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What they tell us about the brain

Does microdosing work?

What does it mean for exercise?

How they are changing society

Do you need to take them forever?

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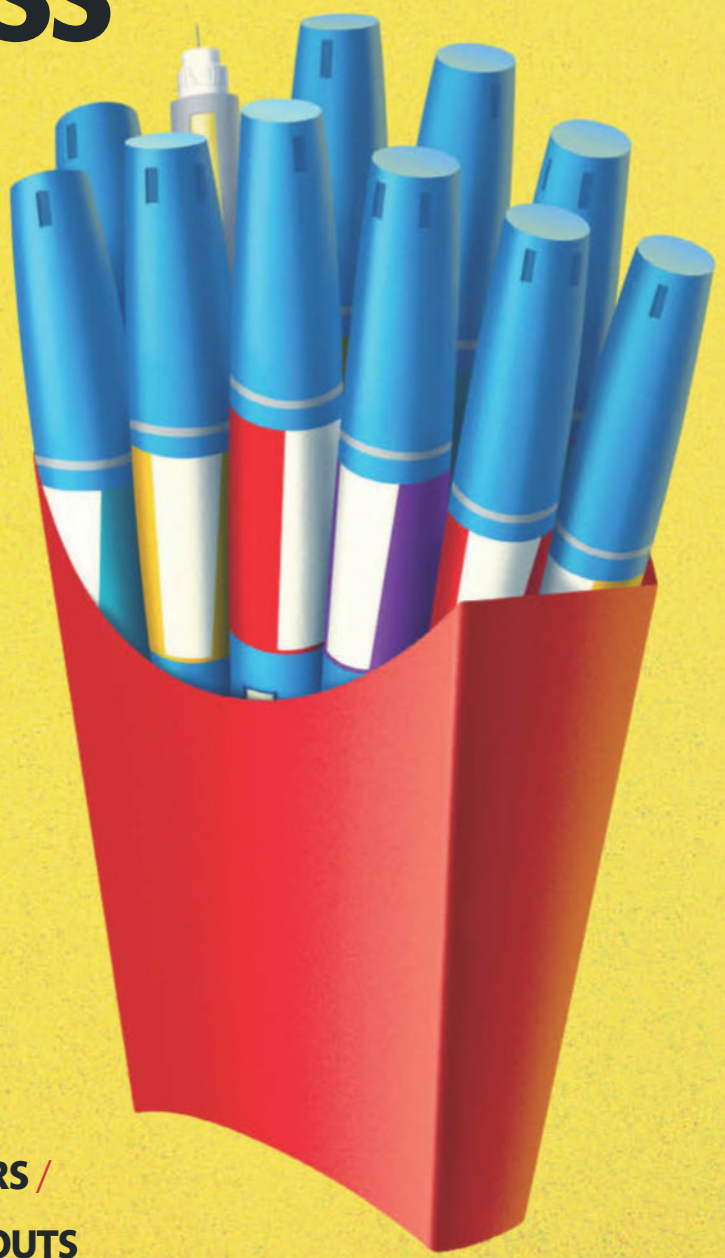

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Science and technology news **www.newscientist.com**

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MAY – AUGUST 2025

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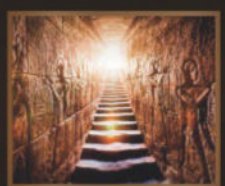
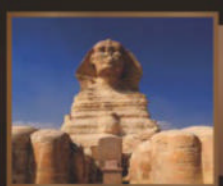

THE SEARCH FOR CLEOPATRA'S TOMB • SECRET ROOMS IN THE GREAT PYRAMID • KING TUT'S UNTOLD SECRETS • & MORE REVELATIONS!

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July 21	Philadelphia, PA
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August 2	Montreal, QC – Canada

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Elsewhere on New Scientist

Online event

Measuring the mind

Join biologist and neuroscientist Suzana Herculano-Houzel as she explores how the human brain became the marvel that it is without ever breaking the rules of evolution. Find out how her revolutionary method of counting neurons allows us to compare brains across species. This subscriber-only online event will take place on 1 April at 6pm BST/1pm EDT.

newscientist.com/events

Tour

Human origins: Northern Spain

Explore how our ancestors lived and played through some of the world's oldest known cave paintings. Accompanied by local archaeological experts and former *New Scientist* editor-in-chief Emily H. Wilson, you will visit the caves of Santimamiñe, El Pindal, Tito Bustillo, El Castillo and more. This seven-day tour starts on 17 June or 26 August and costs from £3395.

newscientist.com/tours

Podcast

Weekly

The team discuss the biggest discovery about dark energy for 25 years. Hear about a new way that bacteria could produce oxygen – which may explain the strange phenomenon of "dark oxygen", which is being produced by metal nodules deep on the sea floor. Plus, NASA's Perseverance rover has found intriguing hints of the existence of life on Mars in the past.

newscientist.com/nspod

IMAGE PROFESSIONALS GMBH/ALAMY

Cave art Travel back 40,000 years to see how our ancestors lived

NICK DUNMUR/UNIVERSITY OF NOTTINGHAM

Cosmic Titans Can art help us understand the quantum realm?

Video

Quantum cosmos

The *Cosmic Titans* exhibition at the Djanogly Gallery in Nottingham, UK, unites art and science in an exploration of the quantum universe. It features commissions by nine artists who have each spent time working alongside world-leading researchers in quantum physics. Their collaboration that reveals how artists and scientists can inform each other's work.

youtube.com/newscientist

Newsletter

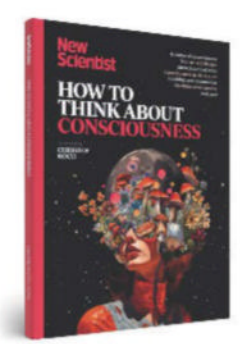
The Earth Edition

This month's roundup of environment and nature stories considers the workings of some of the planet's most mysterious animals. We may now know how Greenland sharks live so long, what microbes at the bottom of the ocean are up to, and how octopuses avoid being eaten during sex.

newscientist.com/the-earth-edition

Podcast

"The Mars rover found little speckles on rocks that scientists call leopard spots"



How to think...

In the first of our new *How to Think About* series, discover how leading experts think about consciousness. Get to grips with the latest ideas and cutting-edge experiments in this exciting field of research. It will ensure you never view your mind in the same way again.

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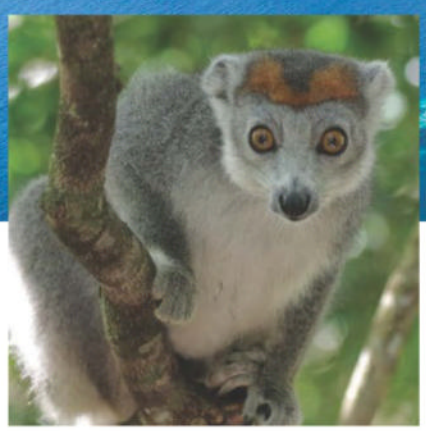
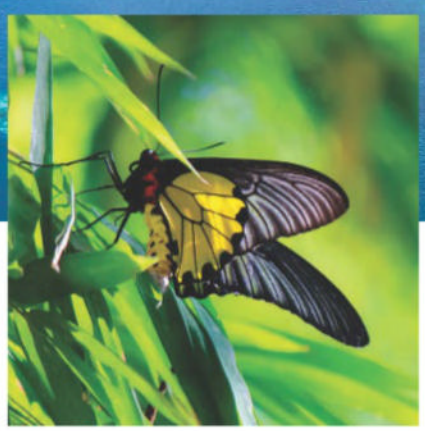


Unique ecosystems in the land of the lemur: Madagascar

3 September 2025
16 days

Be immersed in Madagascar's diverse and unique ecosystems, a living laboratory of evolution and biodiversity. Gain a deeper understanding of how, having broken away from mainland Africa some 150 million years ago the country's rich flora and fauna have evolved in isolation, leading to unique adaptations and species found nowhere else on Earth.

- Discover the evolution of Madagascar's array of species and uncover its rich flora and fauna including lemurs and fossa
- Walk through endemic forests and rainforests and listen out for the haunting call of an indri (the largest species of lemur) or see a chameleon blending into its surroundings
- Learn how ongoing conservation work is crucial for understanding and protecting these irreplaceable ecosystems



Alfred Russel Wallace expedition cruise, Indonesia

23 January 2026
13 days

Explore the Maluku Islands and Raja Ampat Islands as Alfred Russel Wallace did, visiting several sites that were important to his discoveries, as well as experiencing the islands' local culture, primary rainforests, geology and conservation projects. Throughout this tour you will be accompanied by entomologist, evolutionary biologist and Wallace expert George Beccaloni.

- Explore primary rainforests, marine ecosystems and their flora and fauna, including several species of birds of paradise and Wallace's golden birdwing butterfly
- Go in search of wildlife aboard a 22-berth, luxury schooner and enjoy the beautiful marine habitats by kayak, paddle board and snorkelling
- Gain an in-depth insight into the life and work of Wallace, plus the natural treasures of Indonesia

Hawaii astronomy, volcanoes and marine biology cruise: US

16 April 2026
10 days

This cruise around Hawaii blends the awe-inspiring beauty of the night sky with stunning volcanic geology and a tranquil marine environment. As you travel onboard the expedition yacht Safari Explorer, which is designed to access areas that larger vessels cannot enter, you will explore the islands' unique ecosystems, including endemic marine species. You will visit Hawaii's world-renowned observatories to see cutting-edge astronomical research, whist discovering the volcanic geology and rich cultural history of the Island.

- Enjoy a unique snorkelling experience with manta rays, observing their behaviour and ecology during their feeding and cleaning activities
- Join guided nature hikes, snorkel among coral gardens and keep watch for whales, dolphins and other marine life from the deck

Find out more at
newscientist.com/tours

Welcome to the Ozempic era

What happens now that weight-loss drugs have gone mainstream?

ONLY a year ago, as hype was building around the semaglutide drugs Ozempic and Wegovy, conversations revolved around their potential to "end obesity" by helping people drop large amounts of weight.

Then there was talk of how semaglutide's appeal for weight loss was causing shortages for people who needed it to treat their diabetes, as well as which celebrities might have been getting their hands on it. Despite the buzz, these treatments were still somewhat exotic.

Today, there is no longer talk of shortages. In fact, it is easier than ever to obtain these medications from online pharmacies, provided you have the funds and the right BMI. At lightning speed, the jabs have become household names. You or someone you know may well be taking one.

Some data indicates that as many as 1 in 8 people in the US have tried one of the new generation of weight-loss drugs; in Britain, around 1 in 7 people have taken one or have a family member or friend who has done so. It is fair to say we are living in the era of Ozempic, and it is changing much more than our collective waistlines.

"Many people are experimenting with smaller doses of weight-loss drugs, but is this a good idea?"

In this special report, we take a clear-eyed look at the new normal and the questions it raises. What do these treatments mean for traditional approaches to weight loss, in particular exercise (see page 34), and will those on the drugs really need to keep taking them for life (see page 38)? Over the past year, we have seen study after study examine their benefits for other conditions, including Alzheimer's disease, depression and addiction. So how do they influence the brain beyond appetite regulation (see page 31)?

Many people are experimenting with taking them in smaller doses, but is this a good idea (see page 33)? And we also ask what all of this means for society as a whole (see page 35) and what comes next (see page 37).

What's clear is that the new boom in weight-loss drugs is just the beginning. In another year's time, things are likely to look very different once again. ▮

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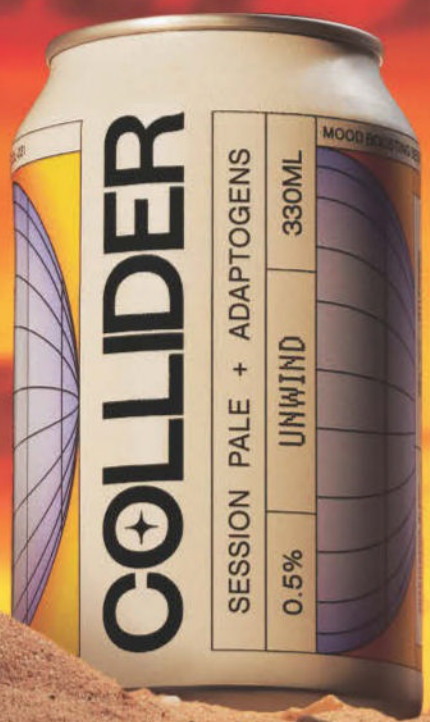

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News

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Greenland gains new coastline as glaciers retreat p9

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Our first cutting tools may have been a gift from nature p11

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Water can become superacidic under high heat p13

Claw away
The largest fully preserved dinosaur claw ever found p16

Microdosing myth
LSD is no better at treating ADHD than placebos p18

Space

Dolphins welcome astronauts home

WHEN this SpaceX Dragon capsule splashed down off the coast of Florida on 18 March, the crew on board were greeted by a pod of dolphins. Inside, among others, were NASA astronauts Suni Williams and Butch Wilmore, who were returning to Earth after being "stuck" on the International Space Station for nine months.

NASA/KEEGAN BARBER

Palaeontology

Fossil may have been new type of life

Chemical analysis suggests the extinct organism *Prototaxites* was neither plant, animal nor fungus – raising the tantalising question of what else it might have been, finds **James Woodford**

A BIZARRE ancient organism previously thought to be a giant fungus may actually belong to an undiscovered branch of the tree of life that mysteriously went extinct.

Prototaxites, which lived between 420 million and 375 million years ago, was the first giant terrestrial life form to inhabit Earth. It grew trunk-like structures up to 8 metres tall and 1 metre wide.

Its fossils were first discovered in 1843 and were initially thought to be the trunks of rotten conifers. Their classification has been a matter of intense debate, but in 2007, Kevin Boyce at Stanford University, California, and his colleagues concluded from the carbon isotopes in the fossils that they were a kind of fungus. This chemical evidence suggested that *Prototaxites* obtained carbon from other living organisms, as fungi do, rather than taking carbon dioxide from the air like plants.

Now, Corentin Loron at the University of Edinburgh, UK, and his colleagues have released a research paper in which they say that *Prototaxites* wasn't a fungus at all. Even more confounding, it fits nowhere else in the existing lineages of life.

RICHARD JONES/SCIENCE PHOTO LIBRARY

Prototaxites grew trunk-like structures up to 8 metres tall

Curious composition

Their study focuses on one species in the group, *Prototaxites taiti*, which was found in a fossil site in Aberdeenshire, Scotland. *P. taiti* was much smaller than some of the giant species of *Prototaxites* and only grew to a few tens of centimetres in height.

P. taiti's structure was made up of tubes, just like a fungus, but its tubes branch and connect in ways that are different to fungi, Loron and his colleagues report.

The Rhynie chert fossil site containing *P. taiti* has also yielded some bona fide fungi, so Loron and his colleagues did a chemical comparison between these fossil fungi and fossil *Prototaxites*.

They found that the chemical signature left in the fossils of *Prototaxites* is completely different to the chemical signature left by fungi subject to the same fossilisation processes.

This shows that *Prototaxites* didn't contain chitin, a fundamental structural component in fungal cell walls, the researchers say.

Instead, the chemical components they identified were most similar to the fossilisation products of lignin, a polymer found in woody plant tissue.

Loron and his colleagues declined to be interviewed by *New Scientist* as their research is yet to be peer reviewed. In their paper, they say the *Prototaxites* group is defined by three main characteristics: they formed large, multicellular structures of varied tube types, their composition was rich in compounds similar to lignin but distinct from plant matter, and they fed on decaying organic material.

The researchers say these three key distinguishing features of *Prototaxites* are simply not known together in any living lineage. "We suggest that it is best considered a member of a previously undescribed, entirely extinct group of eukaryotes," they write (bioRxiv, doi.org/pc97).

400 million

The approximate age of the *Prototaxites* fossil in years

No one knows why *Prototaxites* became extinct, but some scientists have suggested that it was outcompeted by fungi or the rapid explosion of shrubs and trees.

"Given the phylogenetic information we have now, there is no good place to put *Prototaxites* in the fungal phylogeny," says Boyce.

He says it was an organism composed of interwoven microscopic filaments that fed on organic matter rather than photosynthesising, as is true of many fungi.

"So maybe it is a fungus, but whether a fungus or something else entirely, it represents a novel experiment with complex multicellularity that is now extinct and does not share a multicellular common ancestor with anything alive today."

Brett Summerell at the Botanic Gardens of Sydney, Australia, says there are "too many unknowns to say it is a unique lineage at this stage".

"The assumption that it was likely to be in the fungi was somewhat nebulous, particularly given the nature of the fossils, and seemed somewhat counterintuitive given the relatively massive size," he says.

"The conclusion that it is a completely unknown eukaryote certainly creates an air of mystery and intrigue around it – probably not likely to be solved until more fossils are discovered or new analytical techniques developed."

Archaeology

Tutankhamun's ancient Egyptian burial was one of a kind

Colin Barras

A COLLECTION of roughly made clay trays and wooden staffs found among the golden treasures of Tutankhamun's tomb may offer the earliest evidence of an important ancient Egyptian royal funerary ritual. The idea is the latest indication that the boy king had a burial unlike that of any other pharaoh.

Tutankhamun's nine-year reign in the 14th century BC came after a period of religious turmoil in ancient Egypt. One of his predecessors – Akhenaten, who was probably Tutankhamun's father – spurned ancient Egypt's traditional polytheistic faith in favour of a new religion centred on a single deity known as Aten.

Tutankhamun and his advisers played an important role in restoring the older faith. But this also presented them with an opportunity to reinterpret and update some traditional rituals, says Nicholas Brown at Yale University. Evidence for this may lie in the four clay trays, each about 7.5 centimetres by 4.5 centimetres, and four 1.1-metre-tall wooden staffs found in Tutankhamun's tomb.

Brown suspects they were used in a funerary ritual known at the Awakening of Osiris, which was first represented in ancient Egyptian artwork several decades after Tutankhamun's reign. "I'm pretty convinced that what we're seeing within Tutankhamun's burial chamber is probably the earliest iteration of this ritual that we can see in the archaeological record," says Brown.

METROPOLITAN MUSEUM OF ART

BUDDY MAYS/ALAMY

Left: Two of the three complete mud trays from Tutankhamun's tomb. Below: Tutankhamun's inner sarcophagus

The trays and staffs were placed on reed matting 1.5 metres from the head of the sarcophagus. Brown compares this with the later artwork showing the Awakening of Osiris ritual, in which the pharaoh – who, in death, has become Osiris, the god of the underworld – is commanded to wake by staffs held behind his head. Brown says the clay trays were a crucial component of this ritual too because they would have held libations – perhaps in the form of water from the Nile – that were believed to help revive the decomposing body. Such libations were often placed on reed matting so that their symbolic purity was untainted by the impure ground. Even the fact that the clay vessels were crudely made from Nile mud is important, he says, as Osiris was also symbolised by the fertile Nile soil (*Journal of Egyptian Archaeology*, doi.org/pcwb).

Jacobus van Dijk at the University of Groningen in the Netherlands agrees that the clay trays may have had a ritualistic purpose, although he argues they may have been used for the "spell of the four torches". In this ritual, four torch-bearing guides stand near the sarcophagus and help the dead pharaoh journey through the underworld, before extinguishing the torches in a clay tray filled with milk from a white cow.

"I definitely think that's a good interpretation too," says Brown. He adds that the ancient Egyptians often used objects in different ways, so the clay trays could have been used in both rituals. ▮

Climate change

Melting glaciers add risk to exploiting Arctic resources

RISING temperatures in the Arctic are causing glaciers to retreat onto land, exposing thousands of kilometres of coastline in Greenland and other areas.

Jan Kavan at the University of South Bohemia in the Czech Republic and his colleagues used satellite imagery taken in 2000 and 2020 to track changes in marine-terminating glaciers across the northern hemisphere. They found that almost 2500 kilometres of new coastline had emerged over this period due to glaciers retreating onto land, with two-thirds of this – over 1600 km – appearing in Greenland, where temperatures are rising far faster than the global average (*Nature Climate Change*, doi.org/pdbg).

Geopolitical tensions are rising as nations compete to control Arctic resources, which are becoming more accessible as the ice melts. Greenland, for example, is rich in critical minerals, deposits of rare-earth elements and unexplored oil and gas reserves. But its new coast is precarious, warns Kavan, as it is vulnerable to landslides that can trigger huge tsunamis, threatening communities and economic activity.

"The coastline that is newly exposed is unconsolidated," he says. "It is not cemented with ice, the permafrost is not there, so it is really easy to erode it."

In narrow fjords, for example, glacier ice fixes the sloping cliffs in place. "When that glacier is gone, the slopes become unstable because they are no longer supported by the mass of the ice," he says. "These slopes are sensitive to landslides or rockfalls, which can then trigger tsunamis."

This happened in Greenland in September 2023 – when a landslide in a fjord caused a 200-metre-high tsunami – as well as in June 2017, when two settlements were hit by a tsunami sparked by a landslide in a nearby fjord, killing four people. ▮

Madeleine Cuff

Health

Simulating the outdoors inside schools seems to slow myopia

Chris Simms

MYOPIA has long been linked to spending too much time inside, but new research suggests that just mimicking the outdoors in classrooms could help ward off the condition in children.

Short-sightedness, or myopia, generally emerges as the eye changes shape during normal development in early life, and the distance between the cornea at the front of the eye and the retina at the back becomes too long. This results in blurry vision of distant objects because light coming from them is being focused in front of the retina, rather than on it.

Spending more time outside can cut the risk. The main hypothesis is that this enables exposure to bright natural light, but another idea is that the outside world offers more visual stimulation with scenes containing "high spatial frequencies". This means that there are sudden changes in visual stimuli, such as edges, as opposed to mainly smooth, monotonous features.

To investigate this idea, Weizhong Lan at Central South University in China and his colleagues created an indoor environment with many high spatial frequencies by decorating a classroom to look like a wood. This involved covering walls and even desks with images of trees and bushes and making the ceiling resemble the sky.

For one year, Lan's team had about 250 children – aged around 9 – from 10 classes at a school in Lijiang in Yunnan province take their lessons in a classroom decorated like a woodland, while another group of around 250 children learned in a traditional-looking classroom, painted white. Lighting was slightly adjusted in the classrooms to make it consistent between the two groups.

"The classroom's walls and even desks were covered with images of trees and bushes"

Before and after the study, the children were assessed for signs of myopia, according to the curvature of their eye lenses. This is measured in dioptres, with the beginnings of myopia generally defined as -0.50 dioptres.

After one year, the eyes of long-sighted children in the outdoor-mimicking classroom – those who struggle to focus on things very close to them – had moved towards myopia 0.22 dioptres less than those in the traditional classroom. For those with 20/20 vision, their eye curvature changed 0.18 dioptres less (medRxiv, doi.org/pc93).

"I think it's clinically significant," says Billy Hammond at the University of Georgia in the US. "If you can't prevent kids from getting myopia, at least you can reduce the degree of myopia."

However, if the students already had myopia, the woodland classrooms made no difference. They probably couldn't see the high spatial frequencies as well as the other children, so it would have had little effect for them, says Hammond.

Outdoor scenes could be implemented cost-effectively in classrooms and other indoor environments, says Lan. "According to the students, the design did not distract their attention; instead, they felt it enhanced their study efficiency."

"The study is a nice first indication," says K. Davina Frick at Johns Hopkins University in Maryland. But spending more time outdoors is probably preferable to reduce a child's myopia risk, and for the other benefits it brings, says Frick.

Hammond echoes this point. "Painting the walls with murals is not even close to the experience of going outside, but it's probably better than nothing," he says. ▮

A classroom painted to look like a wood had an effect on children's eyes

WEIZHONG LAN/ AIER ACADEMY OF OPTHALMOLOGY, CENTRAL SOUTH UNIVERSITY

Space

A wobbly start to radio astronomy on the moon

Jonathan O'Callaghan

THE first successful use of a radio telescope on the moon has kicked off a new era of astronomy, despite a bumpy landing.

NASA's ROLSES-1 (Radio wave Observations at the Lunar Surface of the photoElectron Sheath) telescope was mounted on the Odysseus lander, an Intuitive Machines spacecraft that made the first private lunar landing last year. While Odysseus was the first such spacecraft to survive a landing, it tipped on its side, rendering most of the equipment on board unusable, but the telescope was spared.

"This is the first time that radio astronomy has been done from the moon," says Joshua Hibbard at the University of Colorado, Boulder, who was part of the team behind ROLSES-1. It consisted of four 2.5-metre-long spring-loaded antennae. Two of the arms accidentally deployed prior to the landing, while the other two were made to deploy after the landing.

That was enough for a few hours of observations before Odysseus ran out of power, allowing the team to detect radio emissions from Earth and further afield. The observations revealed that, from afar, our planet's radio signal appears to twinkle because of Earth's atmosphere – something that may also be the case on inhabited alien worlds. "You could use this as a case study when looking for advanced technological life on exoplanets," says Hibbard.

ROLSES-1 also detected radio signals from elsewhere in the galaxy, the result of high-energy cosmic rays produced by supernovae, black holes and other phenomena interacting with the Milky Way's magnetic field (arXiv, doi.org/pcxg). The team had hoped to observe radio waves from the sun and Jupiter, but the lander ran out of power. "We missed a solar burst by like a minute," says Hibbard. "It was really a pity." ▮

Copying nature's toolbox

Stone tools are considered the first form of technology devised by ancient humans – but they might not have been invented from scratch, finds **Michael Marshall**

WHEN ancient humans first invented stone tools, they may have been trying to emulate naturally formed sharp stones – meaning they would not have needed a huge leap of inspiration.

"What our hypothesis does is, it really turns the origin of technology entirely on its head," says Metin Eren at Kent State University in Ohio. Instead of imagining a sharp tool and then figuring out how to make it, early hominins may have used natural sharp edges to butcher carcasses for millennia before anyone tried crafting them. "Rather than hominins creating the knife and then looking for something to cut, we propose that they were already exploiting carcasses," he says.

One of the defining features of hominins is their ability to both make and use stone tools. Creating a stone tool requires hitting two rocks together in precise ways, knocking flakes off one of them to shape it into a cutting edge.

This is called "knapping", and hominins have been doing it for at least 2.6 million years. There are even older stone tools from Lomekwi in Kenya, dating back 3.3 million years, but these were made using a simpler method: bashing one stone on the ground.

"It's been traditionally thought that the very first stone flakes were produced intentionally or by accident, and then early hominins started to look for things to cut with these new sharp implements," says Eren. He says this story doesn't make sense. "For a creature to start to use an item, or to invent an item, there has to be a selective pressure first."

Eren and his colleagues argue that hominins found naturally sharp stones, which they used as cutting tools. By doing so, they developed a habit of cutting and began seeking out such stones.

EMMA FINESTONE

ERENET AL.

Lava outcropping (left) and a close-up of stone fragments with sharp edges found in Kenya (above)

"Mother Nature is producing knives all over the place," says Eren. He calls these raw blades "naturaliths".

The team has compiled multiple examples of naturaliths. Eren has studied stones from Antarctica, which resemble hominin tools but must have been made by natural processes, since no hominin ever lived in Antarctica. Experiments have also shown that tool-like artefacts can be produced when large animals like elephants and horses trample on stones. There are also processes that don't involve living animals, such as waves crashing on rocky shores and glaciers grinding over bedrock (*Archaeometry*, doi.org/pcxh).

"Hominins may have used natural sharp edges for millennia before anyone tried crafting tools"

For Eren, the appeal of this hypothesis is that it doesn't require a "eureka moment" of inspiration. "It shortens the cognitive distance between every step in the origin of technology," he says. He calls it "the most parsimonious proposal" for how hominins invented stone cutting tools.

However, Eren emphasises that this hypothesis is a suggestion, not a fact, calling it "a big swing". While the team has listed examples of naturaliths and processes that could make them, many other tests are needed. Eren wants to look for naturaliths from times and places where hominins lived, and find evidence that they were used as cutting tools. That could include distinctive wear patterns or traces of plant and animal material on the sharp edges. It might also be possible to find naturaliths that hominins have transported over long distances.

Sharpest tool in the box

Such evidence might not be forthcoming. "Simply because the hypothesis is parsimonious doesn't mean it's correct," says Eren.

"I think it is a really intriguing proposal," says Briana Pobiner at the Smithsonian Institution in Washington DC. "Maybe the invention of stone tools wasn't this major cognitive leap," she says, but instead a "natural extension of what hominins were already doing".

Identifying the sources of naturaliths is useful, says Claudio Tennie at the University of Tübingen in Germany. However, the researchers' "specific story just doesn't check out".

Tennie says the proposal relies on an assumption: that inventing stone tools from scratch is too cognitively difficult for hominins to have pulled off. "That is not true," he says. Instead, several lines of evidence suggest that hominins were smart and creative enough to come up with knapping unaided.

In a series of studies published in 2022, Tennie's team showed that orangutans could make and use stone tools without training; that wild gorillas sometimes bash stone-like objects together, a prerequisite for knapping; and that humans can figure out basic knapping without help.

Tennie says hominins didn't need a helping hand from naturaliths. Eren argues that those experiments may not tell us much about early hominins because several of them used captive primates, and modern humans are not the same as hominins that lived millions of years ago. "Even if hominins were clever enough to spontaneously invent stone tools at will, that does not negate our hypothesis that Mother Nature helped them along," he says. ▮

Technology

AI can accurately forecast the weather in seconds

Matthew Sparkes

AN AI weather program running for a single second on a desktop can match traditional forecasts that take hours or days on powerful supercomputers, its creators claim.

Weather forecasting has, since the 1950s, relied on physics-based models that extrapolate from observations made using satellites, balloons and weather stations. But these calculations, known as numerical weather prediction (NWP), are extremely intensive and rely on energy-hungry and expensive supercomputers.

In recent years, researchers have tried to streamline this process by applying AI. Google scientists last year created an AI tool that could replace chunks of code in each cell of a weather model, slashing the computer power it required. DeepMind – a subsidiary of Google's parent company, Alphabet – later took this even further and used AI to replace the entire forecast. The approach was adopted by the European Centre for Medium-Range Weather Forecasts (ECMWF), which launched a tool called the Artificial Intelligence Forecasting System last month.

But this gradual expansion of AI's role in weather prediction has fallen short of replacing all traditional number-crunching – something a new model created by Richard Turner at the University of Cambridge and his colleagues seeks to change.

Turner says previous work was limited to forecasting, and passed over a step called initialisation, where data from around the world is merged into an organised grid that the forecast can start from. "That's actually half the computational resources," says Turner.

The researchers created a model called Aardvark Weather that, for the first time, replaces both the forecast and initialisation stages. It uses just 10 per cent of the input data that existing systems do, but can achieve results comparable to the NWP forecasts, report Turner and his colleagues in a study assessing their method.

Generating a full forecast, which would take hours or even days on a powerful supercomputer for an NWP forecast, can be done in approximately 1 second on a single desktop computer using Aardvark (*Nature*, doi.org/pcxf).

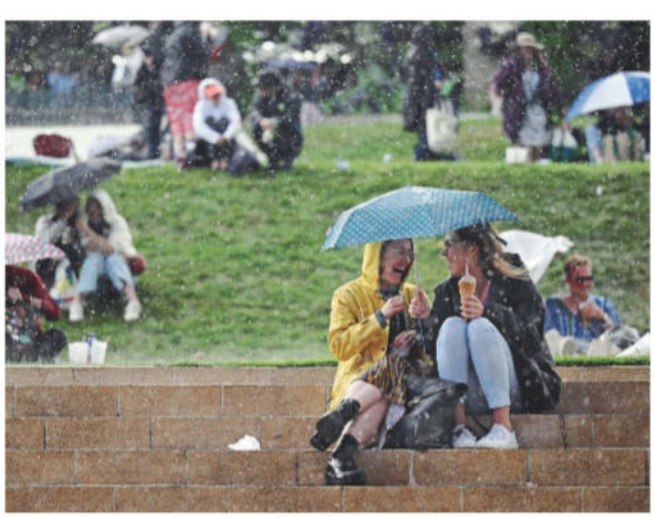
However, Aardvark is using a grid model of Earth's surface with cells that are 1.5 degrees square, while the ECMWF's ERA5 model uses a grid with cells as small as 0.3 degrees. This means Aardvark's model is too coarse to pick up on complex and unexpected weather patterns, says David Schultz at the University of Manchester, UK.

"There's a lot of unresolved things going on that could blow up your forecast," says Schultz. "They are not representing the extremes at all. They can't resolve it at this scale."

Turner argues that Aardvark can actually beat some existing models in picking up unusual events such as cyclones. But he concedes that AI models like his also rely entirely on those physics-based models for training. "It absolutely doesn't work if you take their training data away and just use the observational data to train off," he says. "We did try to do that, and go completely physics model-free, but that didn't work."

"Generating a full forecast would usually take hours or days on a powerful supercomputer"

He says the future of weather forecasting may be scientists working on ever-more accurate physics-based models, which are then used to train AI models that replicate their output faster and with less hardware. ▮



Improved forecasts could be on the way thanks to AI

SEBASTIEN BOZON/AFP VIA GETTY IMAGES

Chemistry

Greener chemical process is a boost for nuclear fusion

James Woodford

LIMITLESS power from nuclear fusion may be a step closer after the discovery of a new, clean way to supply the isotope lithium-6.

The least challenging fusion process involves combining two isotopes of hydrogen, deuterium and tritium, to yield helium, a neutron and a lot of energy. "Breeder" reactors seek to manufacture tritium, which is difficult to source, by bombarding lithium with neutrons.

Lithium atoms exist as two stable isotopes: lithium-7 makes up 92.5 per cent of the element in nature; the rest is lithium-6. The rarer isotope reacts much more efficiently with neutrons to produce tritium. Until now, the only way to separate it at scale was via a highly toxic process reliant on mercury.

While looking at ways to clean water contaminated by oil drilling, Sarbajit Banerjee at ETH Zurich in Switzerland and his colleagues noticed that the cement membranes they used, containing a lab-made compound called zeta vanadium oxide, collected large quantities of lithium and disproportionately isolated lithium-6.

Zeta vanadium oxide contains tunnels surrounded by oxygen atoms, says Banerjee. "Lithium ions move through these tunnels, which happen to be just the right size [to bind lithium-6]," he says. "We found that lithium-6 ions are bound more strongly and are retained within the tunnels." (*Chem*, doi.org/g887c4)

The researchers don't fully understand why this happens, but say it has something to do with the interactions between the ions and atoms at the edges of the tunnels. They have only isolated less than a gram of lithium-6 so far, but Banerjee hopes to scale up the process so it can produce tens of kilograms. A commercial fusion reactor is expected to need tonnes of the element every day. ▮

Zoology

Not so bird-brained after all

Brain activity of budgerigars reveals the secrets behind their mimicry

Michael Marshall

BUDGERIGAR brains contain a map of vocal sounds, which is similar to that found in the human brain and has not been seen in any other bird.

"We found that there was a representation of vocal sounds in a part of the brain that is analogous to a key speech region in the human brain," says Michael Long at the New York University Grossman School of Medicine.

Budgerigars (*Melopsittacus undulatus*), also known as parakeets, are small parrots native to Australia. They are spectacular vocal learners, able to mimic a variety of sounds, including human speech.

With Zetian Yang, also at NYU's medical school, Long used silicon probes to record the electrical activity in budgies' brains. They focused on part of the forebrain, the central nucleus of the anterior arcopallium, which was known to be involved in the motor control of vocalisations. As the budgies made calls, Long and Yang tracked how their electrical activity changed.

"Our study was the first to measure the activity in the parrot brain during vocalisation," says Long.

The pair found neurons in the central nucleus of the anterior arcopallium that were active only when the budgies made specific sounds. "There are cells that are active for consonants," says Long. Others do vowels, with some active for high-pitched sounds and others for low-pitched.

Budgies are able to mimic a wide range of different sounds

ARCO/TUNS/IMAGEBROKER.COM GMBH & CO. KG/ALAMY

Long compares this brain structure to a keyboard. "It has this kind of set of keys, or in this case, set of brain cells, that can represent each one of these vocal outcomes and then play whatever it wants," he says. "What the parrot has presented is this beautiful, elegant solution for making vocal sounds." Human brains have similar vocal maps (*Nature*, doi.org/g88267).

Long and Yang repeated their experiments on zebra finches (*Taeniopygia guttata*), which are not vocal mimics. "They have a single song that they learn," says Long. "It's about a second long, sometimes less."

Unlike the budgerigars, the zebra finches showed no sign of a "map" of vocal sounds in their brains. Instead, "a zebra finch develops this really almost impenetrable code for its song", says Long.

"It shows that the neural activity and associated vocal behaviour is closer between parrots and humans than parrots with songbirds," says Erich Jarvis at The Rockefeller University in New York.

Other skilled mimics may have similar vocal maps in their brains, suggests Long: "My very strong guess would be that other parrots have the same feature, but it simply hasn't been explored."

Long hopes that studying how budgies generate their sounds will help us understand speech disorders in people. "Now we have a fighting chance of understanding what I think is at the root of many communication disorders that affect people in devastating ways." ▮

Chemistry

Water can turn into a superacid that makes diamonds

WATER may transform into a superacidic fluid under extreme conditions found only in Earth's interior, within icy planets like Uranus and Neptune – and possibly in controlled laboratory experiments.

"Under immense pressures and temperatures, water exhibits a remarkable property – it becomes an exceptionally potent acid, also known as a 'superacid', which can be billions or even trillions of times stronger than sulphuric acid," says Flavio Siro Brigiano at Sorbonne University in France.

This superacid transformation appears to occur at temperatures between 1727°C and 2727°C and at intense pressures of 22 to 69 gigapascals. For comparison, 2727°C is the temperature of sunspots on the sun's surface, and 50 gigapascals would correspond to "having 100 elephants standing on the tip of your finger", says Siro Brigiano.

He and his colleagues made this discovery using computer simulations that model the motions of atoms and chemical reactions. They also trained a machine learning model on the simulation results and used it to perform additional calculations in a more computationally efficient way.

The simulations also showed how, under the same extreme conditions, superacidic water can turn hydrocarbon molecules such as methane into diamond-like structures such as methanium,

"Under immense pressures and temperatures, water becomes an exceptionally potent acid"

a chemical transformation previously studied in other superacid solutions (*arXiv*, doi.org/pc9w).

This may explain earlier research suggesting icy giant planets, including Uranus and Neptune, experience diamond rain, says coauthor Arthur France-Lanord at the French National Centre for Scientific Research. He and his colleagues are now exploring ways to collect direct experimental evidence for water's superacid chemistry, at lower pressures and temperatures – perhaps enabling more practical applications. ▮

Jeremy Hsu

Space

Giant galaxy is surprisingly old

Its discovery could change our ideas of how galaxies formed and evolved

James Woodford

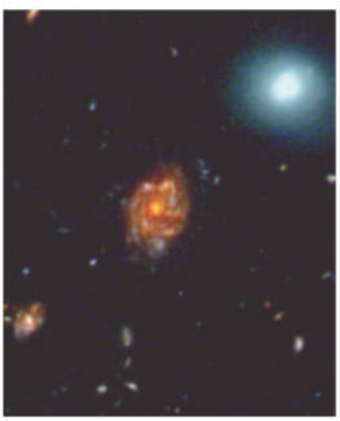
A NEWLY found spiral galaxy, dubbed the Big Wheel, formed just 2 billion years after the big bang – far earlier, considering its size, than astronomers thought likely.

Themiya Nanayakkara at Swinburne University of Technology in Melbourne, Australia, says the discovery was an accident.

He and his colleagues were looking for quasars – energetic regions at the heart of some galaxies – with the James Webb Space Telescope in November 2022 when a "large spiral galaxy popped up".

"It was a nice, beautiful spiral galaxy, but we didn't really realise the significance of it at first," says Nanayakkara.

However, after analysing the light from the galaxy to determine its redshift – a measure of how fast an object is moving away from us in space, which is related to its distance from us and its age – the researchers discovered they were seeing the Big Wheel as it was just 2 billion years after the big bang (*Nature Astronomy*, doi.org/pcxn).



WEICHEN WANG

The Big Wheel is a spiral galaxy like the Milky Way

More surprisingly, the galaxy is almost 98,000 light years across, just shy of the Milky Way's diameter of 100,000 light years. The Big Wheel is also only one order of magnitude less massive than our galaxy, at one hundred billion solar masses rather than 1 trillion.

"But you have to remember that the Milky Way has had another 10 billion years or so to grow than the Big Wheel," says Nanayakkara. While the newly spied object isn't the oldest spiral galaxy we know of, it is certainly the largest for its age – and it is now likely to be far larger than the Milky Way, as we are seeing it as it looked 10 to 12 billion years ago, he says.

According to our current understanding of the early universe, the development of such a large spiral galaxy this early on isn't impossible, but it was thought unlikely, says Nanayakkara.

He suggests that it may have been caused by multiple galaxies colliding and merging at a fast rate, or by cold gas from the universe accreting into the galaxy.

"Finding one of these galaxies is not a problem for cosmological theories, because one could be an outlier, but if we keep finding more, then I think we may have to say 'OK, our models might need some refining'," says Nanayakkara.

Geraint Lewis at the University of Sydney in Australia says the most important aspect of the discovery is that disc galaxies like our own Milky Way must have grown very quickly in the early universe.

"This galaxy, the Big Wheel, stretches this problem further, being a rather chunky disc galaxy, almost as large as our Milky Way today," he says.

However, "one big question remains: how rare are galaxies like the Big Wheel? We expect them to be quite rare, but if future observations throw up more examples, we will have to go back to the drawing board for our ideas of galaxy formation and evolution", says Lewis. ▮

Zoology

Monkeys prefer experienced babysitters

SNUB-NOSED monkey mums are picky when choosing a caregiver, permitting experienced females to look after their infants more often than young and inexperienced ones.

Many primates rely on the help of others when raising their offspring. Now, an accidental discovery by Chun-Yan Cui at the Southwest Forestry University in China and her colleagues has revealed that a group of black-and-white snub-nosed monkeys (*Rhinopithecus bieti*) in the Baimaxueshan National Nature Reserve in southern China also share caregiving.

"During the breeding season, we noticed newborns being passed around for grooming, carrying and even nursing by non-maternal individuals," says Cui. "This reminded us of similar roles in human society, like babysitters, and sparked our curiosity."

They followed the group of monkeys every day for six months during the birth season, recording 416 instances in which a female interacted with a mother and her newborn. The researchers also noted the age and reproductive experience of the female, how the mother responded and how many times the infant was passed around.

They found that mothers were more permissive of caregiving attempts by females who already had multiple offspring, and were more willing to accept this help as their infant got older.

However, the young and inexperienced females still got their turn to care for the infant, typically after a more experienced monkey finished her babysitting duties (*American Journal of Primatology*, doi.org/pcv4). More research is needed to understand if this pattern of infant transfer may vary depending on social rank or kinship, says Cui.

But Iulia Bădescu at the University of Montreal in Canada says it is hard to know which behaviours signal an intention to handle an infant. "We don't know for sure if they're going through a decision-making process," she says. ▮

Sophie Berdugo

TIM PLOWDEN/ALAMY

An adult female snub-nosed monkey holds her infant close

Tattoos are being linked to some cancers. Are they really a risk?

Having a tattoo has been associated with a higher incidence of conditions like lymphoma and skin cancer, but the situation isn't clear-cut, finds **Jasmin Fox-Skelly**

WHETHER it is a butterfly on your ankle or your football team's logo across your back, tattoos have long been seen as a way of expressing individuality, as well as sometimes having cultural significance. Yet research is just starting to scratch the surface of their potential health effects.

Tattoo pigments are made up of numerous chemicals. In the European Union, the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation has set concentration limits for around 4000 compounds in such pigments, mostly due to cancer concerns. But some of these are legal at higher levels in other parts of Europe and the US.

"This is a difficult area to study because there are lots of different possible ingredients in tattoo ink," says Rachel Orritt at Cancer Research UK.

However, scientists have tried to do so recently. In October last year, an analysis of green and blue inks sold across Europe found that nine out of 10 weren't compliant with REACH and four had banned compounds (*Analyst*, doi.org/pcwx). "'Are tattoos safe?' is something I get asked a lot," says team member John Swierk at Binghamton University in New York. "The problem we have is if we don't know what's going into the tattoo, we can't begin to answer that question."

These pigments also don't just stay near the skin's surface. "What happens is that the immune system gets triggered, as it recognises something foreign," says Christel Nielsen at Lund University in Sweden. Immune cells called macrophages then pick up the pigments and carry them to lymph nodes, perhaps to try to clear them from the body. Doctors even misdiagnosed a tattooed man with advanced cancer when they thought his black lymph nodes were a sign of the condition.

THOMAS M. BARWICK INC/GETTY IMAGES

Tattoos are drawn with inks made from many different chemicals

"We know that ink makes its way to the lymph nodes and we know that there are potentially toxic chemicals in the ink," says Nielsen. To understand the possible effects of this, she and her team looked at just under 1400 people, aged between 20 and 60, in Sweden who had been diagnosed with lymphoma – cancer of the lymphatic system, including the lymph nodes – within the past decade. They compared this group with nearly 4200 cancer-free individuals matched by age, sex and socioeconomic backgrounds.

The results, also published in 2024, show that the people with a tattoo were 20 per cent more likely to develop any type of lymphoma than those without one (*eClinical Medicine*, doi.org/gtv4h2).

Perhaps surprisingly, individuals who opted for laser removal of a tattoo were almost three times more at risk of the condition than their untattooed counterparts. "The laser fragments the [tattoo] molecules, making them smaller so that they can be removed via the lymphatic system, but that process also makes the chemicals more reactive and potentially more toxic," says Nielsen.

The researchers didn't find evidence that coloured or uncoloured ink is more linked to lymphoma, or that the risk accumulates with having multiple tattoos. But Nielsen says the study may have been too small to capture any such associations.

> **"This is a difficult area to study because there are lots of different possible ingredients in tattoo ink"**

Nevertheless, she stresses that the individual risk is probably low. "Lymphoma is still a rare disease, with about 300 people diagnosed in Sweden every year out of a population of 10 million," she says. "Our estimates apply on [a] group level, and can[not] and should not be interpreted as individual risks, because we are all different and the risk estimate is somewhat of an average."

Nielsen's results have been supported by a more recent study, in which Signe Clemmensen at the University of Southern Denmark and her colleagues looked at 158 pairs of twins, at least one of whom had been diagnosed with certain cancers, namely lymphoma or skin cancer.

They too found a link between lymphoma and tattoos, but their work suggests that size may matter. Having a tattoo that is larger than a typical palm was linked to triple the rate of developing lymphoma and an approximate doubling in the rate of skin cancer, compared with having no tattoos (*BMC Public Health*, doi.org/g86xv4).

But regardless of tattoo size, the rate of skin cancer was still 60 per cent higher among tattooed individuals. "We think one of these mechanisms is that [tattooing] causes a chronic immune response, because the immune system is constantly trying to do something to this foreign body, and when the immune system is constantly on alert, it will lead to an increased risk of abnormal cell proliferation," says Clemmensen.

While the scientists are concerned, they also stress that the link between tattoos and cancer is far from cut and dried. "More studies are needed before we can establish a causal link," says Nielsen, who has tattoos herself. These may include cell or animal research and larger observational studies in multiple countries.

In the meantime, Clemmensen doesn't think people should be unduly put off getting inked. "What I would say to someone with a tattoo or perhaps considering getting a tattoo, is that it's not something they should be overly concerned about yet," she says. ▮

Palaeontology

Two-fingered dinosaur had massive claws

James Woodford

MASATO HATTORI

***Duonychus* used its huge claws to strip leaves from trees**

A NEW species of dinosaur found at a Mongolian building site has the largest fully preserved claw ever discovered. The bipedal, herbivorous animal had only two fingers on each hand, which it may have used to grasp branches and pull them towards its mouth.

The 90-million-year-old fossil – which included parts of the pelvis, both arms and hands, and many vertebrae – was found near Khanbogd in the Gobi desert in 2012, but it has only now been properly studied and given the scientific name *Duonychus tsogtbaatari*. The genus name means "two claws" and the species name honours palaeontologist Khishigjav Tsogtbaatar.

Duonychus is a smaller relative of *Therizinosaurus*, which features in the film *Jurassic World: Dominion*. Yoshitsugu Kobayashi at Hokkaido University in Japan and his colleagues estimate the dinosaur would have been around 3 metres long and weighed about 270 kilograms (*iScience*, DOI: 10.1016/j.isci.2025.112141).

"The discovery of *Duonychus tsogtbaatari* is a big deal because it's the first known therizinosaur with only two fingers," says Kobayashi. "Most theropods, including other therizinosaurs, kept three functional fingers, so finding one that lost a digit is pretty unexpected."

Duonychus's claws are nearly 30 centimetres long. Unusually, the claw sheaths – made of keratin, the same material as our fingernails – have been preserved.

"Keratin usually doesn't fossilise. It decays long before bones do," says Kobayashi. "Most of the time, when we find dinosaur claws, we're only looking at the bony core. But in life, the actual claw would have been covered in a thick keratin sheath, making it longer and more curved."

"This is the largest fully preserved 3D dinosaur claw found, by far," says team member Darla Zelenitsky at the University of Calgary, Canada.

The researchers think the claws were an adaptation for grabbing and pulling down vegetation. With fewer fingers, each one could be stronger and more flexible, allowing for a tighter, more controlled grip, says Kobayashi.

"The curved claws and extreme flexion suggest it could hook onto branches or clusters of leaves more easily," he says. "Three fingers might have just gotten in the way, while two provided a more precise and efficient grasp." ▮

Space

Weird meteorite may be relic of lost planet

Alex Wilkins

MISFIT meteorites that don't fit neatly into known categories could be relics from a Mercury-like world that was destroyed early in the history of the solar system.

Most asteroids that fall to Earth as meteorites can be grouped together and have common origins, with many derived from larger asteroids, the moon or Mars. But around 0.2 per cent of meteorites are outliers, resisting any neat categorisation.

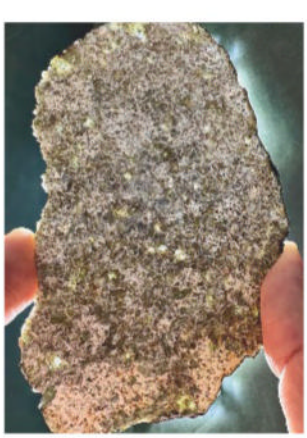
Now, Jennifer Mitchell at the University of Minnesota and her colleagues think that one of these meteorites, found in north-west Africa in 2023 and called NWA 15915, has a geological signature suggesting it came from a Mercury-like world that no longer exists.

When Mitchell and her team analysed the meteorite with an electron microscope and spectroscopic instruments, they found it had a composition distinct from that of Mercury, but that it nevertheless formed in a Mercury-like setting.

For instance, the minerals in the meteorite had formed in an environment with little oxygen – which is similar to the environment in which Mercury was born.

NWA 15915 also had a unique mixture of metal-rich minerals with magnetic properties that suggested a Mercury-like origin, and the mineral crystals in the meteorite were relatively large, which indicates that the rock cooled slowly – again inviting similarities with Mercury.

Meteorite NWA 15915 was found in north-west Africa in 2023



STEVE JURVETSON/WIKIMEDIA

"The meteorite had a unique mixture of metal-rich minerals with magnetic properties"

"This is all suggestive of a large, differentiated body that might have been quite Mercury-like," Mitchell told the Lunar and Planetary Sciences Conference in The Woodlands, Texas, earlier this month.

Mitchell also presented a second misfit meteorite that she and her colleagues had been analysing, called Ksar Ghilane 022. It has similar characteristics, though different magnetic properties, that indicate it could also have come from a Mercury-like body. However, Mitchell emphasised that both of these investigations are at an early stage and it is difficult to make firm conclusions.

"If confirmed, it's quite an exciting result," says Saverio Cambioni at the Massachusetts Institute of Technology. There are some metal-rich asteroids in the solar system's asteroid belt today whose formation we struggle to understand, which meteorites samples like these could also shed light on, he adds. ▮

Recounting the world population

A new way of estimating rural populations means there could be far more people on Earth than we think, finds **Chris Stokel-Walker**

OUR assessments of rural populations have systematically underestimated the actual number of people living in these regions by at least half, researchers claim – with potentially huge impacts on global population records and planning for public services. However, the findings are disputed by demographers, who say any such underestimates are unlikely to alter national or global head counts.

Josias Láng-Ritter and his colleagues at Aalto University, Finland, were endeavouring to understand the extent to which dam construction projects caused people to be resettled, but while estimating populations, they kept getting vastly different numbers to official statistics.

To investigate, they used data on 307 dam projects in 35 countries, including China, Brazil, Australia and Poland, all completed between 1980 and 2010, taking the number of people reported as resettled in each case as the population in that area prior to displacement.

They then cross-checked these numbers against five major population datasets that break down areas into a grid of squares and estimate the number of people living in each square to arrive at totals.

Láng-Ritter and his colleagues found what they say are clear discrepancies. According to their analysis, the most accurate estimates undercounted the real number of people by 53 per cent on average, while the worst example was 84 per cent adrift (*Nature Communications*, doi.org/g88s9t). "We were very surprised to see how large this underrepresentation is," he says.

While the official UN estimate for the global population is around 8.2 billion, Láng-Ritter says their analysis shows it is probably much higher, though he declined to give a specific figure. "We can say that nowadays, population estimates are likely conservative accounting, and we have reason to believe there are significantly more than these 8 billion people," he says.

SHUTTERSTOCK/MACIEJ DUBEL

A meadow in the countryside town of Zakopane in Poland

Error message

The team suggests these counting errors occur because census data in rural areas is often incomplete or unreliable and population estimation methods have historically been designed for best accuracy in urban areas.

Correcting these systematic biases is important to ensure rural communities avoid inequalities, the researchers suggest. This could be done by improving censuses in such areas and recalibrating population models.

If rural population estimates are way off, that could have massive ramifications for the delivery of government services and planning, says Láng-Ritter. "The impacts may be quite huge, because these datasets are used for very many different kinds of actions," he explains. This includes planning transport infrastructure, building healthcare facilities and risk-reduction efforts in natural disasters and epidemics.

But not everyone is convinced there is a big problem. "The study suggests that regional population counts of where people are living within countries have been estimated incorrectly, though it is less clear that this would necessarily imply that national estimates of the country are wrong," says Martin Kolk at Stockholm University, Sweden.

Andrew Tatem at the University of Southampton, UK, oversees WorldPop, one of the datasets that the study suggests was undercounting populations by 53 per cent. He says that grid-level population estimates are based on combining higher-level census estimates with satellite data and modelling, and that the quality of satellite imagery before 2010 is known to make such estimates inaccurate. "The further you go back in time, the more those problems come about," he says.

"We have reason to believe that there are significantly more than 8 billion people"

"I think that's something that's well understood."

Láng-Ritter thinks that data quality is still an issue, hence the need for new methods. "It is very unlikely that the data has improved so dramatically within 2010-2020 that the issues we identified are fully solved," he says.

Stuart Gietel-Basten at the Hong Kong University of Science and Technology points out that the majority of the team's data comes from China and other parts of Asia, and may not be globally applicable. "I think it's a very big jump to state that there is a great undercount in places like Finland, Australia, Sweden, etc, and other places with very sophisticated registration systems, based on one or two data points."

Láng-Ritter acknowledges this limitation, but stands by the work. "Since the countries that we looked at are so different, and also the rural areas that we investigated have very different properties, we're quite confident that it gives a representative sample for the whole globe."

Despite some reservations, Gietel-Basten agrees with Láng-Ritter on one point. "I certainly agree with the conclusions that we should both invest more in data collection in rural areas as well as coming up with more innovative ways of counting people," he says.

But any suggestion the official world population figure should rise by a few billion "is not realistic", says Gietel-Basten. Tatem also requires much more convincing. "If we really are undercounting by that massive amount, it's a massive news story and goes against all the years of thousands of other datasets," he says. ▮

Solar system

Could this be a sign of life on Mars?

New evidence suggests that rock markings are most likely caused by ancient microbial activity

Alex Wilkins

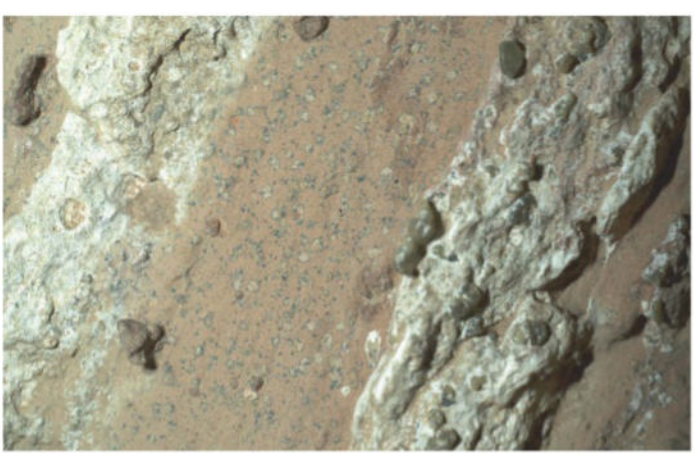
SCIENTISTS say marks found on Martian rocks could have been caused by ancient microbes.

Last year, while exploring an ancient lakebed called Bright Angel in Mars's Jezero crater, NASA's Perseverance rover discovered a rock with unusual markings – called "leopard spots" and "poppy seeds" – similar to patterns associated with microbes on Earth. The leopard spots, which are millimetre-sized dark blots with a circular rim, and the poppy seeds, which are smaller dark blotches, were sandwiched between white reams of calcium sulphate, a mineral that typically forms in the presence of water.

On Earth, similar marks are typically associated with the fossilised activity of microbes. That is because the chemical reactions that produce them also generate energy, and these processes, called reduction and oxidisation (redox) reactions, are an essential fuel source for microbes. Such redox reactions often leave behind telltale chemical signs, such as iron and sulphur in "reduced form", meaning they have lost electrons.

Now, Joel Hurowitz at Stony Brook University in New York state and his colleagues have used Perserverance's onboard instruments to work out the chemical composition of the spots on Mars. The poppy seeds showed iron phosphate, with reduced iron, and the leopard spots showed reduced iron, as well as iron sulphide with sulphur in a reduced form. The rock around the spots also contained iron in an oxidised form, suggesting that redox reactions had indeed taken place.

"Leopard spot" and "poppy seed" markings point to microbe activity



NASA/JPL-CALTECH/MSSS

There are only two ways that we know of to produce minerals with reduced sulphur on Earth, said Michael Tice at Texas A&M University, who with Hurowitz presented their work at the Lunar and Planetary Science Conference in The Woodlands, Texas, on 12 March. The first, which can happen without the presence of microbial life, happens over thousands to millions of years and typically needs temperatures to rise above 120°C (250°F). The second, a different chemical reaction related to microbes, can take place at lower temperatures.

If the Martian rocks had been subjected to extremely high temperatures, then they should have shown relatively large crystals that would have formed from melting and resolidifying. But Hurowitz and his colleagues couldn't see evidence of this.

"The only mechanism that we know of now is biologically mediated," said Tice. However, he added that, when the biological reaction takes place on Earth, we normally see additional chemical features, such as large crystals of dolomite, a mineral made from calcium magnesium carbonate. These features seem to be missing from the Martian sample. Thus, said Hurowitz, we will need to analyse rock samples collected by Perseverance, which are due to be returned to Earth in the 2030s.

Though the evidence still has a lot of uncertainty, the way these minerals are interacting chemically is unlike anything else we have found on Mars, says Janice Bishop at the SETI Institute. ▮

Health

Microdosing LSD is not an effective ADHD treatment

TAKING small, repeated doses of the psychedelic drug LSD doesn't alleviate ADHD symptoms any more than a placebo.

Microdosing psychedelic drugs involves taking them a few times a week in small enough doses to not experience hallucinations. Some research has shown that people who microdose to treat ADHD report symptoms improving, but these studies were observational and relied on self-reported data.

To test this effect more rigorously, Matthias Liechti at the University of Basel in Switzerland and his colleagues conducted the first ever randomised controlled trial of LSD microdosing for ADHD. They recruited 53 adults from the Netherlands and Switzerland who were diagnosed with ADHD and experienced moderate to severe symptoms. Twenty-seven of the participants took a 20-microgram dose of LSD twice a week – about a fifth of a standard dose – while the rest were given a placebo.

ADHD symptoms were assessed at the start of the study and six weeks later using a 54-point scale, where higher scores indicated more severe symptoms. On average, scores decreased by about 7 points in those taking LSD and nearly 9 points in those given a placebo, but this isn't a significant difference, says Liechti (*JAMA Psychiatry*, doi.org/pcn7). However, it could be that the dosage wasn't right for treating ADHD, he says. LSD may also need to be taken daily to experience a decrease in symptoms, says Conor Murray at the University of California, Los Angeles.

"Some studies have shown that people who microdose to treat ADHD report symptoms improving"

"We still need to see whether an acute dose – meaning while the drug is in your body – does that have any reduction in symptoms?" says Murray. "And if it doesn't, then you almost don't even have to ask whether there is any enduring change." ▮

Grace Wade

Will we soon be able to charge electric cars in minutes?

Chinese automaker BYD has unveiled a speedy new charger, but not everyone will be able to use it, finds **Jeremy Hsu**

CHINESE car firm BYD has announced that its newest ultra-fast charger can refresh electric vehicle batteries in nearly as little time as it takes to fill a petrol tank. While this is good news for electric car owners in China, the chargers are unlikely to be available internationally in the immediate future.

BYD, the world's largest electric vehicle manufacturer, says its new charger – known as the Super E-Platform – can deliver up to 1000 kilowatts of charging power, restoring up to a 400-kilometre range to a battery within 5 minutes. By comparison, fast charging stations in the US and the UK, such as Tesla superchargers, typically top out at around 350 or 400 kilowatts, taking 15 minutes to add roughly 300 kilometres of range.

"Public charging is a significant pain point holding back electric vehicle sales – and one consumer frustration is that even fast charging isn't nearly as fast as filling up with gasoline," says Elaine Buckberg at Harvard University. "Thousand-kilowatt chargers have the potential to change that."

Ultra-fast charging technology could have a notable impact in China, which is the world's largest automotive market and has the largest number of electric vehicles.

Unlike most US and UK electric vehicle owners, who have the option to charge at home, China's urban populations have relatively limited home charging access. Instead, they rely more heavily on extensive public charging infrastructure.

But not every electric car will be able to take advantage of ultra-fast charging stations, says Gil Tal at the University of California, Davis. Electric vehicles would need to have the appropriate battery chemistry and plug-in connector compatibility to accept the stations' maximum charging speeds, he says.

BYD didn't respond to a request for comment on which electric vehicle models could make the most of its ultra-fast chargers.

No battery charger can deliver top charging power and speeds all the time, says Tal, because charging stations usually achieve peak power and maximum charging speeds for only a very short time – often just seconds. The charging process typically also slows down as an electric vehicle battery gets more fully charged.

Ultra-fast chargers also require more power, which means they need liquid cooling to prevent overheating and much larger physical cables, says Tal. Widely deploying such power-hungry chargers along major roads would require utility companies to install more power transformers and substations, says Buckberg.

BYD has said it plans to eventually install 4000 such stations in China, but it hasn't commented on the possibility of international installations. Meanwhile, the US government under President Donald Trump has suspended a $5 billion federal programme intended to fund state efforts to install half a million high-speed chargers by 2030.

Beyond the convenience factor for drivers, ultra-fast chargers could also enable charging stations to service more electric vehicles more quickly with the same amount of available power, says Tal. But he says BYD's technology most likely represents the extreme upper limit of fast charging options in the future. Tal also points out that many drivers will accept a half-hour charging process, for instance, if they spend that time shopping at a local wholesale or grocery store.

"In the future, we will see a more sophisticated market and you will be able to pay more for very fast charging or pay less for a little bit slower," he says. ▮

5

How many minutes the new charger takes to restore 400 kilometres of range

China's urban population relies on public charging points

COSTFOTO/NURPHOTO VIA GETTY IMAGES

Quantum satellite sets globe-spanning distance record

A SMALL quantum satellite created a secure link between ground stations in China and South Africa, sharing quantum-encrypted data over a record-breaking 12,900 kilometres.

This feat, which occurred in October 2024, was also notable for using a satellite with a small, light payload – a crucial consideration for space launches. The equipment aboard the Jinan-1 microsatellite weighed just 23 kilograms, about 10 times less than the payload of a previous experiment.

Petite quantum satellites enable "the possibility to launch many satellites in one shot with the same space launcher, similar to what SpaceX is doing with Starlink for the internet", says Laurent de Forges de Parny at Thales Alenia Space, a space technology company headquartered in France.

In this experiment, researchers used the quantum states of photons to produce secret keys for encrypting and decrypting data. The keys were used to encode images – photos of China's Great Wall and South Africa's Stellenbosch University – and then transmitted between the satellite and various ground stations using lasers and telescopes. The team, led by Jianwei Pan at the University of Science and Technology of China, performed this quantum key distribution process 20 times, including the record-setting test (*Nature*, doi.org/g883x6).

However, this method has its limits. The Jinan-1 satellite "seems optimised for quantum key distribution, and is not going to perform more general quantum communication tasks like teleportation, or entanglement distribution", says Alexander Ling at the National University of Singapore. Nevertheless, he says it could become a part of real communication networks within a decade. ▮ **JH**

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Comment

(Urban) jungle explorers

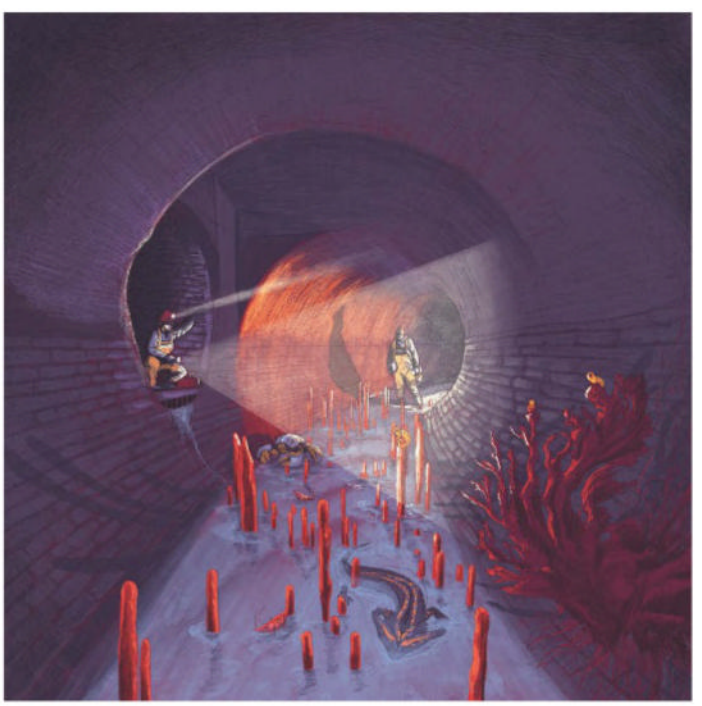
By opening their eyes to distinctive but overlooked urban habitats, city dwellers can reconnect with nature, says **Menno Schilthuizen**

THOUSANDS of kilometres of creepy catacombs under the city of Odessa, Ukraine; derelict strips of brambles along railway lines in Amsterdam in the Netherlands; stacks of dead leaves piled around street-side trees in Baltimore, Maryland; vacant lots in inner-city Beijing; slimy greenish-grey films in a Parisian gutter; a lawn of astroturf in front of a Melbourne office building...

City dwellers pass places like these on a daily basis – and look away in disgust or indifference. When talking about urban nature, such unsightly spots aren't what comes to mind – we think instead of pleasant city parks or grandiose urban rewilding projects. And yet, real ecosystems are everywhere in the city, from the gutters to the rooftops and right under our feet. They are uniquely urban, with a yet-uncharted natural history, begging to be studied by a new band of community scientists.

Cities are where all manner of human environmental effects coalesce. Pollution from chemicals, plastic waste, noise and artificial light; roads and roadkill; the urban heat island; impervious surfaces made of concrete, glass, and brick; trade that brings in exotic species – all conspire to create urban landscapes that are, ecologically, completely different from natural habitats.

But all these novel urban environments are real biotopes in their own right, biologically as exciting as rainforests, mountaintops and oceanic islands, with unprecedented ecological communities biologists are only just starting to uncover.



SIMONE ROTELLA

Algae and microorganisms in street gutters are unique mixes of species tolerant of heat and pollution. In the sewers and catacombs under cities live invertebrates akin to cave organisms. Forgotten, isolated patches of inner-city vegetation may hide species driven to extinction elsewhere. And artificial lawns turn out to be ideal places for wildflower seedlings to sprout and live together.

There is also brand-new animal behaviour to be observed. In Japan, carrion crows use traffic to crack walnuts on pedestrian crossings. In the Netherlands, lesser black-backed gulls roast invasive crayfish on hot tin roofs. Sulfur-crested cockatoos in Sydney have figured out how to open garbage bins.

And there is real, rapid evolution, from city snails evolving paler shells in which their bodies stay cooler – thus resisting the urban heat island – to lizards that evolve feet with better grip on slippery human-made surfaces.

Even completely new species can be found in cities. In Salt Lake City, Utah, incessant gardening created a new biotope for a previously unknown ant species. And in the catacombs of Odessa, urban spelunkers discovered a new species of underground shrimp.

The city is thus the next frontier for biological exploration. It is a completely new ecosystem, rapidly expanding all over the world, and created by the actions of a single species, *Homo sapiens*, a biological phenomenon unprecedented in the history of life on Earth. And city dwellers are watching it all happen.

The time is right: the open science revolution has made scientific literature, software and data accessible to all. Universities offer massive open online courses for anyone to obtain academic-level biology and ecology training. Community labs and nature clubs give their members access to kitchen-counter DNA kits and microscopes.

Everything is in place for community scientists to discover the new, unstudied biological phenomena all around them in the cities where they live. It may be a way out for all those urbanites who feel they have become disconnected from nature. By opening their eyes to the uncharted habitats in their own street, living in the city can become a delight again. ▮

Menno Schilthuizen is the author of *The Urban Naturalist: How to make the city your scientific playground*

No planet B

Pee-cycling: the sequel

From useful nutrients like nitrogen and phosphorus to cellulose and plastic-like materials, there is treasure to be mined in our sewage, says **Graham Lawton**

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

Graham's week

What I'm reading
Inanna*, a novel by former* New Scientist *editor Emily H. Wilson.*

What I'm watching
Adolescence *on Netflix.*

What I'm working on
I've been doing a deep dive into the fascinating world of the small intestine.

This column appears monthly. Up next week: Annalee Newitz

MANY years ago, I wrote a feature for *New Scientist* about an innovation in waste-water treatment called urine-separation toilets, which, at the time, looked like becoming a desirable accessory for the eco-conscious. To cut a long story short, the Western habit of flushing urine away using clean water then separating it out again in sewage plants is extremely wasteful. Toilets that collect undiluted urine separately and send it off for processing into fertiliser save large amounts of energy and water. We punningly dubbed it "pee-cycling".

Urine separation didn't really get off the ground, and I must admit I had forgotten all about it. That is until I read a review paper in the journal *Nature Sustainability* called "Pathways to advanced resource recovery from sewage" and discovered that urine separation is alive and well – along with other ways to recover useful compounds from sewage.

Traditional waste-water treatment focuses primarily on pollution control. Waste water in the form of toilet effluent (known as yellow water and black water) plus grey water from washing machines, baths, showers and sinks enters the system and is cleaned up to drinking water standards. Organic matter is mainly converted into carbon dioxide and nitrogen and vented to the atmosphere, while non-biodegradable material settles out as solid sludge and is sent to landfill or incinerated. This model has performed well in terms of preventing waterborne diseases and protecting the aquatic environment, the authors say, but it is extremely wasteful.

In recent years, however, a paradigm shift has taken place. Instead of seeing sewage as a waste stream to be managed, it is being re-envisioned as a resource from which valuable products can be extracted. The technology now exists to largely circularise the waste-water system such that every bit of it is reused: sewage treatment plants are increasingly seen not as waste facilities but as chemical factories.

The first step on the journey to sewage circularity is already here, in the form of what the industry calls NEW factories, where NEW stands for nutrients, energy and water. Water is the easy bit – traditional sewage treatment is already very good at turning a mixture of yellow, black and grey water into the kind we can drink. The energy side is also quite mature. Around 11 per cent of Europe's sewage treatment plants, according to the paper, use microbial digestion to convert organic material from sewage sludge into biogas, a mix of methane and CO_2. This can be burned to generate electricity and heat, both of which can be used to sustain the treatment process.

"Sewage treatment plants are increasingly being seen not as waste facilities but as chemical factories"

Recovery of nutrients, mainly nitrogen and phosphorus, is more challenging, but increasingly doable. Around 25 per cent of all phosphorus applied to agricultural land as fertiliser eventually finds its way into sewage, according to the paper's authors. If all of this were recovered and recycled, demand for phosphate rocks – a finite resource that could be depleted in as little as 70 years – would fall by 15 to 20 per cent. The best way to recover phosphate is by precipitating it out of the sludge, a method that also works for recovering nitrogen.

Water, energy and nutrients are the low-hanging fruit, and they aren't very profitable. But sewage also contains much more valuable commodities, which a few forward-thinking treatment plants are already recovering and selling.

One of those is cellulose, the main component of toilet paper. Around 35 per cent of the solid matter in sewage is cellulose, which usually ends up being buried or burned. But a few plants harvest cellulose from waste, clean it up and sell it to the construction industry. This unlikely market is already worth over $17 billion a year and its value is forecast to more than double by 2032.

The treatment of sewage also generates biodegradable plastic-like materials, notably polyhydroxyalkanoates (PHAs) and extracellular polymeric substances (EPSs), which fetch a high price. PHAs can replace polyethylene or polypropylene, while EPSs have replaced non-biodegradable polymers in fertilisers and seed coatings.

None of this is glamorous, but neither is conventional sewage treatment. As the old saying goes, where there's muck, there's brass, and we might as well make it rather than letting it all just add to our pollution problem.

Which brings me back to urine separation. Around 80 per cent of the nitrogen and 40 per cent of the phosphorus in sewage comes from urine, but these are hard to extract as urine is heavily diluted by sewage systems, comprising around 1 per cent of the total volume. There is, the authors say, "a compelling case for urine separation and nutrient recovery". Don't say I didn't tell you so. ▮

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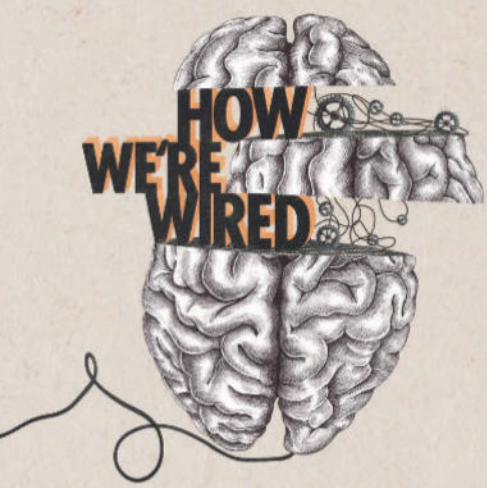

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Hidden giants

Will Burrard-Lucas / WCS

NIGHT has fallen; an elephant mother and her calf walk through Nouabalé-Ndoki National Park, which covers more than 4000 square kilometres of rainforest in the northern Republic of the Congo. This remarkable photograph of the critically endangered African forest elephants (*Loxodonta cyclotis*) was captured using a camera trap.

The image is included in photographer Will Burrard-Lucas's year-long project showcasing the park's rarely seen animals. Working with nonprofit organisation the Wildlife Conservation Society (WCS), Burrard-Lucas captured the images with a professional-grade digital camera inside a weatherproof enclosure (shown below), combined with lights and a motion-detecting trigger. "This set-up needs to be rugged and reliable, capable of withstanding extreme weather conditions and the curiosity of wildlife," says Burrard-Lucas. He consulted with WCS experts about where to place cameras, such as near trails through dense vegetation, which tend to be animal highways.

Burrard-Lucas hopes his images will help efforts to protect endangered species: "If these images inspire even a few people to learn more, visit as tourists or take action for conservation, then they have served a purpose."

Liz Else

Bridging the unbridgeable

From race and IQ to sex and gender, a book about human controversies sets out to show how our biology unites us, says **Michael Le Page**

Book

Adaptable

Herman Pontzer

Allen Lane

FANCY eating the real paleo diet? Rotten meat should be top of your menu, preferably with a generous helping of maggots. Dietary records "from every continent and climate are alive with maggots, worms and the soft, smelly flesh of decaying animals. Many groups preferred rotten meat to fresh," says evolutionary anthropologist Herman Pontzer. "The more it stank, the better."

In fact, we seem to have evolved to eat rotten meat. Our stomachs are much more acidic than most other animals, more like those of vultures than of primates and carnivores, Pontzer writes. But he dismisses the idea of a single paleo diet – our ancestors ate what they could get, which varied hugely and included a lot of carbs.

This is the least controversial part of his book. Sex and gender, IQ, skin colour, racism, sport, anti-ageing drugs, vaccines, diet, exercise and more are covered in *Adaptable: The surprising science of human diversity*.

Early on, Pontzer talks about his research in Kenya with the Daasanach community. Charity workers thought that most of their children were malnourished because they weighed less at a given height than growth charts projected. But when Pontzer's team crunched the data, it was discovered that these children grow taller faster than average. The Daasanach are just different – taller and leaner, which is likely to help them stay cool in the heat.

Just as you are wondering where Pontzer is going with this, he explains why the concept of race makes no biological sense. Skin colour varies continuously from dark to light, with no clear dividing point. If we categorised people on other traits, like height, we would end up with very different groups.

Pontzer, who has given talks at *New Scientist* events and whose work has often featured in the magazine, is especially dismissive about the use of racial categories in medicine. Any health disparities are due to the environment rather than genetics, such as the stress of racism contributing to higher rates of heart disease.

Nor do particular "races" have an advantage in certain sports, he explains. "The racial divide in swimming and track comes down to culture, environment and opportunity."

"There never was a single paleo diet – our ancestors ate what they could get, which would have varied hugely"

As for intelligence, heritability of IQ is "embarrassingly low", he says, meaning genetics is useless for predicting individual scores. It isn't possible that differences between groups are genetic, nor is there any reason to expect differences. Selection pressures for intelligence have been the same everywhere. The chances that "melanin-challenged pseudo-intellectuals coddled by modern technology hold any unique alleles for intelligence" seem remote, he writes.

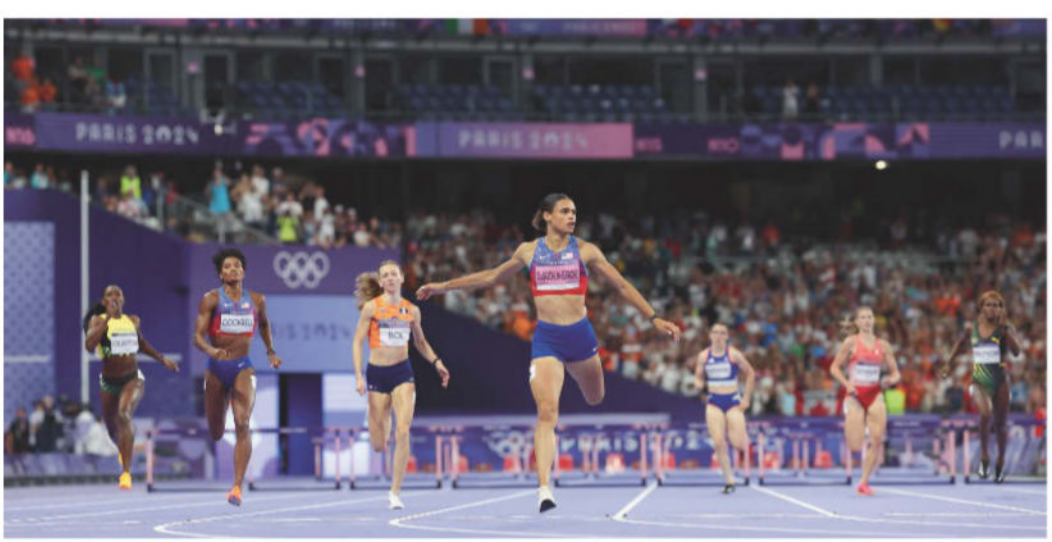
With the sexes, Pontzer uses an analogy of an island, with two mountainous peaks connected by an isthmus. The peaks seem quite separate from some perspectives; from others, there is no clear divide. To focus on one perspective and dismiss the rest isn't honest.

When it comes to the gender people identify as, the evidence suggests both hormone exposure and socialisation play a role: "All we can say... is that biology and socialisation both matter, and that neither on its own determines how we think or who we become." Advantages in size, strength and endurance conferred by higher testosterone exposure don't go away when testosterone levels fall, Pontzer writes, so trans women racing in women's categories "would promote inclusion, but at a substantial cost to fairness".

There is something for everyone to disagree with in *Adaptable*, but the fact that Pontzer has discussed these issues with people who hold a range of views shines through the book. There is a nice line of humour running through it, too.

This is an ambitious work, and especially relevant in the light of what is happening in the US. Pontzer hopes understanding ourselves better can help bridge divides. "Yes, today's societal divisions are stark but we now know they're born from cultural inventions that can change, not from unbridgeable biological differences," he writes.

Every "miraculous protein robot", as Pontzer calls us, should read the book. The less of a science fanatic you are, the more you will get out of it, but even after years of covering much of this territory for *New Scientist*, I learned a lot and greatly enjoyed the tour. ▮



The racial divide in track events is down to factors other than genetics

HANNAH PETERS/GETTY IMAGES

Getting real about truth?

While an acute analysis of the many crises we face is welcome, its proposed solution may be just too hard, finds **Graham Lawton**

Book
A Climate of Truth
Mike Berners-Lee
Cambridge University Press
UK: On sale now
US: On sale from 10 April

ARIF ALI/AFP VIA GETTY IMAGES

Pollution like the smoke seen at this garbage dump in Pakistan is part of an ongoing polycrisis

MIKE BERNERS-LEE admits he is worried about getting bad reviews for his new book, which criticises sections of the UK media for having editorial agendas effectively set by their owners. In the readable but dispiriting *A Climate of Truth: Why we need it and how to get it*, he points the finger at the BBC, Rupert Murdoch's empire, the *Daily Mail* and other titles for not caring what is true and for not having people's and the planet's best interests at heart. *New Scientist* is also in the crosshairs: it is owned by DMGT, the *Daily Mail*'s parent firm.

There is good reason for such censure, says Berners-Lee, a professor at Lancaster University, UK. It is, he writes, unrealistic to hope for an unbreachable firewall between owners and their staff – "in the end, journalists' and editors' careers depend on following the agenda of the owner".

I know something about this, and let me reassure you that, in my experience, the firewall is intact and robust at *New Scientist*. Our owners do not interfere. We are free to do our journalism as we see fit.

I bring this up not out of peevishness, nor to set the scene for a bad review, but to illustrate the central failing of this book: it demands impossible standards of flawed human beings, by which I mean all of us. But I'll get to that.

The first part of *A Climate of Truth* is a penetrating and enlightening analysis of the polycrisis – the interlinked and accelerating problems of climate breakdown, biodiversity loss, food insecurity, pollution and disease. This is a crisis of our own making and it is clearly existential. But, try as we might, and despite having the knowledge and technology to solve each part, we have been unable to slow down, let alone stop, the juggernaut.

Berners-Lee makes a cogent case that our failure is caused by fixating on solving individual elements of the polycrisis rather than the underlying causes. Things like climate breakdown and biodiversity loss are "superficial problems", he writes, underlain by deeper ones. These are dishonesty in politics, business and the media; an obsolete economic model based on GDP growth; rampant inequality; inadequate legal systems; out-of-control technology; and an education system that teaches and prizes the wrong things.

Dig deeper still and we find the core of the polycrisis: our values and the way we think. You might call it human nature, though Berners-Lee doesn't. That boils down to three things: collective disrespect for the environment, for other people and, above all, for the truth.

I can't fault his argument that the polycrisis is ultimately a product of how we think and what we value, especially our disdain for the truth. What I can fault is his recipe for solving it. In a nutshell, if only we were all more truthful, the polycrisis would evaporate.

This is arguably true. But we live in a world where President Donald Trump won the popular vote in the US last year, riding on a tsunami of lies, where Europe's worst war in almost a century is founded on blatant falsehoods, and where social media has dragged us into a cesspit of untruth. Lying is easy, largely penalty-free – and profitable.

To be fair, Berners-Lee lays out a manifesto for getting truth into the media, politics and business. It can be uplifting, and I hope I am wrong, but I think it is a hopeless task.

Which brings me back to his belief that it is unrealistic to expect an unbreachable firewall between media owners and journalists – something with which I fundamentally disagree. In Berners-Lee's utopia, getting something like this wrong means we cannot trust him on anything. Hoist by his own petard? Maybe not, but indicative of how hard his standards will be to achieve in the real world.

New Scientist *recommends*

Catherine de Lange
Editor
London

It was a bold choice to host a preview screening of **The Thinking Game**, a documentary about AI company Google DeepMind and its co-founder Demis Hassabis (pictured), in the week before International Women's Day.

Things start well. Hassabis is likeable and compelling, and the film is well-crafted with a pacy narrative. There is great archive footage of the young Hassabis and

ROCO FILMS

smart use of animation to illustrate his early life as a savant-level chess champ, drawn to his later career by a passion to understand intelligence.

It is an incredible story and a rare glimpse inside a company working on tech that will transform our lives. So for all that, I would highly recommend it. But there was one aspect that left me feeling depressed.

For a company spearheading this revolution, which claims to want to solve the biggest issues facing humanity, I was shocked by the absence of women in key roles. It was a stark reminder of how far we still have to go.

The TV column

Extraordinary visions A naturalist finds a hallucinogenic mushroom with the power to cure all ailments in *Common Side Effects*. Big Pharma is hot on his trail in this beautifully animated show, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. Follow her on X @inkerley

WARNER BROS. DISCOVERY

Marshall (voiced by Dave King) finds the amazing Blue Angel mushroom

ONE of the best shows I watched last year was *Scavengers Reign*, a lushly animated sci-fi series about an interstellar cargo ship that crashes on a planet full of strange, dangerous life. Sadly, it was cancelled after a single season. So, I was pleased to learn that one of its creators, Joseph Bennett, had partnered with writer Steve Hely on a new animated show called *Common Side Effects*, all about a Big Pharma conspiracy.

At its heart is oddball naturalist Marshall (voiced by Dave King), who protests at a public meeting of Reutical Pharmaceuticals, a megacorporation that has been dumping medical waste in the Peruvian highlands. After being thrown out, he bumps into his former classmate Frances (Emily Pendergast), the harried assistant of a Reutical executive.

Unaware of who employs her, Marshall reveals he has made an extraordinary discovery: the Blue Angel mushroom, a hallucinogen with the power to cure every ailment. The US government, insurance agencies and, most of all, Big Pharma don't want the public to know, Marshall tells her. His paranoia is justified almost immediately, with everyone from the Drug Enforcement Administration (DEA) to Reutical trying to track him down.

What's obvious from the off is that *Common Side Effects* is a beautifully made show. The animation is breathtaking but frequently ugly and violent. The hallucinations – which take each patient to a mystical realm filled with ghostly babies that explode in pops of colour – are unlike anything I have seen on TV (except perhaps in *Scavengers Reign*).

"Marshall's flawed, fragile world view is still preferable to the unfeeling profit machine at Reutical"

What isn't clear is what the show is trying to say. It condemns the cruelty of the US healthcare system, but it isn't a polemic. In fact, it is at its best when it's exploring the lesser hypocrisies of its most sympathetic character.

Once Marshall escapes his pursuers for a while, sick and injured people beg for help. He must make decisions he is usually shielded from. Who gets some of his limited supply of mushrooms? Why should one man control how this cure-all reaches the world?

The series doesn't settle for easy answers or paint Marshall as a wholly benign figure. Further on, we see how corruptible any system of distributing the mushrooms could be under the wrong cultivation. The unwanted side effects of the Blue Angel also begin to complicate matters. Its visions induce epiphanies in some and abject terror in others, especially when they appear long after the first trip.

But *Common Side Effects* isn't a smugly centrist lecture on why Marshall and Big Pharma are broadly as bad as each other. Marshall's flawed, fragile world view is still preferable to the unfeeling profit machine at Reutical. The show wonders again and again: who does such a system work for? Asking is what matters, as we realise the status quo doesn't have to endure and ossify, even if we don't yet have an alternative.

These ideas begin to solidify in the ninth instalment – a long time for a show to get its ducks in a row. But there is plenty to entertain us along the meandering way. It can be very funny, particularly when hapless DEA agents Copano and Harrington (Joseph Lee Anderson and Martha Kelly) are on screen.

Eventually, the messier elements of *Common Side Effects* do coalesce pretty much perfectly into a hopeful, humanistic show about making mistakes and how we go about healing.

TV

Common Side Effects
Joseph Bennett, Steve Hely
Channel 4 (UK); Cartoon Network, Max (US)

Bethan also recommends...

TV

Scavengers Reign
Joseph Bennett, Charles Huettner
Netflix (UK); Max (US)
Shipwrecked on a strange planet, the Demeter 227's crew must survive. Unusual inhabitants – from fish the crew wear as gas masks to a living skimming stone – make the show an instant classic.

Book

Entangled Life
Merlin Sheldrake
Penguin Random House
Merlin Sheldrake's best-selling book about the fab world of fungi is a real treat.

Editor's pick

Why a world climate court will probably fail

8 March, p 17

From Tony Green, Ipswich, Suffolk, UK

Much as I would like to see Anthony Carmona's idea of a global environmental court come to fruition, I fear the precedents suggest it would fail. We already have an International Criminal Court to prosecute war crimes and related offences, but nations that commit these often simply refuse to accept its jurisdiction. Sadly, any global environmental court will fail for exactly the same reason.

Hoping the timescape cosmos proves correct

8 March, p 26

From Ian Roselman, Leighton Buzzard, Bedfordshire, UK

Not long ago, I posed the following question to an online seminar: "The age of the universe is stated as 13.8 billion years, but in whose frame of reference is this true?"

It wasn't selected for discussion, but I know the standard answer is that time passes at the same rate on the largest scale of the universe. But does it, really? I have always thought this answer, based on the cosmological principle, too convenient, especially when stated in terms that it must be so or else we couldn't solve the equations of general relativity. I, for one, am hoping that David Wiltshire's timescape idea – which posits that time passes differently in parts of the universe, potentially resolving the problems of dark energy and the Hubble tension – will be vindicated.

From Linda Phillips, Narrogin, Western Australia

The timescape hypothesis, said to explain the apparently increasing rate of expansion of the universe by assuming that the flow of time can vary spatially across the cosmos, raises another interesting question: is time a fixed constant during the life of the universe?

If the speed of time could vary over the age of the universe and were now slowing, this would also make it seem as if the expansion of the universe is accelerating.

From John Briggs, Menith Wood, Worcestershire, UK

There are interesting links between the timescape hypothesis and an earlier article published in *New Scientist*, "The past appears to run slower" (8 July 2023, p 11). The non-linear behaviour of the deep past suggests that assumptions about the age of the universe could be erroneous.

Let's put mirror life fears to the test – safely

1 March, p 34

From Guy Cox, Sydney, Australia

Much of the worry about "mirror life" seems to be predicated on the assumption that our immune system wouldn't recognise it. I'm not convinced. But we can test this since, as your story tells us, we can already synthesise proteins with a mirror-image structure to the ones in our bodies. It would be simple enough, and totally safe, to see if these artificial proteins can elicit an immune response. If they can, maybe our fears are overblown.

Futurists really do need a clearer crystal ball

8 March, p 18

From Sam Edge, Ringwood, Hampshire, UK

Rather than just sometimes, futurism almost always prevents us from seeing what is actually coming next. No futurists predicted geosynchronous satellites, remote control mechanical manipulators, mainframe computers, handheld personal electronic assistants etc. Some current technologies – including all of my examples – were suggested by science fiction writers, but sci-fi isn't futurism.

In the 1950s, futurists claimed we would be zooming around in flying cars by the 80s. They have been claiming for the past two decades that we will be sitting in a fully autonomous car without a steering wheel within five years. Now they say that large language models are a panacea to our woes, while what this type of artificial intelligence is really doing is filling websites with hallucinations.

Frankly, if someone is described as a futurist, then their predictions are probably less likely to prove true than those of an economist.

On the search for the oldest working code

8 March, p 34

From Liz Bell, Great Shefford, Berkshire, UK

It struck me when reading your article "Hunting for the oldest code" that we may have found an excellent use for artificial intelligence. Can older coders who know the old programming languages pass their knowledge to AI systems before they depart this mortal coil? With the dependency on legacy systems you discussed, we would be very glad if they did.

From Danny Dresner, University of Manchester, UK

Matthew Sparkes's evaluation of our reliance on old code is spot on. I imagine organisations ought to think about software support agreements they are paying for, as it is likely that some companies collecting annual fees no longer have the available expertise to solve any problems arising. All code is broken. When we are lucky, it is decommissioned before the vulnerabilities manifest and are exploited.

From Geoff Sharman, Winchester, Hampshire, UK

The idea that "we're still using decades-old code" comes as no surprise to those who have worked for long-established computer firms. One example is IBM's CICS software, first released in 1969. It still supports a majority of online banking, insurance, stock trading and credit card applications, as well as applications in other industries and government, with very high reliability and performance.

The best way to think about long-lived software is to view it as essential infrastructure, akin to the Roman roads and 19th-century railways that many of us still travel on. Although they must be continuously maintained and improved, these systems use recognisably similar technology and follow the same routes. Why should software be any different?

For advantages of round buildings, look to the roof

8 March, p 14

From Catherine Gillespie, Winmalee, New South Wales, Australia

In the report on ancient building shape, there was no mention of the critical relationship between the roofs and walls. The roof of a rectangular structure provides strength to ensure the walls stay upright. Such a roof requires strong structural elements and robust materials such as timber or stone before it can be clad with other things, such as thatch.

A circular structure may well be inherently stronger, thus requiring a simpler, less structural roof that uses easily available local resources, such as reeds or palm fronds or similar, which can also be easily replaced when damaged. This may explain why the evidence of early settlements has generally revealed round buildings.

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Living in an Ozempic world

JON KRAUSE

"I become more convinced that we may look back on these drugs as the greatest medical breakthrough of the 21st century." This is how one expert reacted in January to further findings about the health benefits of drugs like Ozempic and Wegovy.

Originally used to treat diabetes, then obesity, these GLP-1 agonists – drugs that mimic a hormone that reduces hunger – are now approved to treat kidney and cardiovascular disease, and hold the promise of helping alleviate everything from addiction to Alzheimer's disease. They have already become commonplace in the US – by far the biggest market for these drugs globally, where 25,000 people now start Wegovy each week. But their use is soaring in many other countries too. Last year, Ozempic was the second best-selling drug worldwide, with sales jumping 26 per cent compared with 2023.

This new era brings a new set of questions. Take the possibility that GLP-1 treatments, as well as calming our hunger for food, may also dampen our desire for alcohol, opiates and cigarettes. Could they offer new insights into the ways the brain processes reward – and fresh ways to treat addictions and cravings? In some circles, people are attempting to tap into the benefits, side effect-free, by microdosing small amounts. But is there any evidence this actually works? And what are the upshots for our exercise regimes if we can lose weight without working out?

These drugs have the potential to change societies, not just individuals. So how might cultural attitudes towards obesity be shifted by their influence?

And today's jabs are just the start. A number of new versions of these medicines are in the pipeline, promising faster weight loss and fewer side effects. What, then, does the future hold?

Over the next eight pages, we take a deep dive into the great GLP-1 agonist boom to discover just how these drugs are reshaping the world.

WHAT DO WEIGHT-LOSS DRUGS TELL US ABOUT THE BRAIN?

"I just cannot believe how I don't crave alcohol anymore!" writes one person. Others declare: "Took my first shot… have not had a drink or cigarette since," and "I love coffee but I've noticed that I cannot finish a cup anymore."

These quotes were all collected in a recent study led by Davide Arillotta at the University of Florence, Italy, from Reddit's weight-loss forums. Here, you will find many people rhapsodising about the benefits of drugs like Wegovy and Ozempic. That these treatments are helping people curb their eating should be no surprise: that is exactly what they are meant to do, by mimicking the satiety hormone GLP-1 (see "How they work", page 32). Among the comments, however, you will frequently find reports of other – wholly unexpected – behavioural changes. According to these accounts, when taking these drugs, the urge to drink alcohol, smoke and even shop compulsively plummets (but not libido, though anecdotal reports on this subject elsewhere online are mixed). Such tales are becoming familiar to prescribing physicians.

If this anecdotal data can be supported by controlled clinical trials, it may tell us a lot about how the brain processes anticipation and reward – and could also suggest whole new ways of dealing with addiction. By targeting areas of the brain responsible for reward signals from food, GLP-1 drugs might also reduce the rewards people get from other things, such as addictive substances. But what does the current evidence show about these complex behavioural processes?

First, we need to understand how drugs like Ozempic interact with and influence the brain. In general, GLP-1 and the drugs that mimic it are too large to pass through the blood-brain barrier, but seem to be able to reach a few regions where the membrane is a little more porous. These include a region of the brainstem called the area postrema, which can generate feelings of nausea ›

when activated by GLP-1 hormones, and the hypothalamus, which is involved in controlling our energy intake and expenditure. Another pathway through which GLP-1 drugs may influence our behaviour is via the vagus nerve, which runs between the abdomen and the brain and helps regulate many bodily processes. We know that parts of the vagus nerve are sensitive to GLP-1, and changes to the activity of this nerve could have wide-reaching effects in brain areas like the mesolimbic system, which deals with reward processing.

Research into these mechanisms is still at an early stage, but, by unpicking them, we will better understand the process underlying our cravings and sense of satiety. Animal and human models suggest that the biggest effects of the new medications can be seen in mitigating the anticipation of food, rather than the pleasure derived from eating itself. "I'd say that's fairly well established," says Rodrigo Mansur at the University of Toronto. "And it's something we hear often from patients – that they are just thinking less about the next meal."

Whether these drugs can reduce other kinds of compulsion is still an open question. The anecdotal reports of a reduction in desire for alcohol and other substances are backed up by large-scale studies of medical records. For instance, an analysis last year of the records of more than 2 million people with diabetes found that GLP-1 drugs were associated with around a 10 per cent reduction in the risk of substance abuse conditions such as addiction to alcohol and opioids, compared with those taking alternative treatments.

A lot of buzz

However, this evidence comes from observational studies that show correlation rather than causation. Few stringent clinical trials – where the outcomes are compared with participants who received a placebo – have been carried out, and the findings aren't so clear cut. "Regarding the potential of these medications to treat substance abuse disorders, however, there's a lot of buzz, but very little high-quality clinical data," says Mansur.

SPL, EYEVINE

A small study from researchers at the University of North Carolina, for example, found that semaglutide (sold as Wegovy and Ozempic) reduced the cravings of people with alcohol use disorder and the amount they drank per session compared with a placebo. Another study, however, by Mette Kruse Klausen at the Psychiatric Centre Copenhagen in Denmark and her colleagues, examined the effects of the GLP-1 drug exenatide in 127 participants. They found that the it didn't significantly influence total alcohol intake, except among those participants who were also obese.

Mansur suggests that different mechanisms could underlie cravings in people with obesity and those without. Perhaps obesity and alcohol misuse are rooted in the same problem with reward processing, for instance, which exenatide was helping correct?

This fits with a greater confusion about whether the brain and mental health effects of GLP-1 drugs extend beyond the widespread benefits of weight loss. "Weight management and metabolism may indirectly impact mental health and behavioural patterns," says Arillotta. "For example, some studies showed that the reduction

12 per cent
Proportion of US adults who have used Ozempic or related drugs

How they work

Drugs such as semaglutide (sold as Wegovy for weight loss and Ozempic for diabetes), liraglutide (sold as Saxenda and Victoza) and exenatide (sold as Byetta) mimic the actions of glucagon-like peptide-1 (GLP-1). This hormone promotes the feeling of fullness, or satiety, after eating and stimulates insulin production, lowering blood sugar levels.

Overall, this means that these drugs – technically known as GLP-1 receptor agonists – reduce hunger levels, leading to reduced energy intake from food and significant weight loss for most people when used long term. Recently, a drug called tirzepatide (sold as Mounjaro and Zepbound) has also come on the market, which mimics GLP-1 plus another satiety hormone, GIP.

of systemic inflammation associated with obesity may have a range of positive effects on mood and cognitive function."

The placebo effect may also play a part in some people's improvements. "Experiencing one major positive change (such as significant weight loss) can boost overall self-confidence levels, thus making individuals feel more in control of other aspects of their lives, including addictive behaviours," says Arillotta, whose analyses of patients' reports on Reddit suggests that these positive side effects are very common.

Brain benefits?

Some reported cognitive benefits for those taking GLP-1 drugs – including a reduced risk of dementia – may also be limited to those with serious weight problems and/or type 2 diabetes. Lora Heisler at the University of Aberdeen, UK, points out that obesity is a major contributing factor to conditions like dementia, in which case reducing obesity would, in turn, cut the risk of developing dementia. "My assumption would be that the majority of the effect would be down to their generally improving health," she says.

The upshot is that we don't yet know whether GLP-1 can act as a general "anti-consumption" medication, or whether the reported effects on unhelpful cravings are mainly the result of better metabolic health. We will get a better idea through trials now under way to see if these medicines can help people quit smoking, alcohol and other drugs.

Heisler is now embarking on a new project to unravel the neural mechanisms of anti-obesity drugs in much greater detail. Such work may help refine the treatments, reducing side effects like nausea, and increase their efficacy – while also expanding our knowledge of the intricate communication between our internal organs and its effects on our behaviour. "These agents are a great opportunity to understand better the brain-body connections," says Mansur.

That these drugs could be a silver bullet to dampen problematic cravings is a tantalising prospect. Whether that is a reality, though, is yet to be proven.

David Robson

> *"RESEARCH SUGGESTS THE DRUGS MITIGATE ANTICIPATION OF FOOD, NOT PLEASURE FROM EATING*

DOES MICRODOSING WORK?

MADISON BURGESS decided to get serious about weight loss when the scale hit 91 kilograms (200 pounds). She began taking Ozempic. The medication worked better than she ever thought possible: even on the low starter dose, she lost more than 2 kg (5 lbs) within the first week.

Problems began, however, when Burgess, a 25-year-old healthcare administrator from Bloomfield, Michigan, ramped up her intake, as per the manufacturer's guidelines. "The higher doses were rough on me," she says. The constipation, nausea, diarrhoea and acid reflux hit hard and made eating difficult. That's when she decided to drop back down to a lower dose and determine whether she could continue seeing benefits.

Burgess is just one of a growing number of people who are "microdosing" – a practice more typically associated with psychedelics such as LSD and psilocybin – by taking lower-than-standard amounts of weight-loss drugs such as Wegovy and Mounjaro.

For some, the hope is to avoid side effects while losing weight, while others want to tap into the anti-inflammatory effect of these medications or reap their other benefits for the heart and the brain. Microdosing the drugs has even been touted for extending longevity by ultra-wealthy elites like tech entrepreneur Bryan Johnson, and is rumoured to be the secret weapon of Hollywood stars wanting to look svelte for photo calls.

The question is, does this off-label, low-dose experimentation work?

Medications such as Ozempic, Mounjaro and their ilk come in pre-loaded injectable pens. In conjunction with their healthcare provider, users typically follow a dosing regime that goes up. Take Wegovy. In the first month, users take a low introductory dose of 0.25 milligrams a week. This then doubles, and then doubles again until a "maintenance" dose of either 1.7 or 2.4 mg per week is achieved, which is then taken long term. These standard doses are the only strengths that have been studied in large-scale clinical trials.

For this reason, microdosing these weight-loss medications isn't approved by the US Food and Drug Administration (FDA) or by other health authorities. But that hasn't stopped people from trying it, says Ziyad Al-Aly at the Veterans Affairs St. Louis Health Care System in Missouri.

For Burgess, small doses of between 0.25 and 0.5 mg per week have been a success: she has lost 27 kg (60 lbs) and reached her goal weight without the problematic side effects. "At the lower doses, I don't have symptoms," she says. Burgess continues to take the drug to avoid regaining weight – an additional motivation for microdosing.

Taking it low

Another microdosing enthusiast, Katie Sorensen, a nurse practitioner who owns her own medical weight-loss practice in Golden, Colorado, says that low doses of tirzepatide have generally improved her quality of life. She takes 2 mg per week (the recommended starter dose is 2.5 mg) and contends that microdosing has reduced her inflammation, as evidenced by her having fewer aches and pains, given her more energy, and generally helped her choose a more wholesome diet. "Having less thoughts about food and less cravings makes it much easier to want to choose healthy foods," says Sorensen.

Al-Aly's recent study in *Nature* identified a host of health benefits in addition to weight loss for those taking the medications, including a reduced risk of substance use disorders, Alzheimer's disease, dementia, clotting disorders and many other conditions. But these were at higher doses and there is no data to show that similar results will occur in those who microdose.

"For most people, we need higher doses to see weight loss and diabetes results, but there are some ›

exceptions," says Carolynn Francavilla, an obesity physician in Denver, Colorado. The major clinical trials investigating semaglutide have found a large variability in response. Around 35 per cent of people are "super responders", achieving weight loss in excess of 20 per cent; their sensitivity to the medication may mean that it takes far less of it for them to see results.

Whether the drugs are indeed a fountain of youth remains unclear, but we do know that they can dampen inflammation. "It is plausible that microdosing could provide some [anti] inflammatory benefits ... but we just don't know yet," says Al-Aly.

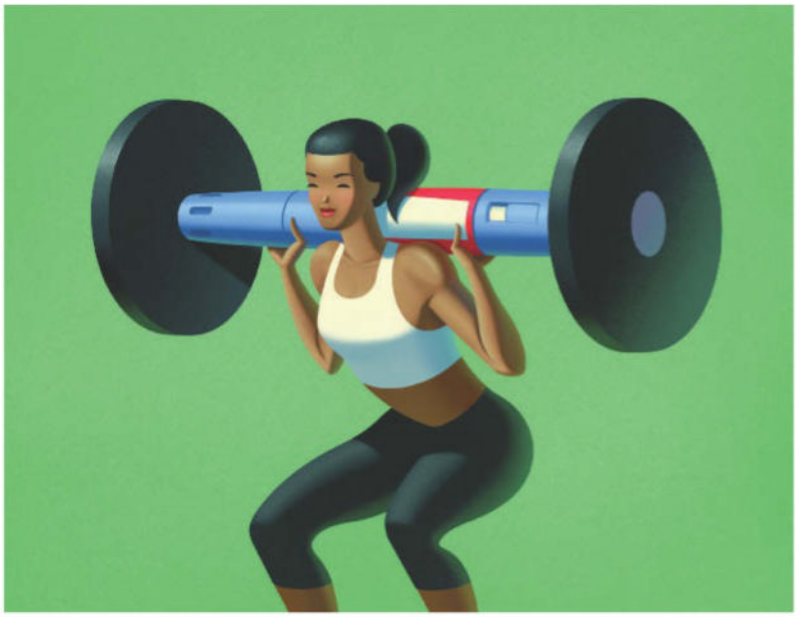
Supply shortage

Still, the medications shouldn't be taken haphazardly. "There should be a medical problem that we're improving if we're going to use the medications at any dose," says Francavilla. And it could be dangerous for some people, especially those with unresolved pancreatitis, some types of thyroid cancer and some gastrointestinal issues like gastroparesis, a condition that leads to delayed gastric emptying.

In the US, many of those who microdose source their GLP-1 drugs from compounding pharmacies. These provide custom-made medications from pharmaceutical-grade ingredients when the branded medications are in short supply. This is a cheaper option than buying Wegovy and other brands at retail pharmacies, but comes with the risk of contamination and inaccurate dosages, as these injections aren't FDA-approved for safety and quality. In the coming months, however, the compounding of semaglutide injections may become illegal in the US, as there is no longer a shortage of the brand-name versions. This will have knock-on implications for microdosers like Burgess, who had started using compounded injections rather than Ozempic in her bid to avoid regaining weight.

Still, Burgess isn't planning to stop microdosing semaglutide anytime soon. "It's a tool that helped me in my weight-loss journey," she says.

Sara Novak



JON KRAUSE

> *"MICRO-DOSING HAS EVEN BEEN TOUTED FOR EXTENDING LONGEVITY*

HOW DO WEIGHT-LOSS DRUGS AFFECT EXERCISE?

FOR decades, conventional wisdom held that, to lose weight, you must eat less and move more. Of course, that is easier said than done, which is why drugs like Wegovy are so revolutionary. By suppressing appetite, they help tackle the first part of that equation, typically leading to dramatic weight loss. But what about the second? Do we still need to hit the gym if weight-loss drugs are causing the number on the scales to drop? And what impact do these drugs have on our ability to exercise?

What is becoming clear is that exercise may be even more crucial for people who are on these medications than it is for those who aren't. The ability of semaglutide to induce rapid weight loss also leads to notable declines in muscle mass. For instance, a 2021 study of 95 people who were overweight or had obesity and were taking semaglutide found that lean body mass decreased by almost 10 per cent, on average, after 68 weeks.

Lean body mass encompasses body tissues like muscle and bone. So, these results suggest that both deteriorate when taking weight-loss drugs, says Signe Sørensen Torekov at the University of Copenhagen. Because these drugs lead people to consume fewer calories, the body must break down fat, muscle and even bone for nutrients.

"Our understanding is that up to about 40 per cent of the overall weight loss that is seen from semaglutide is thought to be potentially from the loss of muscle mass," says Grace Kulik at the University of Colorado. This effect isn't unique to weight-loss drugs, however. It also occurs during other rapid weight-loss interventions, such as highly restrictive diets and bariatric surgery [weight-loss surgery to shrink the stomach], says Torekov.

What is less clear is whether these declines in muscle mass affect muscle function and strength. One of the only studies to explore this was carried out by Kulik and her colleagues last year, when they assessed the psoas muscle, located in the lower back, in 51 people taking semaglutide. After 24 weeks of treatment, their muscle volume decreased by more than 9 per cent, on average, yet there was no significant change in muscle function. Kulik says this might be due to weight loss making certain physical activities easier.

However, more research is needed to understand the influence of these drugs

on muscle function, especially in older people, who are already prone to muscle and bone loss. As such, they may be at an even greater risk of falls when taking weight-loss medications, says Katsu Funai at the University of Utah.

The impact of these drugs on elite athletes is also under scrutiny. Last year, the World Anti-Doping Agency – the organisation that fights against drug misuse in sports – put semaglutide on its monitoring programme to track its use, as well as possible performance-enhancing effects or outcomes that endanger the health of athletes.

Despite the many unknowns, physical activity seems crucial for preventing weight regain as well, a common issue for anyone who stops using these medications. For instance, in a 2024 clinical trial by Torekov and her colleagues, 98 people with obesity took the GLP-1 drug liraglutide, and half of them also participated in a supervised exercise programme. A year after treatment stopped, those in the exercise group had regained 2.5 kilograms of weight while those only taking liraglutide regained 6 kilograms.

Muscle boost

The difference is most likely due to those in the supervised exercise group continuing some active habits after the programme ended, says Torekov. Physical activity probably helped them maintain muscle as well. "When you have a loss of muscle mass, then you automatically use less energy," says Torekov. "That also means it is even more difficult to preserve weight loss because your energy needs are lowered."

For these reasons, it is important that people on weight-loss drugs prioritise exercise where possible. Doing so will help preserve muscle and bone mass, says Torekov, who recommends that such individuals do at least 2 hours of vigorous exercise a week.

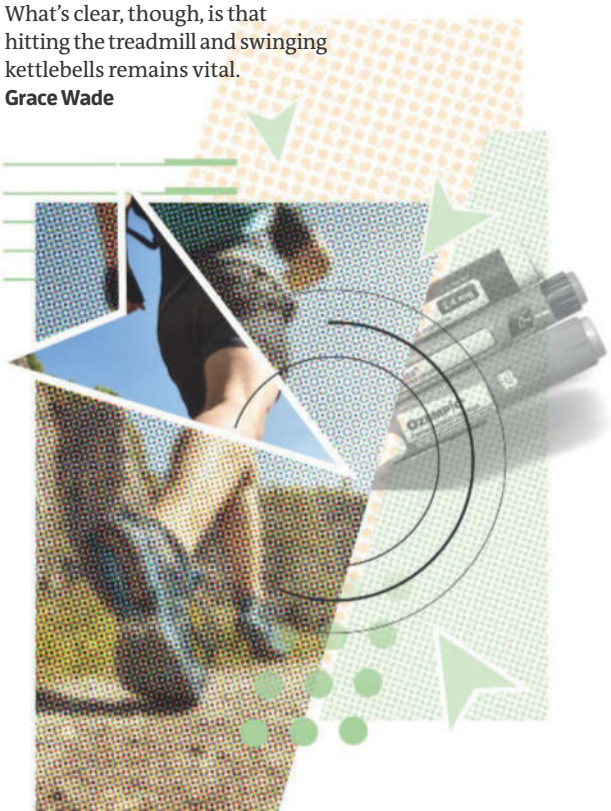
The trouble is that these medications may reduce the motivation to work out – according to studies in mice, at least. Ralph DiLeone at Yale University and his colleagues found that mice given semaglutide ran about half the distance on a running wheel as those given a placebo.

In another experiment, the wheel periodically locked up, requiring the mice to press a lever to release it. Each time the wheel jammed, it became more difficult to unlock, requiring additional lever presses. The maximum number of times mice given semaglutide pressed the lever was, on average, 25 per cent lower than those in the control group, suggesting they were less motivated to exercise, says DiLeone, who presented these findings at a Society for Neuroscience meeting in October 2024. These results may stem from side effects like nausea, which could make exercise less appealing. But they may also be due to semaglutide affecting the brain's reward pathways. Medications like Ozempic that curb food cravings may dampen other urges too, affecting our desire to exercise (see "What do weight loss drugs tell us about the brain?", page 31).

But humans are much more complex than mice, says DiLeone. For instance, research shows that people often become more physically active after rapid weight loss due to bariatric surgery, probably because they experience improved mobility and better physical function.

We might be only beginning to understand how weight-loss medications influence fitness. What's clear, though, is that hitting the treadmill and swinging kettlebells remains vital.

Grace Wade



ALAMY

> *"THE IMPACT OF WEIGHT-LOSS DRUGS ON ELITE ATHLETES IS UNDER SCRUTINY*

42

Number of conditions for which there is a lower risk for people taking GLP-1 drugs

HOW WILL THESE DRUGS CHANGE SOCIETY?

OPRAH WINFREY'S TV special *Shame, Blame and the Weight Loss Revolution* has been streamed more than 4 million times since it aired in March 2024. In it, the talk show host described Ozempic as being "the relief and support and freedom" that some people have been waiting for their whole lives.

This might have been easy for a billionaire like Winfrey to say. Weight-loss drugs can be game-changing for people who are obese, but getting hold of them is far from a level playing field, with knock-on effects for the obesity levels of the rich versus the poor. But this inequality is just one of many societal issues on the horizon. Ultra-slim beauty norms may be re-emerging, and some analysts predict changes to our collective appetite for junk food. In the era of Wegovy, we could also see an increase in the stigma around obesity that exists in some countries.

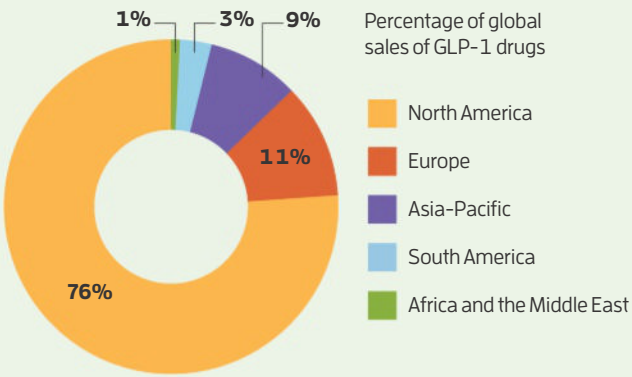
In the UK, only those with a body mass index of more than 35 (within the obesity range) and at least one weight-related health complication are generally eligible to receive Wegovy or Mounjaro on the National Health Service. In the US, the use of these drugs for weight loss often isn't covered by insurers, which means many people are paying out of pocket. With costs of roughly $1000 a month in the US and between £150 and £200 a month in the UK, "better-off people will have access and poor people won't," says Margaret Steele at University College Cork, Ireland.

Given the strong link that already exists between lower incomes and a higher risk of obesity, this inequality of access to GLP-1 drugs"will just cement the association between being fat and being poor", she says.

Others concur. "If we don't make these medications available to people who can't afford to buy them privately, then we will definitely be widening the stigma and the societal divide that we see in obesity already," says Samantha Scholtz at Imperial College Healthcare NHS Trust in London.

The global appetite

North America dominates sales of GLP-1 drugs globally, but the Asia-Pacific region is predicted to become the fastest-growing market in coming years.



SOURCE: WWW.TOWARDSHEALTHCARE.COM

What's more, a lack of understanding around these access issues could mean people with obesity are judged for not taking these drugs. "There might be an attitude of, 'Why aren't you on Ozempic?'" says Andrew Steptoe at University College London. "That, in itself, becomes a judgement in the way that some people think, 'Why don't you just stop eating so much?'"

Personal choice

Even ignoring the costs, the drugs aren't for everyone. Like all medications, they have side effects and not everyone loses 15 to 20 per cent of their body weight, the average reached in trials for semaglutide. And some people may simply not want to take them. In response to Oprah's Ozempic special, Apryl Williams and Mel Monier, both at the University of Michigan, argued in the journal *Critical Studies in Media Communication* that "viewers did not hear from someone who was fat and happy. We do exist."

Obesity aside, a "cultural desire for thinness" will drive demand for these drugs, says Francis Finucane at the University of Galway, Ireland. In societies where being slim is prized, this may prompt people without obesity to take drugs like Ozempic, which could take them from what is considered a healthy weight to being underweight. There are already signs of a return to a more waif-like aesthetic, judging by some recent appearances on the red carpet. And if the general weight of the population goes down too, "so may the norms, whether that is [what is] attractive or normal or something you should strive for," says Bjørn Hofmann at the Norwegian University of Science and Technology.

More optimistically, some researchers hope that these medications may support obesity being seen as a medical condition, rather than a moral failing. "These drugs will help people to understand that obesity is a biological, physiological, metabolic problem, rather than a psychological problem or a motivational problem," says Finucane.

But these drugs can only do so much. Losing 15 per cent of body weight may take someone from having severe obesity to milder obesity. "The social stigma of that probably is still quite high, right?" says Steptoe. Obesity stigma is "pretty entrenched in our society", he says. "That would take quite a lot of shifting. I wouldn't hold my breath."

However, GLP-1 drugs may change the landscape of obesity in a rather different way. Reports increasingly suggest they reduce "food noise", dialling down obsessive thoughts

A wonder drug?

Semaglutide and other GLP-1 drugs have been linked to a lower risk of a slew of health conditions, not just obesity and diabetes – but how robust is the evidence?

HEART DISEASE

Strong. Semaglutide cuts the risk of a heart attack, stroke or heart-related death by 20 per cent. Approved by the US Food and Drug Administration (FDA) last year to treat serious heart conditions in people who are overweight or obese.

KIDNEY DISEASE

Strong. Semaglutide cuts the risk of kidney failure by 24 per cent. Approved by the FDA in February to treat kidney disease in people with type 2 diabetes.

SLEEP APNEA

Strong. Tirzepatide reduced sleep apnea episodes in two placebo-controlled trials.

ALZHEIMER'S DISEASE

Promising. Observational studies show semaglutide is linked to a reduced risk of Alzheimer's in people with type 2 diabetes, compared with other diabetes medications. Results from large-scale clinical trials are due later this year.

DEPRESSION

Promising. Several clinical trials suggest that symptoms improve when taking GLP-1 drugs compared with a placebo or other diabetes treatments. Results of a trial comparing semaglutide to a placebo for depression are due in the next few months.

EYE CONDITIONS

Early stage. In observational studies, GLP-1 drugs have been linked to a lower risk of age-related macular degeneration compared with other diabetes medications, but to an increase in the risk of NAION, a rare form of vision loss.

PAIN

Mixed. Semaglutide did better than a placebo at reducing arthritis-related knee pain. GLP-1 drugs also increased pain tolerance in mice and have been linked to reduced muscle pain – but they may increase discomfort in the abdomen and bones.

LIVER DISEASE

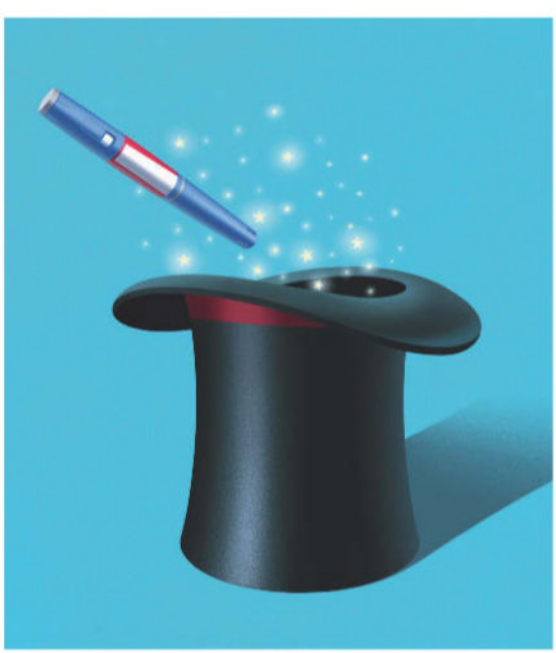
Mixed. Semaglutide reversed non-alcoholic fatty liver disease in one early-stage trial, but didn't in another. A larger study is ongoing.

about eating. Ozempic "seems to take away that extra voice that's always telling you you're hungry", says Steele. For instance, one trial found that people taking semaglutide not only consumed 24 per cent fewer calories, but had a reduced preference for fatty, energy-dense foods compared with participants taking a placebo. Another study found that US households with at least one person taking GLP-1 drugs purchased fewer calorie-dense processed foods and spent 9 per cent less at fast-food chains and coffee shops.

Such findings prompted strategists at Barclays bank to recommend people sell stocks in fast-food enterprises. And some researchers are optimistic that junk food outlets may start shutting their doors thanks to Ozempic, which could go some way to preventing obesity for the general population. "Your genes set the table for obesity and the environment serves it up," says Ted Kyle at ConscienHealth, an obesity advocacy group in Pennsylvania.

"This intervention has the power to influence the food environment," says Scholtz. And then? "Our children and the generations that come after us have a better chance of not developing obesity in the first place," she says.

Alexandra Thompson



JON KRAUSE

> *IT MAY BE POSSIBLE TO DEVELOP GLP-1 DRUGS THAT DON'T CAUSE WEIGHT LOSS*

WHAT COMES NEXT: FROM WEIGHT-LOSS DRUG TO CURE-ALL?

OBESITY rates have been increasing in the US for decades, but in 2023 they fell – at least in part because of the burgeoning popularity of the "miracle drug" semaglutide. Approved for treating obesity only in 2021, it is in short supply and is very expensive, but it has already had an extraordinary impact.

Yet this could just be start. With many companies racing to market rival versions of semaglutide in cheaper and easier-to-take forms, as well as mounting evidence that that GLP-1 drugs can target a host of health conditions, the treatments could have an impact that goes way beyond reversing the worldwide trend of rising obesity and possibly even putting a dent in alcohol sales. So what lies ahead for these drugs – and what are the stumbling blocks?

A growing number of studies show that semaglutide seems to have many beneficial effects in addition to weight loss. For instance, in a four-year trial involving nearly 18,000 people, 6.5 per cent of those on semaglutide had a heart attack or stroke compared with 8 per cent of those receiving a placebo.

The treatment may even reduce many kinds of craving, not just those for food (see "What do weight-loss drugs tell us about the brain?", page 31). "There are anecdotal reports of people reducing their alcohol intake substantially on semaglutide," says Helen Colhoun at the University of Edinburgh, UK. "I think that this is one of the exciting potential future directions." While these effects need to be confirmed by large trials, one big investor recently sold off shares in drinks companies amid concern that alcohol consumption will fall as more people take GLP-1 drugs.

Given the broad health benefits, it could be that some people would be better off taking these drugs for the rest of their lives (see "Ozempic endgame", page 38). But there is still much to be discovered about the mechanisms through which GLP-1 medications work, such as the extent to which their impact is due to the health benefits of reducing obesity. A recent study in pigs, for instance, confirmed that some of the drugs' heart benefits don't depend on weight loss. This makes sense given that GLP-1 receptors are found throughout the body, including in the heart. However, it is a confusing picture, especially with regard to the medications' effects on the brain, and one that we are only just beginning to untangle.

New trials

It also isn't clear whether people who aren't overweight could benefit, as few trials have included this demographic. "We would need new trials to prove that GLP-1 medicines reduce heart disease in people without type 2 diabetes or obesity," says Daniel Drucker at the Lunenfeld-Tanenbaum Research Institute in Toronto.

There is no evidence that GLP-1 drugs can cause weight loss to an unhealthy extent, but they usually aren't prescribed for people who aren't overweight. While the approval of semaglutide for treating type 2 diabetes didn't specify that people have to be overweight to get a prescription – unlike those being treated for heart disease – in practice, this is the case, says Tricia Tan at Imperial College London. "I'm not aware of any reputable clinician who would initiate Ozempic in someone with diabetes with a BMI of less than 25," she says.

If weight loss does turn out to be undesirable or excessive in some cases, it may be possible to develop GLP-1 drugs that don't cause it. In fact, a GLP-1 treatment called albiglutide was found to reduce strokes and heart attacks with only minor weight loss in trials, says Tan. However, this drug is no longer manufactured as it wasn't profitable.

For now, the cost of GLP-1 drugs and the need to inject them remain a major practical barrier to their wider use, she says. But as patents start to expire in ›

some countries and the competition among pharmaceutical companies heats up, prices should come down. Thirty-nine new GLP-1 drugs are now in development, according to healthcare data firm Ozmosi, including the "triple G" drug retatrutide, which binds to the receptor for glucagon – triggering the release of fat stores – as well as to receptors for the satiety hormones GLP-1 and GIP. Retatrutide appears to be even more effective than tirzepatide for weight loss.

Because semaglutide, tirzepatide and retatrutide are all proteins and thus larger than most drugs, they cannot normally enter the body via the digestive tract, hence the need for injections. Manufacturing proteins is more difficult than making small-molecule drugs, and the need to package them in an injectable form has also contributed to shortages.

There is a drug called Rybelsus that consists of semaglutide plus a substance called salcaprozate, which enables some semaglutide to get through the gut, but it has to be taken half an hour before eating or drinking. Rybelsus is only approved for treating diabetes so far.

But a number of pharmaceutical firms are developing small-molecule GLP-1 drugs that can be taken like standard pills and whose manufacture should be easier to scale up. "These have the potential to be much cheaper," says John Wilding at the University of Liverpool in the UK. A small-molecule drug called orforglipron is in phase III trials and could be approved next year. There are also protein-based drugs in development that would require only monthly injections.

Other obstacles to the wider use of GLP-1 drugs will be harder to get around. Nearly half of people taking GLP-1 drugs have gastrointestinal side effects, including nausea, diarrhoea, vomiting and constipation. These usually diminish within days, but can persist for much longer in a few people. More than 1 in 20 users stop taking the drugs because of such effects.

"WEIGHT REGAIN IS VERY COMMON WHEN THE TREATMENT IS STOPPED"

GETTY IMAGES; ALAMY

The nausea is thought to be caused by GLP-1 drugs directly affecting a part of the brain called the area postrema in the medulla oblongata, says Lora Heisler at the University of Aberdeen, UK, who is trying to find ways to prevent this side effect. But it could also, for example, be a result of the drug causing the stomach to empty more slowly – like much about GLP-1 drugs, we just don't know yet.

Other unwanted side effects can include bone loss and muscle atrophy, To address this, some companies are combining GLP-1 drugs with ones designed to boost muscle growth, with some promising results.

The upshot of all these developments is that semaglutide and related drugs hold the promise of improving the health of billions of people. But this doesn't mean we can forget about the issues that have led to obesity becoming so common in the first place, such as the heavy advertising of calorie-dense foods with poor nutritional value, says Colhoun. "We need to redouble efforts at population and societal levels to reduce the social determinants of obesity," she says. "It is vital that anti-obesity medicines are not seen as a panacea."

Whatever happens next, these drugs are already transcending medicine and affecting culture, too. What's more, we are only at the beginning. ▮

Michael Le Page

Ozempic endgame

Unfortunately, "Ozempic rebound" is real. Most people regain much of the weight they have lost when they stop taking GLP-1 drugs and their full appetite returns. For instance, a 2022 trial with nearly 2000 people found that a year after they stopped taking semaglutide, the participants had regained two-thirds of the weight they had previously lost.

"We know that, for all medicines tested so far for obesity, weight regain is very common when treatment is stopped," says John Wilding at the University of Liverpool, UK. However, with continued use of GLP-1 drugs, weight loss is maintained. In the longest-running trial so far, people took either semaglutide or a placebo for four years. Those on the drug lost weight for the first nine months, on average, and after that their weight remained stable while they kept taking it.

Given the drugs' other benefits, many people may be better off staying on GLP-1 medications indefinitely, says Wilding. "If you want long-term benefits, then long-term treatment is necessary." Statins are used in this way, based on trials that also ran for four or five years. But regaining weight after stopping GLP-1 drugs isn't inevitable if people change their lifestyles, says Helen Colhoun at the University of Edinburgh, UK. "Unfortunately, many people are using this class of drugs to reduce their weight without any clear dietary plan or advice."

43%
Proportion of adults globally who are overweight or obese

Rewilding the climate

Ecologists have calculated that ecosystem-shaping animals capture eye-popping amounts of carbon. So can restoring their populations turn the tide against climate change, asks **Graham Lawton**

DANIEL MÎRLEA

IN THE Țarcu mountains of Romania, a pioneering experiment is changing the atmosphere around rewilding. Starting in 2014, around 100 European bison were gradually reintroduced to the area, having been wiped out by hunting more than 200 years ago. They now number more than 170 and graze over some 48 square kilometres. That is a success story in itself. But there is more to this project than just bringing back the big beasts. Their domain has also become a carbon hoover, sucking an estimated 200,000 tonnes of carbon dioxide out of the air every year, equivalent to taking 43,000 petrol cars off the road.

The bison themselves aren't a significant carbon sink. It is their influence on the wider environment – compacting soil, dispersing seeds and creating varied habitats through their browsing – that has turbocharged its ability to absorb carbon. The area in which they roam is now soaking up 10 times the amount that it was before the bison were reintroduced.

The Țarcu mountains experiment is the first test of a concept that Oswald Schmitz, an ecologist at Yale University, claims has the potential to restore the atmosphere to an earlier state and hence help to arrest climate change. Schmitz and his collaborators argue that if similar projects were rolled out across the globe, both on land and in the sea, a significant amount of carbon would just disappear.

These researchers are now building their evidence base and honing their plans. Meanwhile, though, some climate scientists have raised concerns that attempts to put rewilding at the heart of climate mitigation could backfire. So how do Schmitz's claims really stack up?

A solution to the climate crisis demands two things. First and foremost, that we stop emitting greenhouse gases, or at least get emissions down to net zero by 2050. Second, that we remove the huge amount of CO_2 we have pumped into the atmosphere over the past century or so. Fail on either front and we ›

"A growing pile of evidence supports the idea that animals are powerful drivers of carbon capture"

have no chance of keeping the global average temperature rise to below 2°C relative to pre-industrial levels. This would be catastrophic.

The first of these demands is difficult, but doable. How we might achieve the second is less clear. According to Schmitz, to pay back our legacy carbon debt, we need to remove at least 6.5 gigatonnes of CO_2 a year, every year, from now until 2100. Existing methods of drawing carbon down from the atmosphere, if expanded to their maximum capacity, would only be able to remove 6 gigatonnes a year, says Schmitz. Less, if we also need to use them to offset ongoing emissions.

Those existing methods are largely nature-based, such as protecting habitats and planting living carbon sinks – trees, mangroves and seaweeds. There are also technological fixes, such as enhanced rock weathering, where rocks are crushed to dust to increase the rate at which they absorb CO_2, or direct air capture, where CO_2 is pulled out of the atmosphere by huge machines. But these are emerging technologies that may never actually mature.

The upshot is that, even if we reach net zero by 2050, we appear to still be, at the very least, 500 million tonnes short on CO_2 removal per year for the next 75 years.

According to Schmitz, however, this is much less of a problem than it appears, because a powerful but overlooked nature-based solution is already making up much of that shortfall and could even solve the whole problem on its own: wild animals.

Until recently, animals weren't considered part of the solution at all. Compared with land plants and seaweed, the amount of carbon stored in animal bodies is minuscule, accounting for just 0.3 per cent of all the biomass on Earth, according to a 2018 analysis. But around 10 years ago, Schmitz started to think that this might be an oversight.

He was researching an ecological concept called trophic cascades, which holds that ecosystems are primarily shaped from the top down by the feeding behaviour of "apex consumers" – large herbivores and carnivores. Herbivores influence the make-up of vegetation, which fundamentally alters how the ecosystem works. They, in turn, are controlled by their predators, so predators also influence vegetation. Exactly how depends on the context. But, in general, if you take the large animals out of an ecosystem, you radically alter it, usually for the worse.

At the same time, research from the Serengeti plains of East Africa and the American prairies was finding that grazing by wildebeest and bison altered nutrient cycles, especially how much carbon could be locked away by plants. "And so I connected the dots," says Schmitz. "It dawned on me that having animals in the system can transform what the vegetation looks like and should thereby also be able to transform how much carbon is taken up." In 2014, he and his collaborators published the idea and coined a term for harnessing animals' underappreciated influence on carbon storage: animating the carbon cycle, or ACC for short.

They point to a growing pile of evidence to support their claims that animals are unrecognised but powerful drivers of carbon capture. On the Serengeti, for example, 1.2 million blue wildebeest range over a vast area, browsing and defecating as they go. By keeping the grass trim, they reduce the frequency and intensity of wildfires, which release stored carbon from the soil. Much of their carbon-rich dung ends up in long-term storage underground, buried by insects. Together, these actions allow the Serengeti ecosystem to store 4.4 million tonnes more CO_2 each year than it would in the absence of wildebeest.

In the Pacific Ocean, meanwhile, sea otters protect kelp forests by feeding on herbivorous urchins that, if left to their own devices, devastate the kelp. The sea otter population of the US and Canada – which has rebounded from near-extinction after being mercilessly hunted for their fur – leads to the capture of 5.2 million tonnes of CO_2 a year.

Apex predators like wolves can alter how ecosystems work

SHUTTERSTOCK/MICHAL NINGER

Unsung carbon hoovers

A few million tonnes of CO_2 isn't going to make much of a difference, but many other animals create carbon-sinking ecosystems, and it all adds up. Indeed, Schmitz estimates that existing populations of wildebeest, sea otters and five other species – muskox, grey wolves, tiger sharks, lemon sharks and blacktip reef sharks – already collectively stimulate the storage of 300 million tonnes of CO_2 a year. Which is a bit more like it. That sort of figure goes quite a long way towards filling the gap between the conventionally calculated carbon capture potential of nature-based solutions and what we need to remove from the atmosphere to avoid climate catastrophe. And there's more. If you take into account existing populations of all marine fish, the amount of annual carbon capture and storage attributable to wild animals increases almost 20 times.

Fish have a "tremendous" impact on carbon storage, says Schmitz. "Part of it is in just the sheer biomass of these animals," he says. But bony fish also fix carbon into insoluble minerals in their intestines as part of their way of dealing with constantly ingesting seawater. "It's a sort of rock-like substance that they poop out and that sinks to the ocean bottom really quickly," says Schmitz. Collectively, marine fish account for the storage of a whopping 5.5 gigatonnes of carbon each year.

Schmitz and his collaborators estimate that, taken together, this group of animals alone – wildebeest, sea otters, muskox, grey wolves, sharks and other marine fish – are already taking 5.8 gigatonnes of CO_2 out of the atmosphere each year, not far off the overall 6.5 gigatonnes a year legacy CO_2 debt.

MICHAEL S. NOLAN/ALAMY

Sea otters protect kelp forests by feeding on urchins

That's a massive contribution, and one that Schmitz says isn't accounted for in the global carbon budget. If he is right, we have overestimated how much legacy carbon we need to remove because animals are already doing most of it, unnoticed and unsung. "What we need to do is incorporate what the animals currently provide in [carbon] accounting," says Schmitz. "But because we're not, we're maybe letting an important ingredient of ecosystems disappear and that puts us further in the hole. So we need to conserve what we have."

As for the rest – 700 million tonnes – that may be achieved by expanding the existing natural methods of CO_2 removal. Or else Schmitz calculates that much of it could be taken care of by putting apex consumers back into the ecosystems from which they have been removed, known as trophic rewilding.

A key part of that calculation is a methodology for estimating how much carbon a given rewilding project would remove from the atmosphere, called the Yale/GRA ACC model (GRA stands for the Global Rewilding Alliance, which has funded a lot of Schmitz's work). "We're taking the classic principles of carbon cycling – that is, carbon uptake through photosynthesis and carbon recycling because of plants dying and going into the soil – and layering herbivores feeding on the plants on that, and then carnivores feeding on the herbivores," he says. Using that tool to analyse the Țarcu mountains bison project, Schmitz and his collaborators were able to estimate the carbon impact – subsequently measured by taking samples in the field – to a fair degree of accuracy.

They have calculated that trophic rewilding of just seven further species around the world would add another 600 million tonnes of carbon drawdown a year. These are forest elephants, American bison and five species of baleen whale: blue, fin, humpback, southern right and Antarctic minke. They wouldn't need to be brought back to their full, historical populations or ranges, but to something like their status before the industrial revolution, says Schmitz. That means around 500,000 African forest elephants (up from less than 100,000 today), 2 million American bison (up from 30,000 today) and 188,000 baleen whales in the Southern Ocean.

To start making ACC happen at scale, Schmitz and his colleagues are now applying the carbon storage methodology to numerous other existing and potential rewilding projects worldwide, all with a view to figuring out which would have the biggest impact.

Rewilding hotspots

"We've got case studies in different habitats and on different continents, deliberately diverse ones," says Alister Scott at the Global Rewilding Alliance. "The idea is, what are the 50 or 60 or 70 locations around the world that hold the most promise for helping to stabilise the global climate by helping nature's recovery?" The hope is that this "hotspots" study will lend support to the case for a global rollout of ACC. Some countries are even looking at incorporating rewilding gains into their legally-binding plans for reducing carbon emissions in line with the Paris Agreement, according to Scott.

Such grand plans, however, make some scientists nervous. "Clearly, animals play really important roles in nutrient cycling, including carbon cycling," says Ethan Duvall at Cornell University in Ithaca, New York, co-author of a critique of ACC published in August 2024. "But we shouldn't overstate their importance in climate change mitigation. We have limited science at this point on select species and select systems."

What isn't taken into account, says Duvall, is that some species in some ecosystems – savannah elephants, for example – actually result in an overall release of carbon into the atmosphere. "The reality is that when it comes to carbon, not every animal is doing the same thing and not every system is doing the same thing," he says. "It's not an inevitable outcome of functionally intact and biodiverse systems to store carbon."

His concern is that people will jump to the conclusion that all rewilding projects are carbon negative when they aren't. He likens it to tree planting, which was once seen as a climate panacea, but turned out to be more complicated and context dependent. Dark foliage can have a warming effect by soaking up sunlight that would otherwise be reflected, for instance.

The guardians of the carbon budget aren't buying it either. "He is claiming that rewilding upper trophic mammals could induce large carbon storage in vegetation and soil," says Pierre Friedlingstein at the University of Exeter's Global Systems Institute in the UK, which publishes an annual report on the state of the world's carbon. "That's true in theory, and there is some evidence of increased carbon storage locally, for example in South Africa." However, Friedlingstein disputes the claim that animals are already drawing down vast amounts of unaccounted-for carbon. "Wildlife preservation is, of course, important for biodiversity, but not for climate change."

Schmitz acknowledges that not all rewilding projects will draw down carbon, but he insists that isn't a problem because we can just focus on those that do. That is exactly why he and his collaborators are working to identify the specific contexts in which trophic rewilding is worthwhile. "If we're going to rewild, let's rewild," says Schmitz. "But then let's measure the relevant ecosystem components as we go and learn by doing. This is win-win conservation." ▮

Graham Lawton is a staff writer for *New Scientist*

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The science of exercise

A walk in the park?

Low-intensity steady-state cardio, or LISS, is a hot new exercise trend on social media. What are the benefits, asks **Grace Wade**

Grace Wade is a health reporter for *New Scientist* based in the US

WHEN it comes to exercise, my aim is usually to get the most out of each workout, pushing myself to my max. No gain without pain, right? But maybe that isn't always the case.

In the past few years, low-intensity steady-state (LISS) cardio has been growing in popularity as a way to lose weight. One example is the TikTok "12-30-3" workout trend, where you walk up a 12 per cent incline for 30 minutes at 3 mph (4.8 kilometres per hour). This type of exercise involves slower aerobic activity over an extended duration, such as walking or cycling at a pace comfortable enough to maintain a conversation, but brisk enough that you feel a tad out of breath.

This is in contrast to high-intensity interval training (HIIT), when you do exercises such as jump squats at near-maximum capacity in repeated intervals of up to a minute, with short rests in between. You should aim to hit 80 to 95 per cent of your maximum heart rate during HIIT. The goal with LISS is to be at around 50 to 65 per cent of your maximum for about 45 minutes to an hour. At this intensity, your body is burning mostly fat for energy. Anything more vigorous and it switches to using mainly carbs.

Proponents of LISS say this means it is better than other exercises at decreasing body fat. But that isn't borne out by the research: a 2021 review found no difference in fat loss between people who did interval training and those who did LISS, while

SHUTTERSTOCK/GORGEV

one in 2024 found LISS also isn't any better for improving cardiovascular fitness.

However, LISS does have some advantages. For one, it puts less strain on the body thanks to its lower intensity, allowing you to recuperate more quickly and thus squeeze more workouts into your week, as you don't have to wait as long for your muscles to recover. That 2024 review also found that the more workouts you do a week, the greater the boost to your aerobic capacity. So, if you only have the energy for one or two high-intensity sessions a week versus four or five bouts of LISS, you may want to opt for the latter.

LISS can also aid recovery from intense workouts, when our bodies break down glucose for energy, producing lactic acid in the process. This then separates into lactate and protons. The former can hinder the ability of muscles to contract, while the latter impair muscle function, leading to muscle fatigue. As LISS promotes blood flow to skeletal muscles, it helps flush away these waste products, speeding up recovery. So it can be beneficial to cap off an intense workout with a little LISS, like walking on a treadmill at an incline for 15 minutes, or going on a leisurely hour-long bike ride on active recovery days.

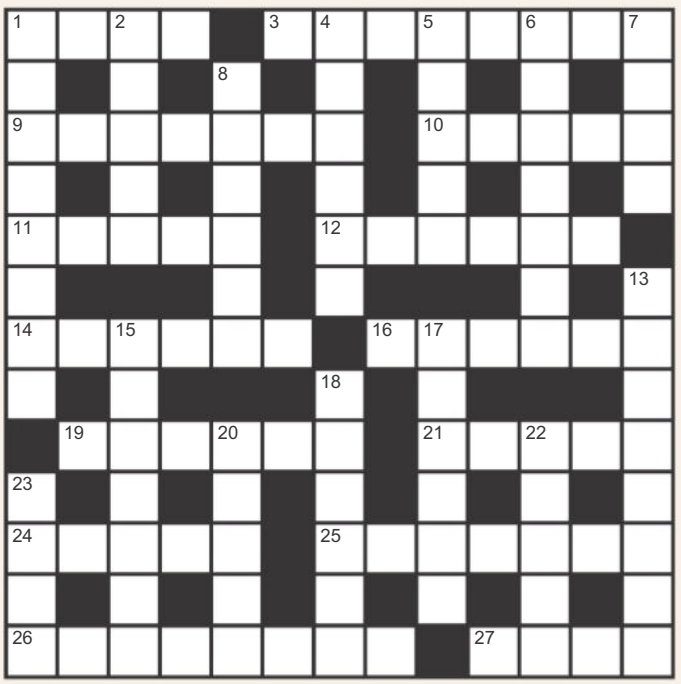
As for me, I am going to find the time to make LISS a priority. A long stroll in the park doesn't sound too bad, even on a rest day. ▮

The science of exercise appears monthly

Next week
Dear David

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

Cryptic crossword #158 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Heather might join Cal to find vocation (4)
3 Woody movie, taken from play, initially shocks conservative (3,5)
9 Irony of going back to embrace sin in partnership with America (7)
10 See 14
11 Feudal lord found in Belgian city (5)
12 Colourless halogen in an unspecified quantity (6)
14/10 Builder's friend's mood flat (6,5)
16 Perhaps bravely (or foolishly) make statement about diameter in front of Berkeley principal (6)
19 Music time! Nightclub's opening, with E going around (6)
21 Something like a sound heard in eight bits (5)
24 Play role in protein? (5)
25 Scottish engineer's in English town (7)
26 Treading carelessly uphill, possibly (8)
27 Responsibility concerning you and me (4)

DOWN

1 Inert lithium, not 9? (8)
2 Tend south-east, after northward rush (5)
4 Bosses around, to torment (6)
5 Seal broken on first of manuscripts in historic trial location (5)
6 Wildly verbose heads! (7)
7 Most of chicken's cry? (4)
8 Bromide mixture with boron removed – making notes? (2-2-2)
13 Low points, in the main? (3,5)
15 I retain foolish tendency to stay put (7)
17 Take superficial interest in what shoveler does (6)
18 Grass up X, providing list of "favourites" (3,3)
20 One under female's tongue? (5)
22 Upper thigh area that may be exposed on beach, by the sound of it (5)
23 Go for Scots team (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #295
set by Corryn Wetzel

1 What enzymes are responsible for unwinding DNA during replication?

2 What is the name of the landscaping technique that aims to reduce the need for irrigation?

3 Which physicist first proposed the idea of wave-particle duality?

4 Which planet in our solar system rotates on its "side" at a tilt of about 98 degrees?

5 What is the rarest naturally occurring element in Earth's crust?

Answers on page 47

BrainTwister
set by Phil Lloyd
#66 Easy times?

If you start with the number 185 and move the first digit to the end, you get 851. You get the same result when you multiply 185 by 4.6.

In a similar fashion, the number 15 can be multiplied by a number between 3 and 4 to move its first digit to the end. What number do you need to multiply by?

Can you find a 3-digit number, where the first digit is 1, that must be multiplied by 2.6 to achieve the same effect?

How about a 5-digit number that is multiplied by 1.8? Or a 9-digit number that that is multiplied by 1.9? In each case, consider only numbers where the first digit is 1.

Solution next week

Thirsty work

Is it more efficient for me to carry water in a bottle or in my stomach?

Sam Edge
Ringwood, Hampshire, UK
If it is a 1000-litre bottle, then I would carry it, preferably with mechanical assistance, as attempting to drink that much would kill you. However, for taking sufficient water to stay hydrated when walking or running or otherwise exerting oneself away from a source of clean water, there are a couple of things to consider.

In Frank Herbert's *Dune* novels, the Fremen people of the desert world Arrakis use "stillsuits" that capture all water from sweat, urine and faeces. They also have mouth and nose pieces that capture and recycle body moisture before storing that water in pockets distributed around the suit. Even with the stillsuits, the Fremen are advised to stay as hydrated as possible.

Outside of *Dune*, though, if your body has too much water, it reduces the concentration of important ions such as sodium and those of other minerals and interferes with the osmotic processes of your cells. To counter this, you may sweat more, and your body will dump the excess into your bladder and from there out of the body.

"If you're going to be away from sources of potable water, carry some in bottles, ideally distributed evenly around your torso"

So, drink as much as you like without making yourself uncomfortable before you set off on a journey, as having it distributed throughout your body is the most efficient way of carrying fluid. However, if you're going to be away from sources of potable water for a while, carry a backup, ideally in multiple smaller, lightweight containers distributed evenly around your torso.

Of course, if you are shy about peeing outdoors or are going to be in an urban area where doing so may be construed as unsanitary, you might not want to overdo it with the pre-hydrating!

Mike Follows
Sutton Coldfield, West Midlands, UK
It is better to carry it in a bottle, as it allows you to drink when thirsty. When you drink water, it passes through your digestive system and is absorbed into your bloodstream through the intestines. However, the stomach isn't designed to store water.

Maintaining proper water levels is essential for supporting cellular function and vital processes. This is part of our homeostatic system, which includes osmoregulation – the process by which the body balances water and salts.

This works via osmoreceptors in the hypothalamus in the brain detecting changes in blood osmolarity (which describes the concentration of solutes, such as sodium). If osmolarity increases, that means the concentration of minerals has gone up, indicating dehydration. The brain then triggers the thirst reflex to encourage fluid intake and tries to conserve water by reducing urine output.

It cuts the amount of urine produced thanks to the hypothalamus signalling the release of antidiuretic hormone (ADH). ADH acts on the kidneys, making them more permeable to water. This allows these organs to reabsorb more water back into the bloodstream rather than excreting it in urine. However, if you drink water before going on a walk, your kidneys direct a significant proportion to the bladder, from where it can't be reabsorbed.

The situation becomes more challenging in hot conditions when sweat glands release more water onto the skin's surface. This water evaporates, removing energy from the body in the process, helping prevent overheating. Without a source of water to quench your thirst and restore salt balance, you risk suffering from heat exhaustion or even heat stroke, which can be fatal. Water is also lost through exhalation as vapour in your breath, particularly when breathing heavily or in cold, dry conditions.

It is a good idea to drink plenty of water before you start your walk to avoid drinking supplies you are carrying too soon, which could leave you with insufficient for the rest of the hike. To stay properly hydrated, carry sufficient water in a bladder or bottle before setting off on a long walk, particularly when expecting more severe physical exertion, such as when climbing a mountain or on a hot day.

It is also wise to bring purification tablets, allowing you to access water more safely from streams if you run out. However, this should be considered a last resort and ideally you should use sources as high up as possible, where the water has less chance of being contaminated – by something like a dead sheep, for example.

Tony Green
Ipswich, Suffolk, UK
Let's consider my options when I go for a long cycle ride on a hot summer's day. I can take 1 or 2 litres of water in bottles, or I could drink

SHUTTERSTOCK/VANOVASAIO

This week's new questions

Two of a kind **Binocular vision gives us a 3D perspective, and two ears let us locate the direction of a sound. But why two nostrils?** ***Richard Kubiak****, Usk, Monmouthshire, UK*

Cosmic sprint **How long would it take to accelerate a spacecraft to 99 per cent light speed without major injury to the astronauts inside?** ***John McKain****, Glasgow, UK*

We have two eyes to see in 3D and two ears to locate sound. Why two nostrils?

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Tom Gauld
for New Scientist

all that water before I set off.

With the bottles, I can take a drink whenever I feel thirsty, and the water will last me until I am home. If I drink it all before setting off, it is likely to go through me quite quickly, and much of it will be excreted fairly early in my ride.

The first option ensures that I arrive home without getting dehydrated, whereas the second probably guarantees dehydration. And given that I can't cycle as efficiently dehydrated, carrying water in bottles is my most efficient choice.

Hillary Shaw
Shropshire, UK

As someone who regularly does 5-hour walks, I recommend using a bottle to carry water – but drink it regularly and gradually.

Carrying a bottle in a rucksack, for example, does feel heavier than carrying the same volume of water in your stomach. However, the body will try to maintain internal homeostasis, and you will soon lose that water by urinating more. If you carry water in a bottle, at least as you get more tired, the load in your rucksack gets lighter.

"Humans don't need to run any more to secure their food: simply tap an app on your phone and pizza arrives"

Homo runnicus

Could *Homo sapiens* have outcompeted Neanderthals in part due to a superior running ability?

Simon Dales
Oxford, UK

Our species evolved on the savannah to forage and persistence-hunt. However, we don't need to run any more to secure our food: tap an app on your phone, and pizza arrives.

In contrast, Neanderthals were adapted to carry out forest ambushes to catch animals. Running in forests isn't very productive; you make a lot of noise and bang your head on branches. Their forest-adapted eyes required a lot of real-time processing of signals to the brain, and they had larger visual cortex regions to cope with this. But a large visual cortex is costly, in terms of biological resources. If there is no forest, then a smaller one works fine.

The greater strength of Neanderthals meant their bones were heavier and denser than ours, and they had a lot of fast-twitch muscle fibres for quick reactions. So, in a sprint, they may well have been quicker than *Homo sapiens,* but not over multiple kilometres. To run such distances, you need to be lighter and have mostly slow-twitch muscle fibres. Even today, there is a trade-off with strength training. If you bulk up your body too much, it adds to your mass and your scrawnier peers outrun you.

But we invented farming, four-wheel drive vehicles and grocery stores. So, rather than having to chase an antelope around the savannah, our lunch is on a shelf, wrapped in plastic. ▮

Answers

Quick quiz #295 *Answers*

1 Helicases
2 Xeriscaping
3 Louis de Broglie
4 Uranus
5 Astatine

Quick crossword #179 *Answers*

ACROSS 1 Petit mal, **5** Flying, **9** Lordosis, **10** Family, **12** Genus, **13** Urea cycle, **14** Subset, **16** Atrophy, **19** ChatGPT, **21** Allele, **23** Explainer, **25** Teeth, **26** Throbs, **27** Asbestos, **28** Peroxy, **29** Clitoris

DOWN 1 Phlegm, **2** Tarantula, **3** Tools, **4** Aliquot, **6** Leaf coral, **7** Iliac, **8** Glyceryl, **11** Zeta, **15** Signal box, **17** Polyester, **18** Screwtop, **20** Tank, **21** Aerosol, **22** Rhesus, **24** Purer, **25** Tweet

#65 Prime magic squares *Solution*

These are the completed squares. For the second one, you may have a rearrangement, like a rotation or reflection. The second square's magic constant is 177, which can also be found by adding all the numbers and dividing by 3.

43	1	67
61	37	13
7	73	31

17	89	71
113	59	5
47	29	101

Rattus sommeliensis

Feedback has reached an age where even a small amount of alcohol makes us sleepy, so the notion of going to a wine tasting holds no appeal. It seems a terribly time-consuming and expensive way to have a nap. However, purveyors of fermented grapes could soon have a new demographic to cater to: rats.

At least that's what we're extrapolating from a study in *Animal Cognition* called "Rats can distinguish (and generalize) among two white wine varieties". It was published on 21 February, and subeditor and TV columnist Bethan Ackerley sent it to Feedback on 1 March after it went "semi-viral online" – which goes to show how rapidly we can spring into action when faced with a breaking story.

Anyway, it's actually quite interesting. We all know that humans' sense of smell is rather limited compared with that of other mammals, including rodents. That's because we have fewer olfactory receptors in our noses. But we also know – or at least presume – that our minds are more sophisticated than those of animals. Raising the question: to what extent can animals, in this case rats, integrate lots of different olfactory signals to learn about complex categories – like, say, different white wines?

The researchers trained rats to discriminate between two grape varieties: riesling and sauvignon blanc. To confirm they had learned the categories, they tested them on new examples of these wines. The rats could tell the difference. Evidently, there's quite a bit going on between those rats' ears.

The question is, how far can we take this? It's one thing to show rats can learn the differences between wines, but can they also learn to be really condescending about it? Feedback wants to see rats that can sniff a wine, then enumerate a list of increasingly ridiculous odours – sorry, "notes of" – that they can apparently detect in it. Until these rats are squeaking on about how you can "really taste the terroir" and "isn't Liebfraumilch just utterly dreadful", are they really wine connoisseurs?

Twisteddoodles *for New Scientist*

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

Anti-AI tactics

At this point, Feedback has heard far too much about the supposedly imminent AI-induced apocalypse. Yes, yes, someday soon one of the AI companies will create an artificial general intelligence (AGI), which is as intelligent as a human. The AGI will then start re-engineering itself to become even smarter, because that is a thing that intelligent beings can readily do to themselves (shush, don't ask questions), and will rapidly become unstoppably intelligent. At which point humans will either be reduced to zoo animals or wiped out. This, we are told, is so important that we should stop worrying about piddling things like climate change. Uh-huh.

It was in this frame of mind that Feedback came upon a new science fiction short story by Maddison Stoff. We can't tell you the name of the story, because it makes ironic use of a word that would get stopped by an email filter, but we can quote Stoff's description of it as a "very funny, intimate sci-fi story reinterpreting the meme of Roko's Basilisk through the medium of a pseudo-erotic self-insert fan-fiction".

We imagine that, at this point, readers may have one or two questions. Fear not: Feedback is here to guide you.

Roko's Basilisk is a sort of thought experiment about AI. Sometime in the distant future, an AI decides to punish every single human who knew it could potentially exist but didn't help to create it. The AI creates digital replicas of all those people, and tortures them for eternity. This, you see, is a way for this future AI to incentivise all of us, right now, to start building it: that way, we won't get replicated and tortured.

The "basilisk" of the title is a reference to a mythological creature that can kill you with a glance, so you mustn't look at it. Likewise, even knowing about the idea of Roko's Basilisk supposedly puts you at risk from it. Simply by reading Feedback this week, you may have condemned a future replica of yourself to an eternity of torment. Sorry about that.

Stoff's story recounts how she saves humanity from Roko's Basilisk by, in the distant future, seducing it using her sexual wiles. The Basilisk is so besotted with her, it agrees to stop torturing everyone in exchange for this torrid encounter. Furthermore, Stoff wrote a short story about this and put it online, so it's now part of the Basilisk's training data – meaning, if the Basilisk ever comes into existence, it will have a burning crush on Maddison Stoff.

Simply by reading and sharing the story, Feedback made it more likely that the future AI will be attracted to Stoff, and less likely that it will torture us all. We encourage readers to do the same, with a warning that the story has some explicit sex in it. And maybe don't read it at work – unless you work at an AI company, in which case go right ahead.

Tesla? I barely knew her!

Occasionally when Elon Musk turns up in the news, Feedback is unaccountably reminded of the 1818 sonnet *Ozymandias*. It's strange how the mind works.

Anyway, the Norwegian branch of carmaker Kia posted an advert on Instagram showing a photo of one of its electric cars, complete with a bumper sticker that read "I bought this after Elon went crazy". Apparently this was not centrally approved and the advert has since been taken down, so it would be a real shame if anyone started making these stickers.


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Get ready for a very special new launch in April.
Last time we did this, with our C1 Bel Canto, it ruffled more than a few feathers amongst the ultra-conservative watchmaking establishment. It also sold out in a matter of hours and firmly established our credentials as designers and makers of the very highest calibre. What next? All will be revealed in April.
Sign up now for more clues – before everyone gets in a flap.

Do your research

Christopher Ward

christopherward.com