puppies happen to find funny."

Finally, the researchers found that gender and parenthood affected people's perception of the jokes. Or as they put it: "In these fraught and uncertain times, rife with mistrust of expertise and reason, it is perhaps reassuring to know that science has found that dads find dad jokes funnier."

Twisteddoodles *for New Scientist*

Got a story for Feedback?
Send it to feedback@newscientist.com
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Consideration of items sent in the post will be delayed

United in urination

Asleep at the wheel as ever, Feedback missed the publication in June of Jo-Anne Bichard and Gail Ramster's book *Designing Inclusive Public Toilets*. Fortunately, reader Brian Reffin Smith is on the case.

The book's argument is simple: public loos need to work for all, but they often don't. "This book provides a critical overview of public toilet design in the UK and presents an urgent need to re-evaluate the accessibility of, and culture around, these essential spaces," the publisher's website explains.

Feedback is immediately on board. We have autistic relatives, for whom the high-pitched whine of some hand dryers is enough to cause a sensory overload, and who also have a lot to say about public toilets' fluorescent lighting. Although we will note that the hardback has a recommended retail price of £70, which doesn't seem very inclusive.

However, following Brian's lead, we do want to flag the book's subtitle. You might expect something dry and long-winded, like "How to design public conveniences to be accessible to everyone, regardless of gender, ethnicity, disability or neurodivergence". But it is, in fact, "Wee the people".

The end is kind of nigh

When you make a big claim and it gets some pushback, there are a few ways to respond. Maybe your critics made some good points, so you add some caveats or otherwise moderate your statements. Or maybe you decide you've been misunderstood, so you try to clarify your views.

This is not a story like that.

Last month (18 October), Feedback reported the dispiriting news that humanity is on track to go extinct in the year 2339. This was based on a paper by demographers David Swanson and Jeff Tayman, who had noted a decline in fertility between 2019 and 2024, and gaily extrapolated 300-odd years into the future. This, Feedback suggested, might be somewhat unsupported.

To our surprise, Swanson got in touch. "Thanks," he writes, "for acknowledging that our piece on human extinction was serious." Which eliminates, once and for all, our lingering suspicion that the whole thing was a practical joke.

Swanson also sent us version 2 of the paper. It contains significant updates, perhaps because they have added in data from 2025. The extinction of the human species has consequently been postponed by almost a century: instead of 2339, we are now set to vanish in or around 2415. So that's a relief.

However, the more significant change is encapsulated in the paper's new title: "A regionally-based probabilistic forecast of human extinction". You see, the researchers have now broken down their forecast by continent. "Asia will be the first region to experience extinction (2280), Europe, the second (2295), followed closely by the Americas (2300), then Africa (2360) and finally Oceania (2415)," they write. Buy that beachfront property on Easter Island, folks.

Feedback can't help imagining a third version of the paper, which will forecast the precise Polynesian island where the very last human being will snuff it.

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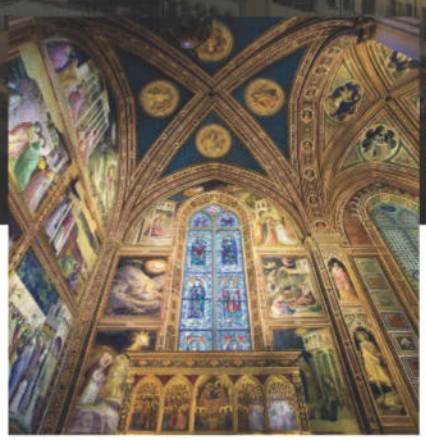

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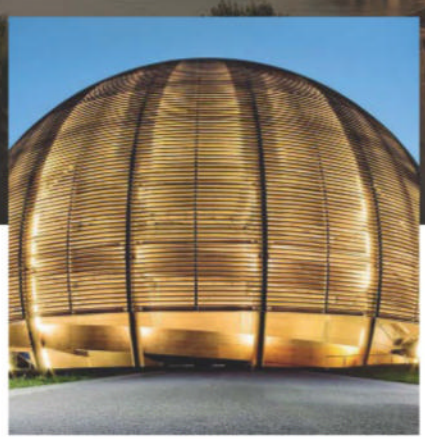

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