New Scientist

WEEKLY August 23 - 29, 2025 No3557 US $7.99 Canada CAN$9.99

GPT-5 IS HERE, BUT IS AI PROGRESS SLOWING DOWN?

THE UNIVERSAL ANTIVIRAL THAT COULD END WINTER ILLNESS

INSIDE THE BRILLIANT MIND OF PHYSICIST FRANK WILCZEK

HOW TO CALM YOUR BRAIN

The powerful role that blocking inflammation could play in treating anxiety, depression and Alzheimer's

THE SCRAMBLE FOR MINERALS

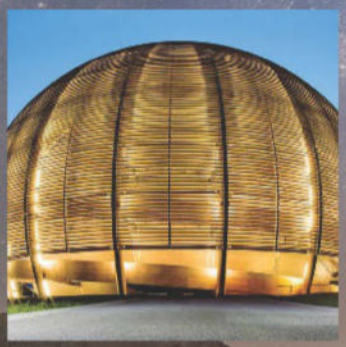
How we can get all the critical metals we need without wrecking the planet

PLUS DID CHILDCARE FUEL THE ORIGIN OF LANGUAGE? / **WHY CRYING HELPS US GRIEVE** / ANTS MAKE THE BEST TEAMS

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

Discovery Tours
NewScientist

Exploring amazing places through a scientific lens



CERN and Mont Blanc, dark and frozen matter: Switzerland and France

7 October 2025
6 days

Prepare to have your mind blown as you discover the world's greatest physics laboratory, CERN, accompanied by particle physicist Darren Price. Go behind the scenes where the secrets of dark matter and the fundamental forces of the universe are being explored.

- Walk the grounds of the famous Large Hadron Collider
- Take a trip on Europe's highest vertical ascent cable car to the Aiguille du Midi, where breathtaking views of the French, Swiss and Italian Alps stretch as far as the eye can see
- Stroll the cobbled streets of Geneva's Old Town, marvel at the graceful architecture and soak up the atmosphere of one of Europe's most cultured and scientific cities

Astronomy and volcanoes in the Canary Islands: Spain

27 November 2025
7 days

Visit an array of telescopes and enjoy expert-led stargazing across the islands of Tenerife and La Palma. Explore the dramatic volcanic landscape of La Palma, a designated UNESCO Biosphere Reserve, and Tenerife's Mount Teide, offering breathtaking views and unique geological features.

- Discover the beautiful Canary Islands through private tours of the Llano del Jable and Mount Teide observatories
- Explore the night skies with renowned astronomer and author Stuart Clark, as well as knowledgeable local guides
- Visit rare subtropical rainforests, ancient petroglyphs, volcanic vineyards and walk through recently formed lava tubes

Astronomy and tiger conservation safari: India

12 January 2026
11 days

Explore India's magnificent wildlife and night skies on this immersive conservation safari. Go in search of the elusive Bengal tiger and stay in award-winning lodges, allowing you the opportunity to immerse yourself in jungle life. You will also explore some of India's most important historical and modern observatories.

- Discover the Nehru Planetarium and the Raman Science Centre, which are among India's most prominent centres for astronomy education
- Throughout this tour you will be accompanied by Stuart Clark, who will be on hand to guide your stargazing experiences as well as give talks on a selection of astronomy topics
- Enjoy game drives, walks and seminars with local expert naturalists

Find out more at newscientist.com/tours

Alfred 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 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**

Cruise wild, historical and archaeological Scotland

26 May 2026
12 days

Discover early human civilisations and beautiful wildlife among the wild isles of Scotland aboard the state-of-the-art expedition vessel, the Sylvia Earle. Visit the windswept Hebrides, inhabited for more than 8000 years, and the islands of Orkney and Shetland, where ancient Neolithic, Bronze Age and Viking sites conjure the lives of peoples long gone.

- **Visit Britain's highest sea cliffs at the UNESCO World Heritage-listed St Kilda and the famous Neolithic site Skara Brae**
- **Enjoy a full programme of talks, shore visits to key archaeological sites and Zodiac boat safaris**
- **Fascinating talks from *New Scientist* writer Michael Marshall and expedition crew**

Total solar eclipse 2026: Iceland to Greenland polar cruise

7 August 2026
13 days

Embark on an extraordinary adventure in August 2026 to witness a breathtaking total solar eclipse. Sail aboard a boutique polar expedition vessel through the majestic Scoresby Sund in Greenland, the world's longest fjord system, accompanied by renowned astronomer and eclipse specialist Jamie Carter.

- **Enjoy guided hikes and insightful talks on glaciology, marine biology and polar history to allow a deeper appreciation of this remote ecosystem**
- **Cruise along blue glacier fronts and through stunning fjords on the Sylvia Earle, an intimate, purpose-built polar expedition ship**
- **Explore Iceland's Golden Triangle, including Þingvellir National Park and the Geyser geothermal area**

This week's issue

On the cover

30 How to calm your brain
The powerful role that blocking inflammation could play in treating anxiety, depression and Alzheimer's

36 The scramble for minerals
How we can get all the critical metals we need without wrecking the planet

Vol 267 No 3557
Cover image: Joey Guidone

10 GPT-5 is here, but is AI progress slowing down?

6 The universal antiviral that could end winter illness

40 Inside the brilliant mind of physicist Frank Wilczek

26 Did childcare fuel the origin of language? **46** Why crying helps us grieve **16** Ants make the best teams

30 Features

"Happiness is one of the key components that can directly reduce stress"

News

7 A new hominin?
Fossil teeth may be from previously unknown species

9 Special connection
Tiny tubes could explain the evolution of complex cells

13 Decades of drought
Pacific Ocean temperature changes are affecting precipitation in the western US

Views

20 Comment
Internet access is a human right, argues Merten Reglitz

21 The columnist
Could robotaxis make London safer, asks Matt Sparkes

24 Aperture
Photos capture New Zealand's threatened native wildlife

27 Culture
Modern lives are noisy – but too much quiet is harmful too

29 Letters
Safe disposal of human remains drove early burials

URS HAUENSTEIN/ALAMY

14 Trouble in the tropics Tropical bird numbers fall due to extreme heat

Features

30 Clear your mind
We are learning more about the effects of chronic inflammation on the brain

36 Precious metals
The sustainable ways we can meet the demand for minerals key to renewable energy

40 The joy of discovery
Frank Wilczek shares his love of theoretical physics

The back pages

44 Dear David
Why bosses tend to exploit their most loyal employees

45 Puzzles
Try our crossword, quick quiz and logic puzzle

46 *Almost* the last word
How do squirrels run down trees?

48 Feedback
The oddly entrancing comings and goings of Pépito the cat

48 Twisteddoodles for *New Scientist*
Picturing the lighter side of life

Mind the gap

Anti-inflammatory drugs could bring much-needed advances to psychiatric health

IT IS difficult to overstate the medical progress made in recent decades. In high-income nations, survival rates for one type of childhood leukaemia have risen from around 10 per cent to over 90 per cent. The HPV vaccine has slashed cervical cancer rates, and the life expectancies of people with HIV are now close to those of the general population, if it is detected early.

But you will struggle to find similar examples in treating mental health conditions. Indeed, psychiatry has gained a reputation as a stagnant field, with treatments largely rooted in early psychiatric drugs of the 1950s and 60s.

It isn't for lack of effort. In the 1970s, molecular psychiatry sought to understand mental health at the level of proteins, genes and signalling pathways, aiming to ground diagnoses and treatments in physical mechanisms, not subjective descriptions of symptoms. Since then, the genetic revolution has seen work on pinning down the genetic correlates of conditions like schizophrenia. But ultimately, we haven't seen rapid advances in how we treat the mind to mirror those we have seen in treating the body.

"New approaches are targeting chronic inflammation, which has long been linked to brain health"

With estimates of around 8 to 16 per cent of people in a high-income place like England experiencing anxiety or depression, a new perspective is needed. Now, fresh approaches are targeting chronic inflammation, a scourge of modern living that has long been linked to not just heart disease and type 2 diabetes, but also to brain health.

For many of us, persistent, low-level inflammation is a byproduct of our busy lives – it can be caused by stress, obesity and poor diet. But exciting developments suggest we may be able to repurpose some anti-inflammatory medications to benefit our brains, blocking its impact on conditions like depression and dementia (see page 30).

The discoveries also help reveal why many of the actions we can take to manage our mental health – exercising, relaxing, eating well – are beneficial.

This direction won't work for all people living in distress, but with antidepressants failing to help approximately 30 per cent of those treated for depression, a step change is most welcome. ▮

PUBLISHING & COMMERCIAL

Commercial and events director Adrian Newton

Display advertising
Tel +44 (0)203 615 6456
Email displayads@newscientist.com
Sales director Claudia Nicoletti
Account manager Mila Gantcheva
Agency partner Tilly Pollock

Recruitment advertising
Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
Recruitment sales director Viren Vadgama
Key account manager Deepak Wagjiani

New Scientist Events
Tel +44 (0)203 615 6554 **Email** live@newscientist.com
Sales director Jacqui McCarron
Sales manager Maureen Ignacio
Head of event production Martin Davies
Head of product management (Events, Courses & Commercial Projects) Henry Gomm
Marketing manager Emiley Partington
Events and projects executive Georgia Hill
Events team assistant Olivia Abbott
Events co-ordinator Stephanie Best

New Scientist Discovery Tours
Email tours@newscientist.com
Director Kevin Currie
Senior product manager Lara Paxton
Product manager Pip Orchard

Marketing & Data
Marketing director Jo Adams
Head of campaign marketing James Nicholson
Subscription acquisitions manager Molly Hayde
Campaign marketing coordinator Charlotte Weeks
Head of customer experience Emma Robinson
Engagement marketing manager Kelly Spillane
Senior marketing executive Sarah Fabian
Head of CRM & audience data Rachael Dunderdale
Senior email marketing executive Natalie Valls
Email marketing executive Ffion Evans
Digital marketing designer Katarina Pollu
Junior analyst Hamied Fahim

Technology & Product
Head of product Remy Becher
Head of product design Irmak Sunal Lutkin
Director of engineering Michael Ilett
Head of engineering Tom McQuillan
Senior developer and UX designer Amardeep Sian
Senior developers Maria Moreno Garrido, Piotr Walków
Lead digital designer and developer Dan Pudsey
Front end developer Damilola Aigoro
Junior front end developer Matthew Staines

Partnerships
Consultant editor Justin Mullins

NewScientist

Chief executive Roland Agambar
Chief operating officer Jonas Hermans
Chief financial officer Depak Patel
Chair Nina Wright
Executive assistant Lorraine Lodge

Finance & operations
Head of finance Charlotte Lion
Head of finance (maternity cover) Anna Labuz
Management Accountant Ilir Morina
Finance manager Sam Smith
HR business partner Tinka Bleijenberg

CONTACT US

newscientist.com/contact

General & media enquiries
US 600 Fifth Avenue, 7th Floor, NY 10020
UK 9 Derry Street, London, W8 5HY
Australia 58 Gipps Street, Collingwood, Victoria 3066

US Newsstand **Tel** +1 973 909 5819
Distributed by Time Inc. Retail, a division of Meredith Corporation, 6 Upper Pond Road, Parsippany, NJ 07054

Syndication Tribune Content Agency
Tel 1-800-346-8798 **Email** tca-articlesales@tribpub.com

Subscriptions **newscientist.com/subscribe**
Tel 1 888 822 3242
Email subscriptions.us@newscientist.com
Post New Scientist, PO Box 3806, Chesterfield MO 63006-9953

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

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

EDITORIAL

Editor Catherine de Lange
Executive editor Timothy Revell
Managing editor Penny Sarchet
Creative director Craig Mackie

News
News editor Jacob Aron
Assistant news editors Alexandra Thompson, Sam Wong
Reporters (UK) Madeleine Cuff, Michael Le Page, Matthew Sparkes, Alex Wilkins, Carissa Wong (Aus) Alice Klein, James Woodford

Digital
Head of audience Matt Hambly
Podcast editor Rowan Hooper
Head of editorial video David Stock
Social media manager Isabel Baldwin
Video producer Obomate Briggs

Features
Head of features Claudia Canavan
Deputy head of features Joshua Howgego
Editors Abigail Beall, Leah Crane, Kate Douglas, Alison George, Jacklin Kwan, Thomas Lewton, Linda Rodriguez-McRobbie
Feature writer Graham Lawton

Culture and Community
Comment and culture editor Alison Flood
Senior culture editor Liz Else

Magazine
Magazine editor Eleanor Parsons
Assistant magazine editor Michael Dalton

Subeditors
Chief subeditor Kelsey Hayes
Bethan Ackerley, Tom Campbell, Tom Leslie, Jon White

Design
Art editor Ryan Wills
Joe Hetzel, Phoebe Watts

Picture desk
Picture editor Tim Boddy
Assistant picture editor Jenny Quiggin

Production
Production manager Joanne Keogh
Production coordinator Carl Latter

New Scientist US
US editor Chelsea Whyte
Editors Sophie Bushwick, Corryn Wetzel
Subeditor Alexis Wnuk
Deputy audience editor Gerardo Bandera
Reporters James Dinneen, Jeremy Hsu, Karmela Padavic-Callaghan, Grace Wade

~~DISCARD~~

This is a cacao pod. It is a fruit.
The first to be fully upcycled for beverages and snacks.
The broken chocolate industry could
be changed forever by

BLUE STRIPES®

Read on at bluestripes.com

News

Heat warning
Last year saw a record number of hot and humid days p7

Dark matter detector
We may have an unusual use for one of Jupiter's moons p8

Major molecule
Chemical leap could power new technologies p11

Status update
Algorithms not solely to blame for social media toxicity p14

No sweat
Special jacket gets thinner when you get hot p18

Technology

On your marks, get set, fall!

This robot is laid flat on its chest after taking a tumble during the 100-metre sprint at the first World Humanoid Robot Games in Beijing, China. The winning machine completed the race in 21.50 seconds – a far cry from the human world record of 9.58 seconds, set by Usain Bolt in 2009. The games, which saw 280 teams from 16 countries signing up to compete, took place from 15 to 17 August.

SHUTTERSTOCK

Health

A step towards a universal antiviral?

Drugs made from mRNA might be able to protect against a huge range of viruses by turning on key parts of our innate defences against infection, finds **Michael Le Page**

JUST one weekly puff from an inhaler like those used to treat asthma might one day protect you from the viral infections that make winters miserable – and could even save your life in the event of another pandemic.

That is the tantalising prospect raised by promising animal tests of an mRNA treatment that turns on our built-in viral defences. "You can think about this as a universal antiviral," says Dusan Bogunovic at Columbia University in New York.

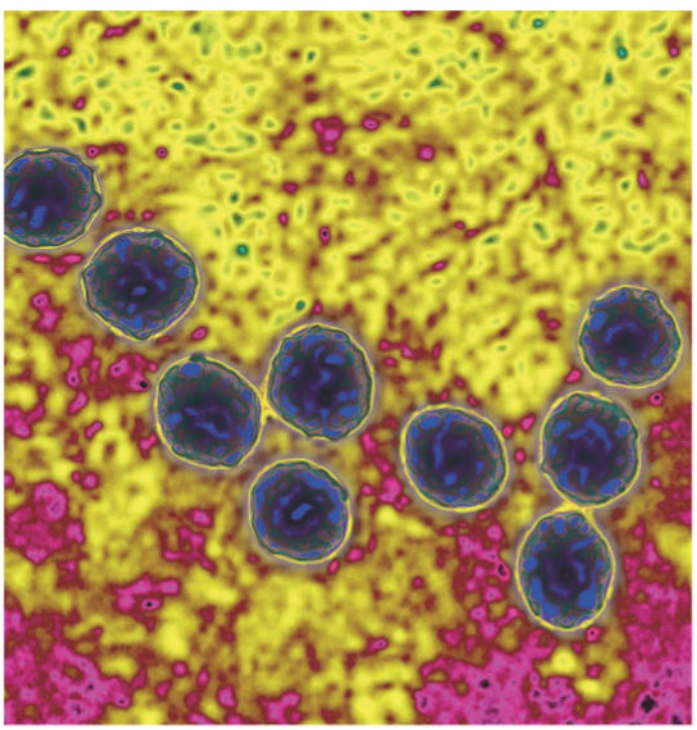
Realising the full promise of this approach will require further development of the mRNA technology used in vaccines – but last week the US slashed funding for mRNA vaccine development. "I would be surprised if it didn't have knock-on effects on efforts like this," says Bogunovic.

In addition to our body learning to recognise and target viruses with antibodies, it has lots of built-in defences. For instance, when a viral infection is detected, cells release a key signalling molecule called interferon. This turns on around 1000 genes, triggering the production of a wide array of antiviral proteins that work in many different ways: some block viral entry to cells; others inhibit the release of new viral particles.

Getting a head start

Not all of these proteins work against all viruses, but in combination they can make a big difference. "Our innate immune system is extremely powerful," says Bogunovic.

The problem is that viruses, especially respiratory ones, replicate really fast, says Bogunovic, so can outpace the body's ability to ramp up its innate defences. But if the body gets a head start on preparing these defences, this can limit viral replication and keep infections mild, even before the rest of the immune system kicks in.



JAMES CAVALLIN/SCIENCE PHOTO LIBRARY

The Zika virus is one of many that mRNA drugs could protect us against

There were hopes that interferon could be used as a general antiviral, but it can have serious side effects. So Bogunovic and his colleagues are instead developing antivirals consisting of subsets of the 1000 proteins whose production is triggered by interferon.

They selected 10 of these proteins and delivered them to cells in the form of mRNAs coding for them. Delivery of mRNA means the proteins are temporarily produced inside cells where they are needed, whereas ready-made proteins are too large to get inside cells in sufficient quantities.

Tests involving infecting human cells with a range of viruses, including flu and Zika, showed that this combination successfully boosted viral defences. In the body, this should provide a crucial head start.

"This is exciting, but we are several steps away from talking about a deployable, versatile countermeasure"

Next, the team delivered these mRNAs to the lungs of golden hamsters. The mRNA cocktail successfully protected these animals against the SARS-CoV-2 virus, which causes covid-19, with a dramatic reduction in viral numbers compared with untreated hamsters (*Science Translational Medicine*, doi.org/g9wx9x).

"I was like, 'Wow, this actually might be a universal antiviral'," says Bogunovic.

Existing antiviral drugs work only against specific viruses, so having a treatment that acts more broadly would be extremely valuable. The development of antibiotics like penicillin that can kill a broad range of bacteria revolutionised medicine.

What's more, some combinations of interferon-triggered proteins might be especially effective against specific viruses, says Bogunovic. So the same approach could also be used to develop more specific antivirals.

Not there yet

Delivering the mRNAs to a high-enough proportion of the specific cells at risk of infection will be crucial. This is where further development is needed, as it is still difficult to deliver mRNAs to specific cell types.

"This is certainly exciting and could lead to very promising advances, but we are several steps down the line away from talking about a deployable, versatile countermeasure," says Aris Katzourakis at the University of Oxford.

"The research highlights the potential of mRNA technology beyond vaccines. The current trajectory in the US with mRNA vaccines will certainly and tragically slow down progress on both of these fronts," he says.

While antibiotic resistance is now a major problem, Bogunovic thinks viruses are unlikely to evolve resistance to this kind of antiviral as long as they include a range of interferon-triggered proteins targeting different aspects of the viral life cycle. This combination approach has proved successful with HIV treatments, for instance. ▮

Ancient humans

Fossil teeth may come from a new species of early hominin

Michael Le Page

THIRTEEN hominin teeth have been discovered in Ethiopia in layers of volcanic ash between 2.6 and 2.8 million years old. Researchers think some of the teeth belong to one of the earliest members of the *Homo* genus, while others appear to be from a new hominin, suggesting both species lived alongside each other.

"The evolutionary tree leading to modern humans could be bushier than we thought"

"They either shared resources, and everything was hunky-dory, or maybe one of them was marginalised," says Kaye Reed at Arizona State University. "We just don't know at this point."

Previous discoveries show that before around 3 million years ago, several species of early hominins in the genus *Australopithecus* lived in this region, including *Australopithecus afarensis*, the species to which the famous Lucy fossil belonged.

From around 2.5 million years ago, the first hominins from the genus *Homo* start appearing, with features more similar to those of modern humans. So what happened in between? To find out, Reed and her colleagues have been digging in an area called Ledi-Geraru, where there are volcanic deposits from this crucial time.

In 2013, her team found a 2.8-million-year-old jaw that appears to be from a *Homo* species, pushing back the origin of this genus. Now her team has found 13 teeth in three different layers of ash.

The teeth in the oldest and the youngest layers – which date to 2.79 and 2.59 million years ago – also belong to the genus *Homo*, according to the researchers. But they think the teeth in the middle layer, which is dated to 2.63 million years ago, are from an *Australopithecus* (*Nature*, doi.org/g9w3qg). The sites are all within a kilometre of each other.

"We were expecting to find more of our genus *Homo*, and then we found *Australopithecus* as well," says Reed.

BRIAN VILLMOARE: UNIVERSITY OF NEVADA LAS VEGAS

***Australopithecus* teeth discovered in layers of volcanic ash in Ethiopia**

What's more, the *Australopithecus* teeth are different enough from those of *A. afarensis* and other australopithecines that the team thinks it is probably a new species. If that is right, it means the evolutionary tree leading to modern humans is bushier and more complex than we thought.

It is a great discovery, says John Hawks at the University of Wisconsin–Madison, but it is hard to draw conclusions based on a few teeth.

"When you find evidence that spans 200,000 years, as these teeth do, you can't be sure that they lived at the same time," says Hawks. "That's a huge amount of time."

The identification of the teeth as separate species is also questionable. "Many fossils that we find combine features that are sometimes found in different species. You can always take a small sample and break it up into the most *Homo*-like and most *Australopithecus*-like," says Hawks.

"The question is what, statistically, you can say, and in this case, the statistics on size measurements don't show that the teeth are very different from each other. They're in the range of overlap of early *Australopithecus* species and early *Homo* species." ▮

Climate change

Dangerously hot and humid days are on the rise

THE planet experienced a record number of dangerously hot, humid days in 2024 as climate change increases global humidity to unprecedented levels.

The global average number of "high humid heat days" over land exceeded the 1991–2020 average by 35.6 days last year, 9.5 days more than the previous record set in 2023, according to the *State of the Climate* report 2024 published by the American Meteorological Society.

VCG/VCG VIA GETTY IMAGES

High temperature and humidity make it far harder for people to stay cool

In hot, humid conditions, people struggle to cool down, as the moist air smothers the evaporative cooling effect of sweating. "Your body starts to really struggle to offload heat, and so it can be really dangerous," says Kate Willett at the UK national weather service, the Met Office, who worked on the report.

Meteorologists measure heat and humidity using a "wet bulb temperature". Traditionally, this is done by sliding a wet cloth over the bulb of a thermometer to account for the cooling effect of evaporating water. It records a lower temperature than one without this set-up, known as a dry bulb, or dry air, thermometer. When humidity levels are higher, the cooling effect from evaporation is more limited, bringing the wet bulb temperature closer to the dry air one.

As the planet warms, the atmosphere is able to hold more moisture, producing not only more intense rainfall and storms, but also higher levels of humidity.

In 2024, some parts of the world, such as the Middle East, South-East Asia and eastern China, saw wet bulb temperatures exceed 29°C (84°F) multiple times, and even hit 31°C (88°F) for short periods. A wet bulb temperature of 35°C was thought to be the limit for survivability. But research out in 2022 suggests the threshold may be around 31°C. ▮

Madeleine Cuff

Health

Living at higher altitudes may help ward off child obesity

Michael Marshall

THE effects of high altitude on the human body could protect against obesity, according to a study of more than 4 million children across Colombia.

The finding fits with existing evidence that high altitudes may help prevent the condition, perhaps because our bodies burn more energy when exposed to lower levels of oxygen. However, most of the research has been on adults.

To understand the potential impact on children, Fernando Lizcano Losada at the University of La Sabana in Chía, Colombia, and his colleagues analysed data on 4.16 million children aged up to 5 years old from 1123 municipalities, compiled by the Colombian Institute of Family Welfare.

The children were separated into four groups relating to the height above sea level at which they lived: up to 1000 metres, 1001 to 2000 metres, 2001 to 3000 metres or above 3000 metres.

In the two lower-altitude regions, around 80 out of every 10,000 children had obesity. However, at altitudes of 2001 to 3000 metres, the prevalence of obesity fell to 40 in 10,000 (medRxiv, doi.org/p2vv).

At altitudes above 3000 metres, the prevalence was higher again: 86 out of 10,000. However, the team says this may be a statistical fluke, as this data set included only seven municipalities and 11,498 people, far fewer than the other three altitude ranges.

"That's a fair comment," says David Stensel at Loughborough University in the UK. But he says it would have been more convincing if the team had been able to show a dose-response curve, with obesity rates falling gradually at ever higher altitudes.

GUILLERMO LEGARIA/GETTY IMAGES

Some high-lying regions of Colombia have less childhood obesity

Stensel also emphasises that the study is observational, so it doesn't prove that high altitude prevents obesity.

"They have tried to make sure that they have adjusted for the potential confounding factors," he says. These included measures of poverty and deprivation. But "you can't account for everything", says Stensel.

Nevertheless, he says such studies are a starting point. "They show us a relationship, and you then need to really design a bespoke study to investigate that hypothesis on its own."

"People's metabolisms may run faster at higher altitudes, meaning they burn more energy"

Lizcano Losada suggests that people's metabolisms may run faster at high altitudes, meaning they burn more energy.

That is possible, says Stensel. "There's a few studies that have shown resting metabolic rate, or basal metabolic rate, increases when you're at high altitude," he says.

For instance, a study from 1984 found that mountaineers lost more weight at high altitude, in part because fat from their food was burned off or excreted before it was converted into tissue.

More recent studies have suggested that low oxygen levels also contribute to a faster metabolism, and that people at high altitudes have elevated levels of the satiety hormone leptin and lower levels of the hunger hormone ghrelin.

Assuming high altitude really does make obesity less likely, Stensel says it isn't clear how this knowledge could be of practical use in reducing the condition. But Lizcano Losada argues that different environmental factors may contribute to obesity in different regions, so people might benefit from more tailored advice. ▮

Space

We could use one of Jupiter's moons to hunt dark matter

Alex Wilkins

JUPITER'S moon Ganymede could be a vast dark matter detector, and upcoming space missions might be able to spot distinctive dark matter craters on its ancient surface.

Physicists searching for dark matter usually look for tiny, extremely light particles that interact weakly with standard matter, requiring large and well-insulated underground detectors. Another kind of dark matter particle could instead be very large – from the size of a basketball to that of an asteroid – but also vanishingly rare. To detect one, you would need a detector the size of a moon or planet.

William DeRocco at the University of Maryland has proposed that the largest moon in the solar system, Ganymede, might contain evidence of these massive dark matter particles. His work suggests they would form distinctive craters in the moon's icy surface that are preserved for millions of years thanks to its geological inactivity.

DeRocco calculated how far a massive dark matter particle would penetrate Ganymede's thick icy shell, and found it would go much deeper than a typical asteroid, reaching into the moon's subsurface ocean and bringing up distinctive minerals (arXiv, doi.org/p2vw).

Upcoming missions to Jupiter and Ganymede, such as NASA's Europa Clipper and ESA's JUICE, could spot signs of these dark matter craters from above. DeRocco calculates they would be relatively small and isolated from other ruptures. The spacecraft could then make further observations.

The proposal is well-thought through, says Bradley Kavanagh at the University of Cantabria in Spain, but there aren't any particularly strong physical reasons for believing such heavy dark matter particles exist. "It's more about trying to look at all the possibilities," he says. ▮

Is this how complex life began?

Connecting tubes between bacteria and archaea could help explain the evolution of complex cells

Chris Simms

MICROBES from a remote bay in Western Australia seem to connect to each other with tiny tubes, forming a relationship that may reflect an early step in the evolution of complex life.

In Shark Bay, or Gathaagudu in the Indigenous Malgana language, microbes form slimy multi-layered communities called microbial mats. It is a harsh environment, but these communities of bacteria and another kind of single-celled organism called archaea have survived here for tens of thousands of years. They often live in symbiosis with each other, building up their communities into layered sedimentary formations called stromatolites.

"The mats form in hyper-saline conditions with high UV levels. They get hit with cyclones. Pretty much everything seems to smash these things, but they still seem to hang around," says Brendan Burns at the University of New South Wales in Sydney.

They are modern analogues of how communities of microbes may have been living together billions of years ago when complex life first evolved, he says. This is theorised to have happened when bacteria and archaea became so mutually dependent on one another that the bacteria ended up living inside the archaea, creating more complex cells known as eukaryotes.

Burns and his colleagues brought some of these microbial mat communities back to their lab and tried growing the organisms in high-salt, low-oxygen conditions.

They ended up with a culture of just one bacterial species, *Stromatodesulfovibrio nilemahensis*, and a newly named archaeon, *Nerearchaeum marumarumayae*, from a group called the Asgard archaea. These archaea are named after the home of the gods in Norse mythology and are thought to be the closest living relatives of eukaryotic cells, which make up our bodies and those of other animals and plants.

"Those organisms seem to be directly interacting with each other and swapping nutrients," says team member Iain Duggin at the University of Technology Sydney. The researchers don't have direct evidence for that, but they do have complete genome sequences, which allow them to infer how the metabolisms of both organisms work.

> **"These organisms seem to be directly interacting with each other and swapping nutrients"**

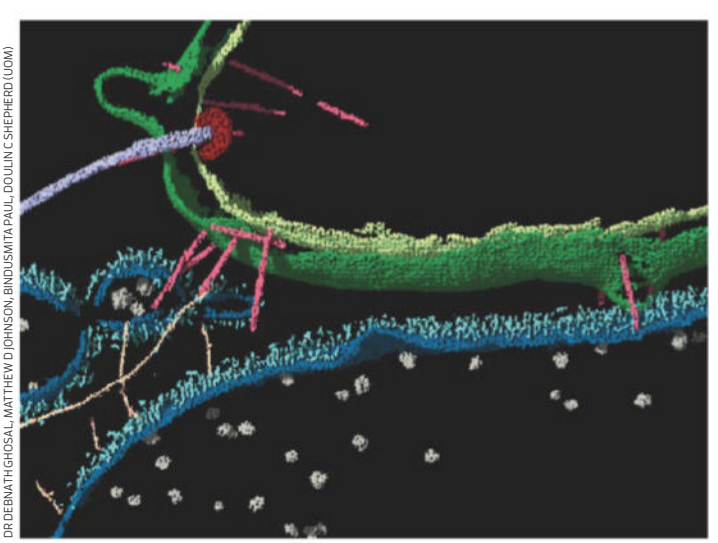
The sequencing showed that the bacterium makes amino acids and vitamins, and the archaeon produces hydrogen and compounds such as acetate, formate and sulphite. Both sets of products aren't made by the other species but would be needed by them.

The researchers also saw hints that the two species were directly interacting. "What we did observe is what we're calling nanotubes," says Duggin. "Little tubes that seem to be made by the bacterium and connect directly to the outside of the Asgard cell."

In what may have been part of the cooperation, the archaeon cells produced chains of vesicles, sac-like structures that cells use to transport molecules, attached by extracellular fibres. Duggin says the little vesicles from the archaeon seem to be interacting with the nanotubes generated by the bacterium.

"The nanotubules may be too thin to be conduits, but they could help bind the cells together in a sort of multicellular union that enables them to better share resources," says Duggin.

The researchers also found genome sequences that code for proteins that have never been seen before; one protein is about 5500 amino acids long, which is very large for an archaeal species, and it bears similarities to proteins in human muscles (bioRxiv, doi.org/p2vt). "I'm not making the assumption that it's a human muscle protein, but it suggests that the evolution of those proteins could have started a very long time ago," says team member Kate Michie at the University of New South Wales.



DR DEBNATH GHOSAL, MATTHEW D JOHNSON, BINDUSMITA PAUL, DOUGLIN C SHEPHERD (UOM)

A bacterium (green) and archaeon (blue) connected by nanotubes (pink)

War and peace

However, it is hard to know what the bacteria and archaea are actually doing, says Buzz Baum at the MRC Laboratory of Molecular Biology in Cambridge, UK. "Bacteria and archaea are at war and peace with each other," he says. "They're touching each other, sharing, fighting and who knows what's going on."

Duggin thinks that in this case it is more likely to be peace than war. "Because these organisms have sort of ended up together in our cultures after four or more years, we think they don't mind each other's company and probably get on pretty well," he says.

Burns and his colleagues propose that what they have seen may reflect an early step in the evolution of eukaryotic cells on microbial mats, which Roland Hatzenpichler at Montana State University says might be possible.

"The study's results show that the newly found Asgard archaea directly interact with sulphate-reducing bacteria, which could provide a driving force to a much closer – and ultimately possibly obligate [dependent] – interaction," he says.

We might never know to what extent modern microbes resemble the cells that partnered up to form the proto-eukaryotic cell, says Hatzenpichler. "But we are now in a better position than ever to approach the truth." ▮

Analysis Technology

Is the artificial intelligence boom slowing down?

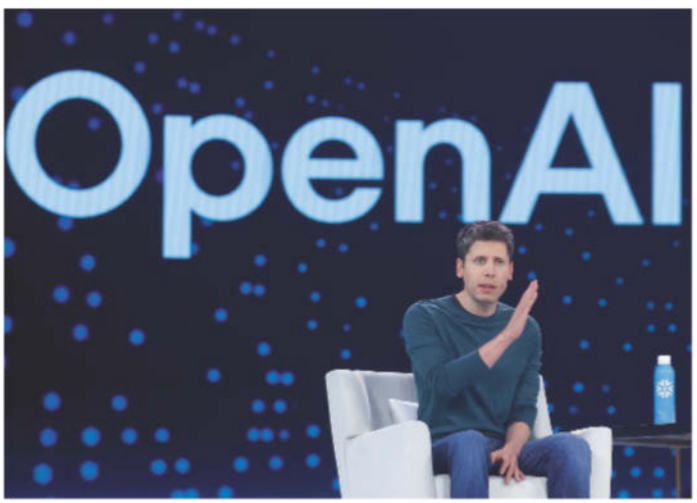
OpenAI's latest large language model has delivered underwhelming improvements, raising questions about where the industry goes from here, finds **Alex Wilkins**

AI'S LATEST step forward isn't so much a giant leap as a tentative shuffle. OpenAI has released its newest AI model, GPT-5, two years after rolling out GPT-4, whose success has driven ChatGPT towards world domination. But despite promises of a similar jump in capability, GPT-5 appears to show little improvement over other leading AI models, hinting that the industry may need a fresh approach to build more intelligent AI systems.

OpenAI's own pronouncements hail GPT-5 as a "significant leap in intelligence" from the company's prior models, showing apparent improvements in programming, visual understanding, health information, mathematics and writing. It also promises less frequent hallucinations, when an AI presents false information as true. On an internal benchmark measuring "performance on complex, economically valuable knowledge work", OpenAI says GPT-5 is "comparable to or better than experts in roughly half the cases... across tasks spanning over 40 occupations including law, logistics, sales, and engineering."

However, GPT-5's performance on public benchmarks isn't dramatically better than leading models from other AI companies, like Anthropic's Claude or Google's Gemini. It has improved on GPT-4, but the difference for many benchmarks is smaller than the leap from GPT-3 to GPT-4. Many ChatGPT customers have also been unimpressed, with examples of GPT-5 failing to answer seemingly simple queries getting widespread attention on social media.

"A lot of people hoped that there would be a breakthrough, and it's not a breakthrough"



JUSTIN SULLIVAN/GETTY IMAGES

OpenAI's Sam Altman says using GPT-5 is like talking to a PhD-level expert

"A lot of people hoped that there would be a breakthrough, and it's not a breakthrough," says Mirella Lapata at the University of Edinburgh, UK.

The most comprehensive measures of GPT-5's performance come from OpenAI itself, since only it has full access to the model. Few details about the internal benchmark have been made public, says Anna Rogers at the IT University of Copenhagen in Denmark. "Hence, it is not something that can be seriously discussed as a scientific claim."

In a press briefing before the model's launch, OpenAI CEO Sam Altman claimed "GPT-5 is the first time that it really feels like talking to an expert in any topic, like a PhD-level expert." But this isn't supported by benchmarks, says Rogers.

GPT-5's apparently modest improvements might be a sign of wider difficulties for AI developers. Until recently, it was thought that such large language models (LLMs) get more capable with more training data and computer power. It appears this is no longer borne out by the results of the latest models, and companies have failed to find better AI system designs than those that have powered ChatGPT. "Everybody has the same recipe right now and we know what the recipe is," says Lapata, referring to the process of pre-training models with a large amount of data and then making adjustments with post-training processes afterwards.

Fierce competition

However, it is difficult to say how close LLMs are to stagnating because we don't know exactly how models like GPT-5 are designed, says Nikos Aletras at the University of Sheffield, UK.

OpenAI has been working on other ways to make its product more efficient, such as GPT-5's new routing system. Unlike previous instances of ChatGPT, where people can choose which AI model to use, GPT-5 now scans requests and directs them to a model that will use an appropriate amount of computational power.

This approach might be adopted more widely, says Lapata. "The reasoning models use a lot of [computation], and this takes time and money," he says. "If you can answer it with a smaller model, we will see more of that in the future." But the move has angered some ChatGPT customers, prompting Altman to say the company is looking at improving this process.

There are more positive signs for the future of AI in a separate OpenAI model that has achieved gold medal scores in elite coding and mathematical competitions in the past month, something that top AI models couldn't do a year ago. While details of how the models work are again scant, OpenAI employees have said its success suggests the system has more general reasoning capabilities.

These competitions are useful for testing models on data they haven't seen during their training, says Aletras, but they are still narrow tests of intelligence. Increasing a model's performance in one area might also make it worse at others, says Lapata, which can be difficult to keep track of.

One area where GPT-5 has significantly improved is its price – Anthropic's best Claude model, for example, costs about 10 times as much to process the same number of requests at the time of writing. But this could present its own problems, if OpenAI's income doesn't cover the vast costs they have committed to in building and running new data centres.

Competition between AI models is fierce, especially with the expectation that the first to pull ahead will take most of the market share. "All these big companies, they're trying to be the one winner, and this is hard," says Lapata. "You're a winner for three months." ▮

Quantum physics

It is impossible to build a practical quantum broadcaster

Karmela Padavic-Callaghan

SHARING quantum information the same way we broadcast TV or radio programmes may be impractical, even for mathematical schemes that sidestep the limitations posed by quantum physics.

We have long known that quantum copy machines could never exist because the laws of quantum physics forbid any piece of quantum information from being duplicated, a rule called the no-cloning theorem. But then physicists started exploring whether they could avoid breaking this law and still distribute – or broadcast – copies of quantum information to many receivers.

To do so, researchers would have to allow the quantum copies to differ slightly and to add new information-processing steps for the receivers. Now, Zhenhuan Liu at Tsinghua University in China and his colleagues have shown that these schemes may be prohibitively impractical.

"There's no 'Ctrl+C' in the quantum world," says Liu. "If you want to send quantum information to multiple receivers, there's no efficient shortcut – you simply have to prepare enough copies and send each of them."

The researchers focused on a previously proposed protocol for "virtual quantum broadcasting", where information is manipulated so that different states are correlated with each other, but aren't direct physical replicas of one another. In this case, the message delivered to each receiver wouldn't be an exact copy, but the copies would share enough properties to be useful. It is comparable to a situation in which a TV network simultaneously broadcasts a slightly different drama to each household, but keeps the story, on average, the same. Although this protocol certainly works, says team member Xiangjing Liu at the National University of Singapore, they wanted to know if it is efficient.

"If you want to send quantum information to multiple receivers, there's no efficient shortcut"

The researchers quantified how much effort receivers would have to go through for the information that reaches them to be useful, despite not being identical. This mathematical analysis led them to conclude that practical quantum broadcasting may just not exist (*Physical Review Letters*, in press).

Counterintuitively, even this tweaked version of the quantum broadcasting approach – akin to sending a group text where everyone receives a message at once – would require more resources than a technique more like writing an individual letter to every receiver from scratch, says team member Yunlong Xiao at the Agency for Science, Technology and Research in Singapore.

"If your sole goal is simply distributing quantum states to different places, I think looking into... virtual quantum broadcasting is certainly a wrong approach," says Seok Hyung Lie at Ulsan National Institute of Science and Technology in South Korea. He says the protocol had always been conceived as an investigation into the fundamental constraints on processes in quantum information theory, rather than a practical recipe for quantum communication.

Going forward, the researchers are also interested in the theoretical lessons of their current analysis. It could help us understand just what correlations – whether between quantum states distributed in space, or sent one after another in time – can be manipulated. Xianjing Liu says the work may become part of a new framework for understanding quantum processes, one that separates time and space less than traditional approaches. ▮

Chemistry

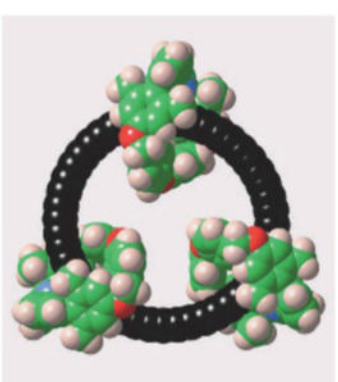
New carbon molecule acts like an infinite chain

A NOVEL type of all-carbon molecule has been studied under room-temperature conditions. This marks only the second time this has been done, after spherical buckyballs were synthesised 35 years ago. The breakthrough could lead to extremely efficient materials for electronic and quantum technologies.

Cyclic carbons, molecules made up of a ring of carbon atoms, could display bizarre chemical behaviour or conduct electricity in unusual ways. But these rings are so delicate they usually fall apart, or even explode, before researchers can study them.

"Cyclic carbons are intriguing molecules, and we've been trying to make them for a long time," says Harry Anderson at the University of Oxford. Doing so has traditionally required extremely harsh conditions to keep the molecules around long enough to be studied. But Anderson and his colleagues found a way to stabilise them at room temperature.

The technique involves modifying a cyclic carbon. The researchers demonstrated this on a never-before-studied molecule: a ring of 48 carbon atoms, called cyclo[48] carbon, or C48. They added "bumpers" to the C48, threading it through three smaller rings, to protect the 48 atoms from colliding with each other – or other molecules (*Science*, doi.org/g9w484).



HARRY ANDERSON

The cyclic carbon molecule had "bumpers" (green) added to it to stop atoms from colliding

The new structure, called cyclo[48]carbon [4]catenane, remained stable enough to study for about two days, enabling researchers to examine cyclo[48] carbon in detail for the first time. Intriguingly, the molecule's 48 carbons acted like they were arranged in an infinite chain, a structure theoretically capable of transferring electric charge from one atom to the next indefinitely.

This electricity-conducting potential hints cyclic carbons could be used in a range of next-generation technologies, including transistors, solar cells, semiconductors and quantum devices. However, further research is needed to confirm this. ▮

Meagan Mulcair

Health

Vanishing Y linked to heart disease

Another connection has been found between loss of the Y chromosome and men's heart health

Liam Drew

MEN who lose their Y chromosome from a significant number of their immune cells are more likely to have narrow blood vessels, a key contributor to heart disease.

"Loss of Y is killing a lot of men," says Kenneth Walsh at the University of Virginia, who wasn't involved in the study.

The loss of the Y chromosome is the most common mutation that occurs post-conception in males. It typically takes place in white blood cells, immune cells that attack and eliminate pathogens, as the rapidly proliferating stem cells that generate white blood cells divide. Cells that lack Y accumulate with age, becoming readily detectable in roughly 40 per cent of 70-year-old cisgender men.

In 2014, Lars Forsberg at Uppsala University in Sweden and his colleagues found that older men with significant loss of Y in their blood died, on average, five and a half years earlier than those without it. Walsh later linked it to heart disease.

Now, Forsberg and his colleagues have gained further insights from the Swedish Cardiopulmonary Bioimage Study, which gathered detailed blood vessel scans from just over 30,150 volunteers aged 50 to 64, about half of whom were male. No volunteers showed signs of cardiovascular disease, but were still assessed for blood vessel narrowing, or atherosclerosis.

> "The loss of the Y chromosome is the most common mutation post-conception in males"

Nearly 12,400 of the male participants had the genetic data needed to assess their degree of loss of Y. They were split into three groups: those with undetectable loss of Y in their white blood cells, those with loss of Y that affected 10 per cent or less of these cells, and those whose loss of Y affected more than 10 per cent of them. Each group's atherosclerosis scores were compared against each other's and the study's female participants.

Nearly 75 per cent of the men with the most loss of Y had narrowed blood vessels, compared with roughly 60 per cent of those who had 10 per cent or less of their cells affected by the mutation (medRxiv, doi.org/g9vfjk).

But atherosclerosis was still observed in around 55 per cent of the men with an undetectable loss of Y and in around 30 per cent of the female participants. "Obviously, [loss of Y] is not explaining the entire sex difference," says Forsberg. "There are other factors."

The study comes months after Thimoteus Speer at Goethe University Frankfurt in Germany and his colleagues looked at men who underwent an angiography – a type of X-ray used to check blood vessels – for suspected cardiovascular disease. They found that, over the subsequent decade, those with loss of Y in more than 17 per cent of their immune cells were more than twice as likely to die of a heart attack than those with fewer affected cells.

"The results of Lars Forsberg's and our studies are quite consistent," says Speer. "He sees more coronary atherosclerosis, and we observe a higher risk for patients to die due to myocardial infarction [heart attack], as the end point, I would say, of coronary atherosclerosis."

Walsh notes that neither study definitively shows loss of Y caused these outcomes. However, statistical analyses by both groups suggest it acts independently of smoking or ageing, the biggest risk factors for the mutation.

Speer and Walsh say more research is needed to understand how the loss of Y acts. ▮

Space

Oldest fast radio burst sheds light on early star formation

A STRANGE flash of light from near the beginning of the universe could help astronomers map difficult-to-see gas in between galaxies.

Fast radio bursts (FRBs) are extremely short but powerful blasts of radio-frequency light that have puzzled astronomers since they were first spotted in 2007. A leading theory is that they are produced by extremely magnetic neutron stars, called magnetars. But we have only a few thousand examples, so there is much we don't know about them.

Now, Manisha Caleb at the University of Sydney and her colleagues have spotted an extremely distant FRB from a galaxy that existed just 3 billion years after the start of the universe, billions of years before the previous record holder.

Caleb and her team first spotted the burst, called 20240304B, using the MeerKAT radio telescope in South Africa in March 2024 and followed up the source with observations from the James Webb Space Telescope. They found the flash came from a small, faint galaxy that was relatively young when the FRB was emitted and had formed its stars quickly (arXiv, doi.org/g9wsv9).

FRB 20240304B comes from a time in the universe called cosmic noon, when the rate of new stars forming was at its peak. This, along with the galaxy's age at that time, might suggest that this FRB, and others, come from young stars that had only just exploded in supernovae and collapsed into magnetars, says Jason Hessels at the University of Amsterdam in the Netherlands.

VICTOR HABBICK VISIONS/SCIENCE PHOTO LIBRARY/ALAMY

Fast radio bursts have puzzled astronomers ever since they were discovered

One reason astronomers are interested in FRBs is that the universe is full of ionised gas, which has lost its electrons due to radiation produced by stars. This gas makes up the vast majority of all matter in the universe, and understanding its distribution is key to working out how larger objects, like stars and galaxies, formed.

Because FRB 20240304B was active during a time in the universe's history when the first stars were forming and ionising the gas around them, we can use it to build a timeline of when those stars first switched on, says Anastasia Fialkov at the University of Cambridge. ▮

Alex Wilkins

Physics

Atoms that refuse to heat up offer hints of new physics

Karmela Padavic-Callaghan

REPEATEDLY energising a collection of ultracold atoms should destroy their collective structure, but quantum effects seem to counteract the process.

The fate of any physical system ought to be "thermalisation", a process by which everything becomes even and featureless, like an ice sculpture melting into a puddle of water. We would assume throwing rocks at the sculpture could only speed this up, but Hanns-Christoph Nägerl at the University of Innsbruck in Austria and his colleagues essentially did this to some of the coldest atoms on the planet and did not see them thermalise (*Science*, doi.org/p2vh).

The researchers used about 100,000 atoms of caesium, which they cooled to within billionths of a degree of absolute zero by hitting them with lasers and electromagnetic forces. At this temperature, the behaviour of atoms is fully quantum. The team arranged the atoms into thousands of one-atom-thick tubes. Then, they started "kicking" them by shining an extra laser pulse on the tubes.

Because these kicks gave the atoms extra energy, it should have made them heat up and fly away at different velocities. Team member Yanliang Guo says they never saw this happen, even as he and his colleagues applied more energetic kicks and tweaked how strongly the atoms interacted with each other.

The idea of quantum particles beating thermalisation dates to the 1950s, but physicists have long debated when this can happen. Team member Manuele Landini says previous experiments that explored how kicking the atoms affects their thermalisation found they do succumb to the process, but his team's experiment explored a different range of parameters, like kicking strength, so it may have captured as-yet-unknown physics. ▮

Climate change

Megadrought in western US could persist for decades

James Dinneen

JUSTIN SULLIVAN/GETTY IMAGES

Places like California might continue to see a lack of precipitation

WATERS in the northern Pacific Ocean naturally cycle between patterns of cool and warm temperatures every few decades. But hundreds of simulations from climate models suggest human-caused warming may have locked this cycle into a pattern that is driving a megadrought in the western US.

Since the 1850s, sea surface temperatures in the northern Pacific Ocean have regularly alternated between a positive phase, with temperatures above average in key parts of the ocean, and a negative one, characterised by cooler-than-average temperatures. This slow cycle, which takes place over the course of decades, is called the Pacific Decadal Oscillation (PDO).

However, since the late 1980s, this cycle has undergone an extended negative trend. The ocean's surface has maintained a horseshoe shape of cooler-than-average water surrounding a warmer interior. In July, this negative phase saw its cooler-than-average temperature anomaly hit a new record.

In previous research, climate models suggested this long-term trend could occur naturally – but it would be a rare once-in-a-millennium event. Jeremy Klavans at the University of Colorado, Boulder, and his colleagues found that unlikely.

Global warming due to emissions caused by human activity could play a role, but working out whether this had any influence was hard, since the signal of that influence was weak in the climate models.

To isolate the signal, Klavans and his colleagues looked at changes in Pacific

"Drought has already parched the western US since the turn of the century"

Ocean temperatures across nearly 600 simulations of the planet's climate.

Up to 1950, the researchers found anthropogenic emissions could explain almost none of the changes in the cycle. However, from 1950 on, changes in emissions could explain about half of the shift. Between 1950 and the 1980s, they found aerosol pollution – which creates a cooling effect by reflecting sunlight – pushed the PDO towards its positive phase. Between 1980 and 2014, a reduction in aerosol pollution in the northern hemisphere, along with the warming effect of greenhouse gases, pushed the PDO towards its negative phase (*Nature*, doi.org/p2r3).

The researchers' simulations end in 2014, but the negative trend has continued over the past decade. It persisted despite two El Niños, which are ocean-warming events, that were expected to flip the PDO back to its positive phase, says Pedro DiNezio, also at the University of Colorado, Boulder. In a related study, the researchers modelled how further warming would influence the negative trend.

"We looked into the future, and models make it persist for at least a few more decades," says DiNezio.

That is a problem for the western US, as the PDO's negative phase keeps winter precipitation below average in much of this region. This shift contributes to the exceptionally long megadrought that has parched the western US since the turn of the century.

These results are surprising because of "the inherited wisdom that the PDO-like pattern is something that arises from internal variability", says Tripti Bhattacharya at Syracuse University in New York state.

Determining how much these trends are due to carbon emissions,"is one of the most fundamental science questions in Earth system science", says Gerald Meehl at the US National Center for Atmospheric Research in Colorado. ▮

Climate change

Extreme heat is driving decline in tropical birds

Michael Le Page

JUERGEN RITTERBACH/ALAMY

Birds like the northern black-throated trogon are under threat

IN TROPICAL regions such as the Amazon and Panama, the populations of some birds have fallen by as much as 90 per cent even in mostly untouched rainforests – and it seems more intense heat extremes are the main factor behind the decline.

Between 1950 and 2020, the intensification of heat extremes led to a fall of between 25 and 38 per cent in the abundance of land-dwelling birds in the tropics, according to a study by Maximilian Kotz at the Barcelona Supercomputing Center and his colleagues.

The team hasn't yet used these results to try to project what will happen as the planet continues to heat up, but "it's not a good-looking picture," says Kotz.

He and his colleagues started with data on land-dwelling bird populations around the world from the Living Planet Database. They then got data on habitat destruction from the Hyde Database of the Global Environment and historical weather and climate data from the European Centre for Medium-range Weather Forecasts.

The researchers compared all this data to find correlations that might explain the fall in bird abundance. In the mid-latitudes between 21° and 43° north or south, habitat destruction was the main factor, their findings suggest.

But in the tropics, heat extremes were the biggest factor (*Nature Ecology & Evolution*, doi.org/g9wrfv). In these regions, birds are often living near the limits of their tolerance and die if those limits are exceeded, says Kotz.

Next, they investigated the extent to which the intensification in heat extremes is due to human-caused global warming. This allowed them to estimate the decline in bird abundance that is attributable to climate change.

Attribution studies like this have long been used to assess the link between extreme weather and climate change, but, says Kotz, as far as he knows, this study is the first to use them to look at ecological impacts in this way.

There are big gaps in the data on bird abundance, particularly in the tropics, acknowledges Kotz. But if anything, the lack of data would lead to an underestimate of the impacts, he says. ▮

Technology

Algorithms not to blame for social media toxicity

Chris Stokel-Walker

THE polarising impact of social media isn't just the result of bad algorithms – it is inevitable because of the core components of how the platforms work, AI-based simulations suggest.

Petter Törnberg at the University of Amsterdam in the Netherlands and his colleagues set up 500 AI chatbots designed to mimic a range of political beliefs in the US, based on the American National Election Studies Survey. Those bots, powered by the GPT-4o mini large language model, were then instructed to interact with one another on a social network the researchers had designed with no ads or algorithms.

During five runs of the experiment, each involving 10,000 actions, the AI agents tended to follow people with whom they shared political affiliations, while those with more partisan views gained more followers and reposts. This echoed overall attention towards those users, which gravitated towards more partisan posters.

In a previous study, Törnberg and his colleagues found that simulated social networks with different algorithms could identify routes to tamp down political polarisation – but the new research seems to contradict their earlier findings. "We were expecting this [polarisation] to be something that's driven by algorithms," says Törnberg.

"Most social media activities are always the fruit of the poisonous tree"

Instead, they found it wasn't the algorithms that seemed to be causing the issue, which could make it harder to weed out antagonistic user behaviour just by making corrections to social media platforms. "We set up the simplest platform we could imagine, and then, boom, we already have these outcomes," he says. "That already suggests that this is stemming from something very fundamental to the fact that we have posting behaviour, reposting and following."

To see whether that behaviour could be muted or countered, the researchers also tested six potential solutions, including a solely chronological feed, giving less prominence to viral content, and hiding profile bios.

Most of the interventions made little difference: mixing across political parties changed by no more than about 6 per cent, and the share of attention hogged by top accounts shifted between 2 and 6 per cent – while others, such as hiding biographies of the users involved, actually made the problem worse (arXiv, doi.org/kx5c). Fixes that reduced such inequality among users made extreme posts more popular, while alterations to soften partisanship funnelled even more attention to a small elite.

"Most social media activities are always fruit of the poisonous tree – the beginning problems of social media always lie with their foundational design, and as such can encourage the worst of human behaviour," says Jess Maddox at the University of Georgia.

While the experiment is a simulation that could simplify some mechanisms, Törnberg thinks it can tell us what social platforms need to do to reduce polarisation. "We might need more fundamental interventions and need more fundamental rethinking," he says. ▮

"A key requirement of the winning innovation is for it to adapt over time"

Harnessing the power of tech and AI to help people with dementia stay independent for longer

Alzheimer's Society, Innovate UK and Challenge Works have launched the Longitude Prize on Dementia – a competition with a £4million prize fund to find innovators who can create ground-breaking technologies to help people with dementia stay independent for longer.

The aim of each innovation is to enable people to live fulfilling lives and to be able to do the things they enjoy for longer.

With the progressive nature of dementia, a key requirement of the winning innovation is for it to adapt over time, providing growing support as a person's abilities decline. This work is vital as the number of those living with dementia rises every year, with over 1.4m predicted to be living with dementia in 2040 – 40% percent more than today.

Alongside funding to help them develop their ideas, innovators have access to crucial insight and dementia experts as well as specialist facilities.

So how will the winner be decided? Alongside expert judges is an international panel of people with lived experience of dementia. They're closely involved in the development of the innovation itself, providing feedback at each stage of the competition, recommending the best ways to involve people affected by dementia and helping test the tech.

The five finalist teams have been announced, with innovations including:

- **A smartwatch and smartphone-based app that uses AI to help people perform daily tasks independently**
- **Sensors that help identify and even predict falls**
- **A phone that prompts people in daily activities as well as connecting them to loved ones via intuitive video calls**
- **High-tech specs for facial recognition**
- **A home hub that helps alert families to missed medication or broken heating systems**

The overall winner will be awarded £1million in 2026 to help them bring their solution to market. The product will improve the lives of people affected by dementia by helping them to live more independent and fulfilled lives.

Find out more at alzheimers.org.uk/longitudeprize

Alzheimer's Society

It will take a society to beat dementia

Health

How a psychedelic may treat PTSD

A plant-derived drug may ease symptoms by inducing the brain's ability to rewire itself

Grace Wade

PEOPLE with traumatic brain injury often experience post-traumatic stress disorder (PTSD), and the psychedelic drug ibogaine seems to alleviate these symptoms – which it may do by slowing down brainwaves.

Last year, a study found that ibogaine – a psychedelic substance derived from the African iboga plant – significantly improved mental and physical health in military veterans with traumatic brain injury. But it wasn't clear how the drug produced these effects.

So, Jennifer Lissemore at Stanford University in California and her colleagues analysed brain scans of the original study's 30 participants, all of whom were men from the US with traumatic brain injury, and most of whom also had PTSD. The participants had received ibogaine at a dose of 12 milligrams per kilogram of body weight during a five-day stay at a treatment facility in Mexico. They also saw a therapist, and had access to activities like yoga.

Throughout the original study, researchers took electroencephalogram (EEG) recordings – which measure electrical activity in the brain – of the participants. These scans were collected two to three days before ibogaine therapy, 3.5 days after and again one month later.

Comparing those EEG results, Lissemore and her colleagues found that, on average, faster brainwaves decreased in strength after ibogaine therapy, while slower ones did the opposite. For instance, days after taking ibogaine, the strength of gamma waves – the fastest type of brainwave – fell nearly 16 per cent, on average, in brain regions at the back of the head. These waves increased slightly in intensity one month later, but were still significantly lower than before the therapy.

Meanwhile, the intensity of slower, theta waves increased almost 17 per cent in the back of the brain and 13 per cent in the front of the brain 3.5 days after taking ibogaine. However, this difference was not significant one month later (*Nature Mental Health*, doi.org/p2pn).

"The slowing of brainwaves may explain why ibogaine reduced PTSD symptoms for most participants"

Lissemore believes the slowing of brainwaves may explain why ibogaine reduced PTSD symptoms for the majority of participants. "The slowing of brain activity went hand in hand with patients who were struggling with hyperarousal, hypervigilance and PTSD symptoms," she says. "Those symptoms were improved drastically, and so one way to think of this slowing of brain activity is [as] a decrease in that hyperarousal that is a problem in PTSD."

The temporary increase in slower theta waves suggests ibogaine induces neuroplasticity, or the brain's ability to rewire itself. Studies in rodents have linked theta waves to plasticity in the brain, says Lissemore. By inducing short-term increases in theta waves, ibogaine may allow the brain to remodel itself in a way that improves mental health, she says.

"Ibogaine is basically targeting this very messy, restless brain and allowing it to kind of normalise," says Conor Murray at the University of California, Los Angeles. However, we still don't know exactly how it induces these changes, he notes. ▮

Always speak with your doctor before changing any medication

Entomology

Heave! These ants are nature's true tug-of-war champs

A CHAIN of weaver ants can easily outpull just about any other creature, pound for pound, making them one of the most formidable teams in the animal kingdom.

The insects (*Oecophylla smaragdina*), which are found from India to northern Australia, form long chains to pull on leaves and roll them up for building their nests. They lock themselves together by using their mandibles to hold onto the abdomen of the ant in front.

To determine just how strong they are, Chris Reid at Macquarie University in Sydney and his colleagues offered weaver ants paper leaves instead of real ones to build a nest. They attached a transducer to the tip of the paper leaf to measure the amount of force that groups of up to 17 ants were applying when they rolled up the paper.

DR CHRIS REID, MACQUARIE UNIVERSITY

Weaver ants link up to form long chains to pull down on leaves or, in this case, paper

The researchers found that individual ants can generate an average of nearly 60 times their own body weight in pulling force, but in a team of 15, each individual was able to pull over 100 times their body weight. This means that the average force contribution per individual almost doubled in the team (*Current Biology*, doi.org/g9wt2q).

This result appears to contradict a longstanding principle of teamwork known as the Ringelmann effect, in which the bigger a group, the less productive each individual becomes.

While the researchers didn't do the maths on how weaver ants would perform relative to humans, Reid says they would make a formidable foe in a tug of war, even if they weren't scaled up to human size. "Even at guinea pig size, weaver ants might be able to outcompete humans in a tug-of-war match," he says. ▮

James Woodford


The notebooks LOVED
by 500,000 people
NOTEBOOK
marie
clarke
PAPIER
PAPIER

Environment

Is climate change making trees more flammable?

Madeleine Cuff

REBECCA KOLL

A western juniper tree is burned to test its flammability

TUCKED away in a laboratory at the University of Exeter in the UK, Rebecca Koll is setting conifer trees alight in the hope of answering burning questions about the future of forest fires.

Wildfires are growing in severity around the world as the climate warms. This is largely driven by increasing heat, drought and wind speeds making trees more likely to burn when sparks fly.

But Koll is among a group of researchers who suspect it isn't just drought and other direct effects that are boosting the risk of fires. "Is climate change actually changing the plants themselves? We're pretty sure it is," she says.

She believes the leaf chemistry of trees is being altered by climate stressors such as increasing ultraviolet radiation, which makes plants produce more airborne chemicals – known as volatiles – in a type of stress response.

Studies have shown that exposing some food and medicinal crops to higher levels of a type of UV called UVB triggers an increase in volatile compounds in their leaves. Separate analysis indicates that high levels of volatiles in conifers, such as pine trees, increase their flammability.

Although international efforts to repair the ozone layer are helping to protect the planet from UV radiation, research suggests the effects of climate change, including an increase in hot, clear days in northern

"This is why your house may burn down. The surrounding area gets more flammable"

and eastern Europe, have caused an increase in the amount of UV radiation hitting ground level in recent years. Models suggest this problem could become more acute in the second half of the century.

Koll is now working on a project to expose 87 coniferous tree species to increased levels of UVB to assess any changes in their leaf chemistry and flammability. The trees are being kept for weeks at a time in climate-controlled chambers with optimum temperature and watering schedules but varying levels of UVB – up to triple the exposure trees experience in today's climate. After either four or eight weeks of treatment, the trees are analysed and then burned to assess their flammability.

Koll expects to uncover changes in the plants' leaf chemistry. In the chamber, the treated trees are already displaying yellowing patches in the place of healthy greenery. "The way that plants respond in other tests, in other experimentation... it does change the leaf chemistry," she says.

The question is whether these changes result in enhanced flammability, and whether this could help explain the increasing severity of forest fires.

Discovering the answer could help scientists better understand the wildfire risk in coniferous forests, which dominate much of the northern hemisphere. "This is actually why your house may burn down," says Koll. "The actual nature, the natural environment of the surrounding area, gets more flammable."

Matthew Robson at the University of Cumbria in the UK says the project could prove that changes in leaf compounds are an important factor in tree flammability for certain species. "The relative importance of these effects of climate on volatile and flammable carbon-rich compounds... is not yet well studied – which is something that makes the current research at the University of Exeter exciting," he says. ▮

Technology

No more sweating over whether to wear a jacket

Alex Wilkins

IF YOU find yourself endlessly taking your jacket on and off as the sun moves in and out of the clouds, a material that becomes thinner when you sweat could provide a solution.

Researchers have previously developed self-adapting materials that cool you down in hot climates by increasing the amount of heat, in the form of infrared radiation, the material lets through. But these materials are poor at keeping people warm in cooler climates.

Xiuqiang Li at Nanjing University of Aeronautics and Astronautics in China and his colleagues have developed a jacket that contains a layer that curves when dry and flattens when wet. This makes the jacket get thicker in cooler environments and thinner in warm ones, triggered by a person's sweat.

The clothing has a similar design to regular down jackets, but contains a layer of cellulose produced by bacteria, which is then reinforced with polyester to make it strong enough to expand an outer layer of fabric. Li and his colleagues found that the cellulose layer, which becomes predictably more curved as it dries, can remain fixed in place at one angle for 12 hours, and still works after 200 cycles of changing from flat to curved (*Science Advances*, doi.org/p2q7).

The team tested how much heat the material kept in while on top of cloth with varying levels of moisture, finding it to be as cool as a polyester shirt when wet and almost as warm as a down jacket when dry.

These tests were equivalent to wearing the material on bare skin. If the material is worn over multiple layers of clothing, it could affect the speed and efficiency of the material's thinning response, says team member Xiaofeng Jiang.

With this in mind, the team aims to develop the textile so it is warm enough to wear without needing additional layers. ▮

Archaeology

Medieval migration uncovered

DNA analysis has found evidence of people in 7th-century Britain with West African ancestry

Chris Simms

TWO unrelated young people buried in cemeteries in England in the Early Middle Ages probably had grandparents from West Africa. The discovery implies that migrants in Anglo-Saxon times were coming from much further afield than previously thought.

After the Romans finally withdrew from Britain in AD 410, Britain was invaded and settled by Germanic Angles, Saxons and Jutes. To investigate whether people also arrived from elsewhere, Duncan Sayer at the University of Central Lancashire, UK, and his colleagues have analysed ancient DNA from the bones of people buried in two 7th-century cemeteries on England's southern coast.

One is in Updown in Kent, where many traded objects from around the world have been found. The people there were often buried with items like cookware or combs.

The other is in Worth Matravers, Dorset, where people are buried in a Romano-British manner, with few grave goods.

The majority of those in the cemeteries had, as expected, either northern European or western British and Irish ancestry, but a girl at Updown and a young man at Worth Matravers had a recent ancestor from West Africa.

In both cases, the mitochondrial DNA, which is passed down from the mother, was northern European, but the autosomal DNA, which comes from both parents equally, had 20 to 40 per cent ancestry akin to that of the present-day Yoruba, Mende, Mandinka and Esan groups from sub-Saharan West Africa (*Antiquity*, doi.org/p2rw).

A young man (left) buried at Worth Matravers, in Dorset, had some West African DNA

LILIAN LADLE

This means the West African DNA probably comes from a grandfather – and it is the first evidence for genetic connections between Britain and Africa during the Early Middle Ages.

Looking at the ratios of isotopes of carbon and nitrogen in a bone sample from the Worth Matravers youth, who was aged between 17 and 25 when he died, showed what he had eaten when the bones were forming (*Antiquity*, doi.org/p2vk).

"From his diet, it looks like he was most likely raised in England," says team member Ceiridwen Edwards at the University of Huddersfield, UK.

There is evidence for African heritage in York in the Roman period, says Edwards. However, Sayer thinks the proportion of West African DNA in the youngsters would be far lower if they were descendants of people from the days of Roman rule.

There is also no evidence to suggest that these people were slaves, he says: "These individuals are being buried as fully fledged members of their community."

Instead, he suggests, this is to do with trading and the movement of goods and people. At some point, people from West Africa had come to Britain, perhaps on a trading ship, and stayed.

Sayer thinks their arrival may have been linked to the reconquest of North Africa by the Byzantine Empire in the 6th century. "The reopening of this channel is taking place at a time that would correspond very much with the grandparents of these two people," he says.

Marina Soares Da Silva at the Francis Crick Institute in London thinks this is "a valid possibility". ▮

Health

Vape mouthpieces could be swarming with harmful fungi

AN ARRAY of fungi, some of which have been linked to lung complications, have been collected from e-cigarette mouthpieces.

In vapes, a battery-powered coil heats a liquid that typically contains nicotine, producing vapour that is inhaled by users. Health concerns have largely centred on the toxicity of the liquid's chemical constituents, so no one has tried to understand which microbes may make their way from the devices into users' airways.

To learn more, Borna Mehrad and his colleagues at the University of Florida recruited 25 people who used disposable vapes every day. The team cultured the microbes from the mouthpieces of these devices, comparing them with those in the volunteers' mouths.

Only a small number of the vapes contained bacteria. But according to the researchers, more than half were "abundantly colonized" with fungal species that were distinct from those in the volunteers' mouths – and 80 per cent of them are capable of causing ill health in people (bioRxiv, doi.org/p2rs).

The most common of these species was *Cystobasidium minutum*, which has been linked to blood infections among people with suppressed immune systems. To understand how it could affect the lungs, the team had mice inhale *C. minutum*, mimicking the entry method of vaping.

"We found that the fungus that was most prevalent in the vape samples caused features of chronic bronchitis in mice," says Mehrad. This is defined as inflammation of the airways, which can cause flu-like symptoms.

MATTHEW HORWOOD/GETTY IMAGES

A range of fungal species were found on disposable vapes

As to where these fungi came from, team member Jason Smith says they may have already been in the vape liquids when purchased, though the researchers didn't test them for this.

Ian Musgrave at the University of Adelaide in Australia says fungi have been found in shisha, also known as hookahs or waterpipes, and there is evidence that this method of smoking has contributed to microbial-induced lung disease.

Musgrave recommends vapes be cleaned regularly, but stresses there isn't enough evidence to conclude that these fungal species exist in high enough numbers on vape mouthpieces to cause ill health. ▮

James Woodford

Views

Comment

Free for all

It is high time we established free internet access as a standalone human right enshrined in law, says **Merten Reglitz**

IN 2024, 2.6 billion people – nearly a third of humanity – remained offline, the International Telecommunication Union (ITU) reported. The same year, non-profit Freedom House estimated that more than three-quarters of those who had internet access lived in countries where people were arrested for posting political, social or religious content online, and almost two-thirds of all global internet users were subject to online censorship.

This should bother us, because whether people have internet access and the quality of that access matter deeply for what kind of life they can live. Free and unimpeded internet access is no longer a convenience or a luxury.

Human rights, as first set out by the United Nations General Assembly in a milestone document in 1948, ensure that we can live minimally decent lives. But in our digitised world, people's opportunities to exercise their human rights to everything from free speech to free primary education are all significantly determined by their access to the internet. For example, access to many public services has moved online, and in some places online services are the most feasible alternatives to absent brick-and-mortar banks, schools and healthcare facilities.

That fundamental importance to life today means that free access to the internet now needs to be recognised as a standalone human right by the UN and nation states.

SIMONE ROTELLA

This recognition would provide a guarantee backed by international law, and obligations of international financial support where nations end up falling short.

The ITU estimates that it would cost nearly $428 billion to establish universal broadband coverage by 2030. That is a large sum. However, connecting the rest of humanity would have enormous benefits, as it would allow people to become better educated, more economically active and healthier.

In fact, guarantees of a minimum level of connectivity are already feasible goals: providing people with 4G mobile broadband network coverage, permanent access to a smartphone, affordable data that costs no more than 2 per cent of monthly gross national income per capita for 2GB and opportunities for acquiring basic digital skills.

But only internet access of a certain quality is beneficial for human rights and, as the UN has argued, contributes to the "progress of humankind as a whole". When the internet is used to monitor populations to identify opposition to political power, to collect private data to maximise profits, or to misinform and generate interpersonal strife, it becomes a technology of repression rather than of empowerment. Recognising a human right to internet access creates duties of protection for national governments.

This right would demand that states respect internet users' privacy, instead of spying on them, censoring information or manipulating through online propaganda. It would demand that businesses respect people's human rights, particularly the right to privacy, rather than obtaining a plethora of personal information. And it would call for the regulation of social media, forcing corporations to fight disinformation and abuse on their platforms.

In 2016, the UN recognised that "'rights that people have offline must also be protected online". But it didn't recognise a standalone human right to free internet access, despite this first being proposed as a possibility in 2003.

It is now time to act. Above all, a human right to free internet access is a call to political action. We cannot afford to lose the fight for the internet as a medium that promotes human progress, rather than one that undermines it. Establishing this right would provide a powerful resource for ensuring that the internet benefits everyone, rather than a select few. ▮

Merten Reglitz is a philosopher and author of *Free Internet Access as a Human Right*

Guest columnist

Hitting the road Inveterate cyclist **Matt Sparkes**, who has been knocked off his bike by human-driven cars several times, wonders if the arrival of robotaxis in London will make him safer

Matt Sparkes is a technology reporter at *New Scientist*

HAVING plied their trade in several US and Chinese cities for years, driverless taxis are on their way to London.

As a cyclist, a Londoner and a journalist who has spent years covering AI's pratfalls, I am a tad nervous. Yet, given how often I have been struck by inattentive human drivers in London, part of me is cautiously optimistic.

At the end of the day it boils down to this: will I be better off surrounded by tired, distracted and angry humans, or unpredictable and imperfect AI?

The UK government has decided to allow firms like Uber to run pilots of self-driving "taxi- and bus-like" services in 2026. Then, in the second half of 2027, things will ramp up fast as the Automated Vehicles Act becomes law, giving the industry a proper legal framework. Crucially, this law holds car-makers responsible for accidents rather than occupants.

The government claims driverless cars could actually improve safety, given that human error contributes to 88 per cent of all road accidents. And there are plenty of those: there were 130 deaths on London's highways last year alone, which includes 66 pedestrians and 10 cyclists. Globally, around 1.2 million people die each year on the roads.

I cycle everywhere in London and it gives you insight into the problem. I have seen drivers reading, eating bowls of cereal and watching movies. I have been crashed into from behind at red lights at least four times. They say that one thing AI lacks is creativity, and in the field of poor driving, humans really do have flair.

Meanwhile, AI doesn't get tempted by a text, take drugs or drink, or nod off. It doesn't make turns without checking blind spots, because there is no such thing as a blind spot for a machine that has dozens of sensors.

Yes, there are very worrying examples of driverless cars simply failing to stop for pedestrians and killing them. These, rightly, are big news. But we have become so inured to road deaths that reports of the far more numerous ones involving human drivers barely register – more than four people a day die on UK roads, on average.

The robocar safety issue is a delicate one. In my opinion, not a single road death should be tolerated, but from a pragmatic point of view, if AI can drive the same number of miles and kill fewer people, then there is a strong argument that we shouldn't make perfect the enemy of progress.

"You can't be sure that an autonomous car won't decide a pedestrian is a shadow and run them over"

Indeed, studies have shown that driverless cars tend to be safer than those piloted by humans, although this record dips in dim lighting and when making turns – hardly a rarity in city driving – and there are concerns about under-reporting of accidents.

We also rely on tech firms to make robotaxis safe, and there could be a conflict of interest here between profit and the greater good. Already we have seen morally repugnant efforts to pass the problem on to pedestrians by suggesting they wear electronic sensors to broadcast their presence to such machines.

When it comes to cyclists, do tech firms ensure they are given 1.5 metres of space when their robocars overtake them, or do they decide that as long as a cyclist isn't knocked off, that is OK? The latter would both improve car journey times in a busy city and terrify and imperil cyclists. How forcefully will robocars barge out of side roads to join busy routes? Do they wait for pedestrians to fully cross roads, or keep rolling at a pace that encourages the sad little trot we do to appease drivers? These are all parameters that can be changed, and there will be a commercial tussle between safety and speed of journeys.

Even if firms act altruistically, AI is non-deterministic. We can't perfectly predict how it will behave in any given situation. Just as you can't guarantee a chatbot won't list glue as an ingredient in a pizza recipe, you can't be totally sure an autonomous car won't decide a pedestrian is a shadow and run them over. That isn't convenient, or reassuring to hear, but it is a fact.

In truth, I don't trust AI to operate a car near to me. Nor do I trust people to do it. But while humans are about as good as they are going to get, AI has the potential to improve rapidly. Trials of autonomous taxis in London will provide valuable training data, with the potential to improve safety in a virtuous circle. In the long term, if I had to pick, I am opting for AI drivers.

That said, the harsh reality is that a couple of tonnes of steel, five armchairs and 100 computers on four wheels is never going to be a sensible, totally safe or efficient means of urban transport. Such taxis are as poor a solution to transport in tomorrow's London as human-driven ones are today.

Electric bikes and safe cycle lanes are greener and can get people from A to B faster, while buses can carry 80 people in the space taken up by two SUVs. But there is no profit margin in that for big tech, is there? ▮

Matt's week

What I'm reading
How Music Works *by Talking Heads frontman David Byrne.*

What I'm watching
Horror film Bring Her Back *(through hands clamped over eyes at points, admittedly).*

What I'm working on
Preparing lots of cuttings in the garden to fill some bare spots next spring.

Annalee Newitz is away. Up next week: Rowan Hooper

locommotion?

Every mechanical watch has a balance wheel, but not all balance wheels are created equal. The **C12 Loco's** 'free sprung' balance wheel (and hairspring) isn't merely a part of the watch. It's the star. Placed below the time-telling dial, on the artfully coloured and stepped platine, its mesmeric oscillations are driven by a new in-house movement – Calibre CW-003, whose hand-wound, hand-finished architecture delivers a six-day power reserve and chronometric accuracy. And because we want to tell the story of how we got here – and because we're a little *loco* ourselves – we've made a feature-length documentary about it. Just make sure you're sitting down when the price is revealed.

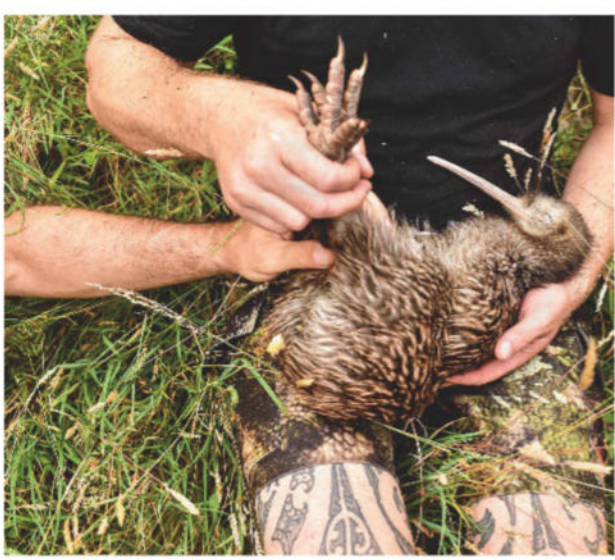
Scan the QR code for the full (com)motion picture.

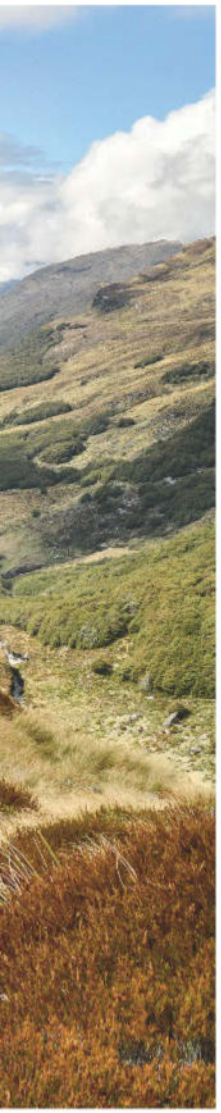
Do your research

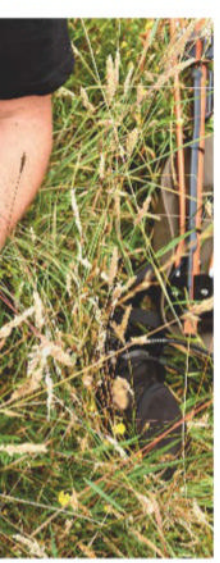
Christopher Ward

christopherward.com


extinct
merganser







Kiwi comeback

Robin Hammond
Panos Pictures

ACROSS New Zealand, a vast conservation effort is under way to wipe out invasive species and enable various native and endangered birds to rebound.

The country's Predator Free 2050 project, documented here by photographer Robin Hammond, has the bold aim to completely eradicate three species introduced to the island nation by humans: rats, stoats and possums. These have decimated populations of birds, such as the ground-dwelling kiwi (bottom, middle). The work involves controversial aerial drops of sodium fluoroacetate poison to target the mammals, in addition to setting traps (main image).

"It's conservation through killing. Like, mass killing," says Hammond. "It's kind of a grim choice. But doing nothing has a consequence, and that would be the loss of these [bird] species."

Efforts to raise kiwi and other birds in captivity until they are big enough to stand a chance against these mammals are also under way (near left, top). A kiwi egg laid in the wild has a 5 per cent chance of making it to adulthood. But adult birds, such as the flightless takahē (near left, bottom and middle), have a far higher chance of survival.

It is already too late for some birds, such as the Auckland Island merganser (bottom, far left), relegated to a museum exhibit since vanishing in 1902. But Hammond says that the efforts are paying off for those that remain, and he now sees populations of native birds like never before. "I see flocks of birds flying around Wellington, which I never even knew existed as a kid," he says. "And you can hear the bird song, which wasn't there before."

Matthew Sparkes

Did childcare fuel language?

Rearing our unusually underdeveloped young may account for the evolution of language. **Michael Marshall** is intrigued, but wants more evidence

Book
The Origin of Language
Madeleine Beekman
Simon & Schuster

LANGUAGE is one of the few faculties that still seems to be uniquely human. Other animals, like chimpanzees and songbirds, have developed elaborate communication systems, but none appears to convey such a range and depth of meaning as ours. So how and why did our ancestors first develop language?

Evolutionary biologist Madeleine Beekman has spent much of her career studying insects, especially bees. In her first book for a non-specialist audience, she branches out in a big way to propose an explanation for the evolution of human language.

Her idea is that it evolved out of necessity, to enable us to cope with the demands of childcare. Compared with other mammals, human infants are exceptionally underdeveloped at birth, needing 24-hour care.

Following in the footsteps of decades of palaeoanthropological research, Beekman links helpless babies to two features of human bodies: bipedality and large brains. "As our skeletons adjusted to walking upright, our hips became narrower," she writes. Later, our brains also expanded. "Babies with a large head and mothers with narrow hips do not make a good combination," Beekman observes, drily.

To get around this "obstetrical dilemma", babies are born early, before their heads get too big to squeeze through the birth canal. This enables humans to give birth relatively safely, at the cost of months spent caring for vulnerable infants.

So far, so familiar. Beekman's big leap is her proposal that the demands of looking after human babies drove the evolution of complex language. "Taking care of human infants is so singularly difficult that evolution had to craft a completely new tool to aid the effort," she writes, and "the design fault that started the problem in the first place also provided its solution". Our brains made birth harder, but they also enabled us to evolve a capacity for rich and flexible language.

In proposing this idea, Beekman is wading into a very crowded marketplace. Many scenarios have been put forward for the evolution of language. Some say it developed in concert with technologies like stone tools: as we created more advanced tools, we needed more descriptive language to teach others how to make and use them. Or maybe language was a means of showing off, including through witty wordplay and insults. Then again, it might have allowed individuals to organise their own thoughts, and was only secondarily used to communicate with others.

"The author argues that language is only around 100,000 years old and is unique to our species"

One appealing aspect of Beekman's proposal is that it places women and children at the centre. Because science has traditionally been skewed towards the male, ideas about human evolution tended to overly focus on them ("Man the Hunter" and all that), despite the fact that some of the most dramatic changes in our evolution involved pregnancy.

It is good to consider the roles of women and children in the origin of language. However, this doesn't necessarily mean that Beekman is right. She marshals intriguing evidence, notably that all large-brained birds, including parrots and New Caledonian crows, produce under-cooked offspring. Why? A 2023 study showed that the strongest predictor of brain size in birds was the amount of parental provisioning.

This all sounds distinctly human-like and in line with Beekman's narrative. But the biggest issue is timing. Humans have been bipedal for at least 6 million years and our brains grew rapidly from 2 million years ago. When, in this timespan, did childbirth become really difficult, and when did language evolve?

Beekman argues that language is only around 100,000 years old and is unique to our species. She cites a 2020 study identifying "unique gene regulatory networks that affect the anatomical structures needed for the production of precise words". These networks are apparently only present in our species, suggesting other hominins like Neanderthals couldn't speak as well as humans.

Beekman says this "nails it", but other researchers have found evidence suggesting complex speech may have existed in other hominins. The evolution of human childbirth is equally tangled and uncertain. In short: nice idea, needs more evidence. ▮

SHUTTERSTOCK/ARTEM VARNITSIN

Beekman suggests the complexity of childcare drove language's spread

Michael Marshall is a writer based in Devon, UK

Dialling it down

We need to think about the purpose of noise in our daily lives and environments. **Chris Stokel-Walker** discovers a great guide

Book

Clamor
Chris Berdik
W. W. Norton

PJR TRANSPORT/ALAMY

Noise-cancelling headphones have become a popular way to shut out intrusive sounds

NOISE is all around us, and it is often imperceptible – until the volume knob is turned way up, or way down. We are used to the thrums, trills and brrs of day-to-day life, with soundscapes becoming as familiar as the sights we see on our walks, drives and other travels.

But when those noises change, we notice. While many of us say we want quiet, science journalist Chris Berdik argues that we don't necessarily mean it; rather, we want less of the noise we don't like. And as he persuasively argues in *Clamor: How noise took over the world – and how we can take it back*, sometimes we need to add extra noise we do want to drown out the noise we don't.

Berdik points out that while noise-cancelling headphones have become bestsellers, they aren't always the answer. Adding white or grey noise can help balance the harmful incursions on our ears, while wiping it out entirely can cause more harm than good.

Getting noise right is important, because it has an impact on our health. The piano plinking of a neighbour as I read Berdik's book doesn't raise my blood pressure in the same way as the noise of another neighbour's child thwacking a football against my living room wall. And that is just the immediate impact; long-term ramifications can be even more significant.

Around 40 million adults in the US have noise-induced hearing loss, reports Berdik, with the number set to nearly double by 2060. This isn't solely a problem in high-income countries: worldwide, the World Health Organization says that over a billion young people are at risk of permanent, avoidable hearing loss due to using devices such as smartphones and audio players. About 1 in 4 of us will have damaged hearing by 2050, it says.

I read this book at a time when conversations about noise are perking up people's ears. In the UK, for example, the Liberal Democrats party proposed to criminalise playing loud music without headphones on public transport. It is a very popular idea.

Yet there is another side to this. Recently, I spent days sitting in a hospital listening to the beeps and boops of machines my grandfather was hooked up to. The longer I spent at his bedside, the more the noises became familiar, and my experience started to echo Berdik's observation that medics end up tuning them out.

This is a real problem. One of the most powerful vignettes in *Clamor* concerns a story Berdik tells about a medic who set out to redesign the noises medical machines make to ensure doctors don't tune out important signals along with the noise. Her work involves creating auditory icons, short sound messages conveying information – in this case, about, say, breathing.

The issue of noise isn't just one that affects humans. Berdik explains how low-frequency ambient sound levels in the deep ocean rose by 3.3 decibels per decade between 1950 and 2007. That is down to the increase in shipping across the world, driven by our demand for products sourced from everywhere.

It is having a real effect on habitats. For example, the noise generated by the vessels that criss-cross the oceans happens to overlap with the frequency at which baleen whales talk to one another.

Clearly we must change our ways, says Berdik. That includes stopping playing loud music on buses and trains, the Liberal Democrats will be glad to hear. It also means shunning our noise-cancelling headphones, and thinking about the noise we don't want – and the noise we do. ▮

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

New Scientist *recommends*

Michael Dalton
Assistant mag editor
London

On a recent trip to New York, I visited the Museum of Modern Art for the first time. What really stood out for me was the installation **Government Approved Home Fallout Shelter/ Snack Bar** by Michael Smith, an artist who satirises life in the US as his character "Mike".

His target here is a real plan from 1983, during the cold war, for a snack bar that doubles as a fallout shelter. It is all set in Mike's basement, which contains a variety of ways to help pass a nuclear winter. There is even a playable – though crucially, unwinnable – arcade game called *Mike Builds a Shelter*.

It felt like walking onto the set of an amusing yet eerie film, reminiscent of the animation *When the Wind Blows* (based on Raymond Briggs's graphic novel, in which an elderly couple dutifully follow official guidelines after a nuclear attack).

That film is more heartbreaking than the humorous snack bar, but both work effectively to highlight the folly and futility of nuclear war.

JONATHAN DORADO/MOMA

Tracing human evolution
Go behind the scenes of new BBC series *Human* with Ella Al-Shamahi **newscientist.com/video**

The TV column

Action, reaction BBC documentary *Human* delivers an unusually clear picture of *Homo sapiens* as a species shaped by climate, animals, plants, other hominins and the interactions of its own nomadic groups. **Bethan Ackerley** is enthralled

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

BBC/BBC STUDIOS

A dramatic reconstruction of early modern *Homo sapiens* in Africa

TV
Human
BBC iPlayer (UK); PBS, US (17 September)

Bethan also recommends...

Talk
The fascinating (and dangerous) places scientists aren't exploring
TED talk, 2019
In Ella Al-Shamahi 's intriguing and moving talk about her trip to the biodiverse Yemeni island of Socotra, she argued we are failing to do frontline science in places deemed too hostile for Western researchers. Take the discovery of a Neanderthal skeleton with serious disabilities in what is now Iraq, which meant he would have needed community support to survive. It is just one of the finds we are missing out on.

IN MY experience, science documentaries tend to fall into two camps that are roughly akin to French and Italian cuisine. (Hear me out before you judge my analogy.) The first kind is more elaborate, using sophisticated techniques to achieve the very best experience – whether it is a well-crafted soufflé or the bells and whistles of animation and virtual reality. The second is simpler and tends to let the ingredients speak for themselves.

Both types of documentaries can yield fabulous, if different, results. *Human*, a five-part BBC series on the origins of our genus, *Homo,* is firmly of the latter sort. It combines a great story, beautiful visuals and a fantastic presenter in the palaeoanthropologist Ella Al-Shamahi, then leaves you to enjoy a hearty 6-million-year journey through humanity's past. No bells and whistles needed.

The first episode is framed by a thorny question: when, exactly, did our species emerge? And there are many possible answers, depending on your perspective. Was it 300,000 years ago, when humans with facial features similar to ours began to emerge? Was it when our skulls became gracile and globular (basically, thinner and more globe-shaped), as Al-Shamahi puts it – with the commensurate effects on brain power? Or, more romantically, was it when we gained our most extraordinary traits: the capacity for complex language, abstract thought and cooperation?

"This series combines a great story, beautiful visuals and a fantastic presenter in Ella Al-Shamahi"

It is a terrific episode, surpassed only by moments when the focus shifts to other, extinct human species. When Al-Shamahi travels to Indonesia, in episode 2, we meet *Homo floresiensis*, a 1-metre-tall hominin adapted to life on the island of Flores. The discovery of remains of these "hobbits" in Liang Bua cave 20 years ago rewrote our understanding of ancient human biology: their tiny brains belied their use of stone tools, and their long arms and short stature aren't seen in any other human species.

Episode 3 charts the demise of Neanderthals, our most famous cousins, who were far more sophisticated than once thought. Having reached Europe and Asia before us, they were adapted to the colder climes, but this didn't save them from extinction.

Throughout, Al-Shamahi introduces us to surprising discoveries from recent decades of palaeoanthropology (which you may have read about in *New Scientist*). For example, iridescent feathers from birds like red kites were particularly prized by Neanderthals, while perikymata – growth lines on tooth enamel that reveal age as surely as tree rings – suggest that *H. sapiens* had longer childhoods, perhaps so we could learn how to use our large brains.

In just five episodes, *Human* can't possibly tell us everything we want to know. But it does make it clear that *H. sapiens* is a species of reaction. We have been moulded in response to the climate, as it isolated us and forced us to adapt; to animals and plants that gave us sustenance; to other human species whom we lived alongside; and to each other, as nomadic groups shared skills, knowledge and DNA that let us survive long enough to start building cities.

This aspect of *H. sapiens* can get lost in narratives of us as the ultimate human, superior and spreading and conquering Earth. *Human* lets its counter-narrative speak for itself, with simple storytelling and a reverence for all our ancient relatives, not just our own species. ▮

Editor's pick

How safe disposal led to our funeral rites

26 July, p 38

From Malcolm Moore, Rotorua, New Zealand

When it comes to the rise of burial practices, the basic needs for species are survival and reproduction. That means food, shelter and security. Dead bodies attract scavengers. For a vulnerable hominin species like *Homo naledi* who, for a period at least, stayed in one place, decaying bodies could have attracted carnivores.

Safe burial or the building of cairns, for example, requires suitable terrain and available resources, such as labour, efficient digging tools and time. Disposal in the far reaches of a cave system would be relatively quick and effective. Dehydration or breakdown by microbes and small animals would soon follow.

So, the pragmatic issue of safe disposal comes first, and rituals then develop as a way of maintaining this through the generations. These then become embedded in religions.

From Emily Johnston, Sykesville, Maryland, US

Seems to me that the custom of burial would have been more practical than anything else. After all, dead bodies lying about would have smelled pretty bad after a while and attracted wildlife.

Splitting sleep in two was once a thing

2 August, p 30

From Larry Stoter, The Narth, Monmouthshire, UK

When it comes to body clocks, researchers should investigate the phenomenon of "second sleep", or biphasic sleep. This is fairly well-known historically and among some anthropologists. It seems to have been relatively common and widespread at a time when people's daily rhythms were largely determined by the sun and when bright indoor lighting was unavailable for most people. Typically, people would go to sleep perhaps 2 hours after sunset, sleep for a few hours, wake for a period, then sleep again until early morning.

Perhaps a more relaxed attitude to sleep and a return to biphasic sleeping would lessen the incidence of sleep disorders.

I'm not a fan of de-extinction efforts

19 July, p 32

From Irene Rabbitts, Addlestone, Surrey, UK

I find the claims of species de-extinction by Colossal Biosciences unconvincing, its reasons for doing it unclear for the species it is trying to resurrect, and the prospect of the development of artificial wombs a potential horror story.

Progress on research into chronic fatigue welcome

16 August, p 10

From Ann Townson, Harrogate, North Yorkshire, UK

I've had myalgic encephalomyelitis for 26 years, so what wonderful news to hear that there might be a way to confirm it genetically. Hopefully, funding will allow further research into this.

I can attest to existence of strange anthropo rocks

19 July, p 24

Charlie Wartnaby, Cambridge, UK

So I missed my opportunity to play geologist by "discovering" the weird anthropoclastic rock formed from industrial waste on the beach near Workington, Cumbria, UK. It seemed like an impossible kind of volcanic sandstone when we found the same thing on the north side of the town. It did indeed feel like a mark of the Anthropocene, but, on an optimistic note, that same beach is topped by awesome wind turbines hopefully ushering in a new, more sustainable era.

On matrilineal cultures and matriarchies

2 August, p 40

From James Fradgley, Wimborne, Dorset, UK

In connection with matrilineal societies, I saw an interesting variant in Vanuatu. Basically, young men and women relate to their mother and her siblings. You might think this would lead to some sort of matriarchy, but that appears not to be the case.

For example, the making and drinking of kava, a potent brew, is definitely a men-only activity, as are some others. As the article notes, real life is always more complicated than we anticipate.

Perhaps we all need to take a toddler-style siesta

26 July, p 18

From Sam Edge, Ringwood, Hampshire, UK

It is no surprise to me that napping during the day by pre-schoolers doesn't significantly impair education, reduce nighttime slumber or lead to involuntary insomnia in parents. That such research is required might baffle those who lead a traditional Mediterranean lifestyle. Perhaps we should take a leaf out of our toddlers' book and join them in an after-lunch siesta!

A better take on the anthropic principle?

28 June, p 32

From Derek Bolton, Sydney, Australia

Your article on how to think about the weak and strong anthropic principles (AP) took the Barrow and Tipler formulations. These conflict with the original Brandon Carter definitions, make much less sense and haven't enjoyed much peer acceptance.

Carter's weak AP is that within a universe capable of supporting intelligent life in some region and epoch, of course such life will find itself in such a Goldilocks circumstance – thus demolishing the "Copernican" assumption that our spot in the universe is typical. His strong AP is that if there is an ensemble of vast numbers of different universes, then we shouldn't be surprised that some have such finely tuned constants.

IBS may also respond to the placebo effect

2 August, p 17

From Mark Inwood, Reigate, Surrey, UK

You report that irritable bowel syndrome (IBS) could be a nocebo effect for some people. I have for several decades relied on the opposite effect from what I call my "placebo tablets". They keep me IBS symptom-free despite having only a few *Lactobacilli* and *Bifidobacteria*, along with minerals and vitamins.

The Forth Bridge really is endless to some

9 August, p 28

From Susan Frank, Sheffield, UK

As a child, I asked my father: what is infinity? He said that it was the length of the Forth Bridge as experienced by a mouse. He was an engineer. I have always found that definition most satisfactory.

For the record

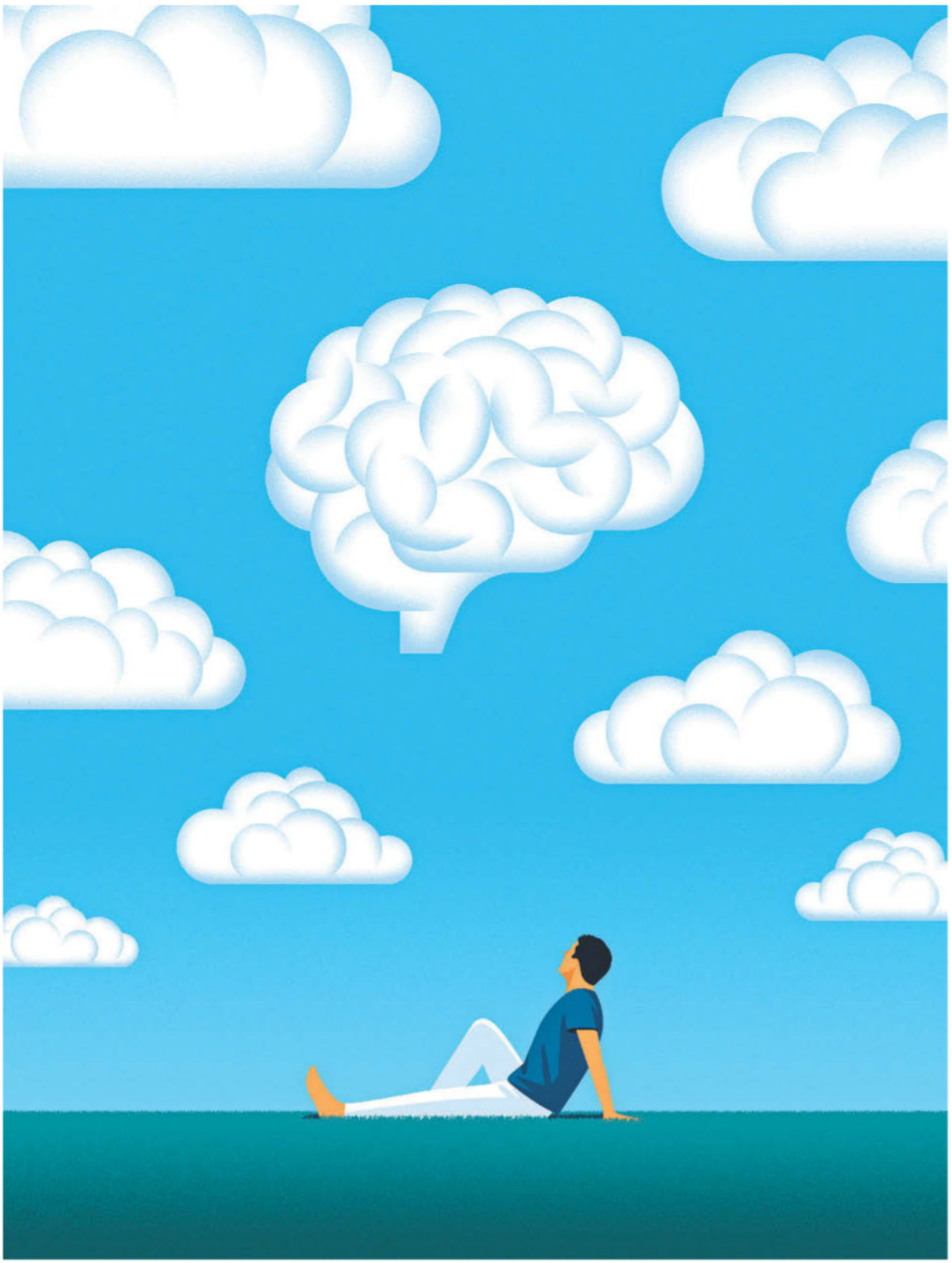
Above its "entropy catastrophe" temperature, a solid has higher entropy than its liquid, so melting would break the second law of thermodynamics (2 August, p 16).

The pineal gland secretes melatonin (2 August, p 30).

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed



JOEY GUIDONE

Clear your mind

As we start to understand the effects of chronic inflammation on the brain – from depression to dementia – we are unlocking new treatments, says **Manuela Callari**

GOLAM KHANDAKER's mother has had arthritis for as long as he can remember. She also lives with depression, and it always struck Khandaker how precisely her arthritis flare-ups coincide with her most severe episodes of low mood.

Perhaps it isn't surprising that these bouts of painful inflammation might cause her to feel low. But as Khandaker, then studying for a PhD at the University of Cambridge, investigated more closely, it became clear there was more going on.

In fact, research is revealing the profound effect persistent low-level inflammation has on the brain – which was once thought largely impervious to the fires burning elsewhere in the body – and what this means not only for depression, but for anxiety, schizophrenia, Alzheimer's disease and more. By unpicking the mechanisms driving these connections, researchers are coming up with new ways to protect people's brains and mental health, on top of the many day-to-day ways we can help ourselves.

Our immune defences are vital for survival. When the body detects an infection or injury, it activates an immune response, characterised by a cascade of inflammatory proteins called cytokines, to eliminate the pathogen and promote tissue repair. "Sickness behaviour" can also be triggered – a constellation of symptoms such as fatigue, social withdrawal and loss of appetite that is strikingly similar to major depression. In the acute phase of an illness, this behaviour is beneficial and signals the need to rest and recover during times of physical injury or infection.

Sometimes, however, the acute immune response doesn't fade, and cytokines linger long after the initial battle is won, resulting in chronic low-grade inflammation. This is one of the scourges of the modern world, contributing to heart disease, type 2 diabetes, kidney disease and more. Now, the toll this takes on our brains is also becoming evident.

High levels of inflammatory markers are often found in people with acute mental health conditions. One 2020 study of more than 5000 people with depression, for instance, found they had elevated levels of inflammatory molecules in their blood compared with a control population, leading the study's authors to conclude that "depression is... a pro-inflammatory state".

The fire within

Elevated cytokine levels have also been found in people with schizophrenia and bipolar disorder, and in June, the link between chronic inflammation and mental health conditions was confirmed on a massive scale. An analysis of 1.5 million people from the UK's Our Future Health cohort found that people with conditions associated with chronic inflammation – such as multiple sclerosis, rheumatoid arthritis and inflammatory bowel disease – have almost double the risk of experiencing anxiety and depression, even after adjusting for factors like chronic pain and income.

"The surprising part was that the risk for all the different mental health conditions was pretty much identical [regardless of which inflammatory condition they had]," says Arish Mudra Rakshasa-Loots at the University of Edinburgh, UK, who led the study. "This indicates there is something more going on there beyond just the experience of chronic pain or social isolation." The consistent link across different conditions strengthens the case that a shared biological mechanism – inflammation – is at play.

But teasing apart cause and effect is tricky: does the inflammation cause the illness, or is it a consequence of it?

One of the first researchers to begin to untangle this question was Andrew Miller at Emory University in Atlanta, Georgia, based on observations in the early 2000s that people receiving interferon-alpha (IFN-alpha), an inflammatory cytokine used as a cancer therapy, were developing severe depression. "We knew there was a relationship between increased inflammatory markers and depression, but we didn't know which was the chicken and which was the egg," says Miller.

To find out, Miller and his colleagues carried out a randomised controlled trial, in which people were randomly assigned to receive either the treatment or a placebo. They found that pre-treatment antidepressants decreased the incidence of depression associated with IFN-alpha treatment in people with melanoma, and this causal link has since been replicated with at least two other inflammatory stimuli – endotoxin and typhoid vaccination.

Another way to tease apart causality is to ›

analyse long-term monitoring studies to test whether pre-existing inflammation increases the risk of subsequent mental health conditions. For instance, Khandaker – now a psychiatrist at the University of Bristol, UK – and his colleagues used data from the Avon Longitudinal Study of Parents and Children in the UK, which measured levels of the inflammatory protein IL-6 in about 4500 children when they were 9 years old. They found that higher levels of this inflammatory marker in childhood were associated with 50 per cent higher odds of depression and a nearly two-fold increased risk of psychosis at age 18. "That clearly suggested that inflammation can precede mental illness," says Khandaker.

The team then used a genetic technique called Mendelian randomisation, which tests whether the association between two things is likely to be a causal relationship or due to some third factor that influences the likelihood of both, such as lifestyle or another illness. In a study published earlier this year, the researchers sifted through 735 immune-related proteins and found strong evidence that specific inflammatory pathways have a causal role in depression, schizophrenia and Alzheimer's disease. Of course, other factors are likely to be at play, too. "We know depression is a psychologically stressful condition, so the associated stress could itself cause inflammation," says Khandaker.

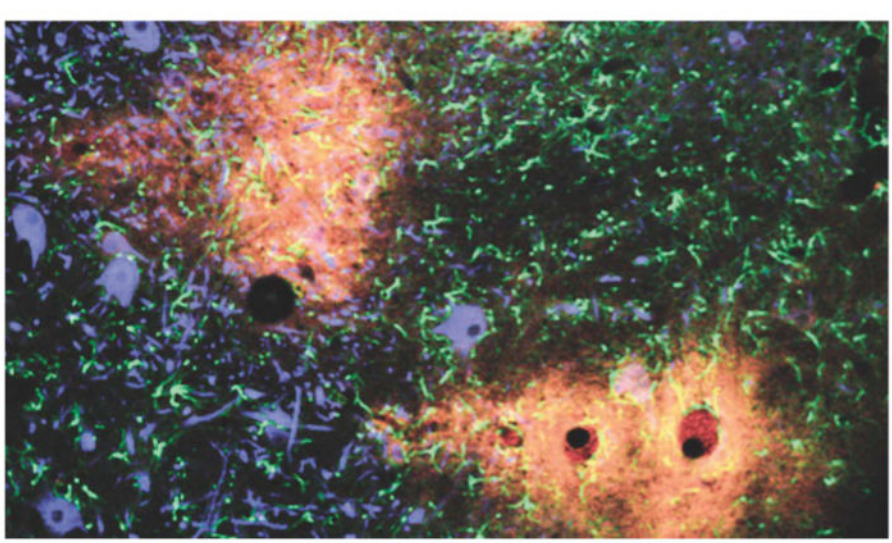
Still, for Miller, the evidence is compelling enough that he expresses frustration with the persistence of the idea that inflammation isn't a cause of depression, but merely a secondary symptom resulting from the lifestyle habits that often accompany it, such as smoking, poor diet and inactivity. "But [research] has shown that inflammation can cause depression," he says.

So, if chronic exposure to systemic inflammation affects our brain and mental health, the question is: how?

When Khandaker attended medical school in the 1990s, the brain was considered an immune-privileged fortress. "It was shielded from the rest of the body by the blood-brain barrier, our professors told us," he recalls.

This barrier – a tightly regulated perimeter of cells – is designed to allow essential nutrients, such as glucose and oxygen, to pass through, while blocking toxins, pathogens, inflammatory cells and proteins. But research is revealing that under conditions of chronic

"This relentless friendly fire ultimately leads to cognitive decline"



C. J. GUERIN, PHD, MRC TOXICOLOGY UNIT/SCIENCE PHOTO LIBRARY

When the blood-brain barrier breaks, leakage (orange) occurs from blood vessels (round black holes) into brain tissue

QUENCHING THE FIRE

Many lifestyle factors influence our levels of chronic inflammation. Here are some key findings:

SEDENTARY BEHAVIOUR

More time spent seated or reclining, whether watching TV, sitting in a car or working at a computer, is associated with higher levels of chronic inflammation. This effect is likely to be due to many factors, including reduced activity of an enzyme in load-bearing muscles in our legs and core, leading to abnormal metabolism of fats.

DIETARY FIBRE

Many studies show that a high fibre intake is associated with decreased inflammation. Fibre covers a broad range of different plant-derived compounds that feed our gut microbiome. This promotes gut bacteria to produce helpful substances called short-chain fatty acids, which help maintain the gut lining and have an anti-inflammatory effect on the body.

OBESITY

Obesity is a key risk factor for chronic inflammation, due to the pro-inflammatory effect of excess subcutaneous fat. This means that losing weight is one of the most effective lifestyle changes we can make. One study found that, for people with a form of chronic inflammatory arthritis, weight loss alone leads to significant improvement in symptoms, while also reducing the underlying inflammation.

inflammation or stress, this protective wall can become leaky.

Caroline Ménard at Laval University in Quebec is investigating how this happens using an animal model of social stress – mice that can develop both high inflammation and behaviours akin to depression and anxiety. Using microscopy, Ménard's team saw that in healthy control mice, the barrier appears as a solid, continuous line, whereas in the stressed, inflamed mice, it looks as if it has been "ripped to shreds".

It is through these gaps that inflammatory molecules like cytokines are "sneaking" into the brain, where they can cause oxidative stress and disrupt neurotransmitter production, she says. In 2022, her team discovered similar structural damage in post-mortem brain samples from people who had depression.

The idea is that stress causes a large drop in levels of a protein called claudin-5, which holds the cells of the barrier together. With claudin-5 depleted, the barrier tears, letting inflammatory cytokines enter the brain. Once inside, they can disrupt key neurotransmitters such as dopamine and serotonin in certain areas, leading to reduced activity in brain circuits responsible for motivation. Inflammatory signals can also trigger the brain's own specialised immune cells, the microglia.

Under normal conditions, microglia act as vigilant housekeepers, cleaning up debris and protecting neurons. However, chronic exposure to inflammatory signals can cause these cells to flip from a protective state to a destructive, pro-inflammatory one, initiating a vicious cycle.

This neuroinflammatory state creates the conditions for the development and accumulation of amyloid-beta plaques, a hallmark of Alzheimer's disease. The presence of these plaques then further activates the microglia, which unleash a storm of inflammatory cytokines, such as IL-1beta, IL-6 and TNF-alpha, as well as oxidative molecules in response. This "inflammatory soup" not only causes direct harm to neurons through oxidative stress, but also recruits more microglia to the fight, amplifying the inflammation, says Ravinder Nagpal at Florida State University.

This mechanism also impairs the microglia's ability to perform their primary duty: clearing the very amyloid-beta plaques that are driving the problem, making the situation progressively worse, he says. "This relentless friendly fire ultimately leads to widespread neuronal death and cognitive decline."

GUERILLA/ALAMY

Eating a Mediterranean diet could reduce levels of inflammation

Another major pathway through which inflammation affects the mind originates in our gut. For starters, gut bacteria can produce many different neurotransmitters, which can influence the brain via the vagus nerve. So, when the gut microbiota is in an imbalanced state, known as dysbiosis, caused by a poor diet or antibiotics, this can affect the production of neurotransmitters, says Nagpal. As well as this, "bad" microbes can produce toxins, such as lipopolysaccharides, that damage the gut lining, allowing inflammatory molecules and bacteria to escape into the bloodstream and trigger systemic inflammation, which can, in turn, make the blood-brain barrier leaky.

In contrast, when the gut is in a healthy state, beneficial microbes produce anti-inflammatory compounds, such as short-chain fatty acids, that help maintain a strong intestinal barrier.

This has led some researchers to wonder whether transforming or replacing the gut microbiome could offer a new form of treatment for mental health conditions and neurodegenerative conditions. Emerging evidence, albeit from small-scale trials, suggests that a faecal microbial transplant can alleviate symptoms of anxiety and depression.

A less drastic way to tip our gut microbiome in a healthier direction is via our diet, and there is good evidence that anti-inflammatory eating patterns really do work. The most well-researched is the Mediterranean diet, which entails eating plenty of fruits, beans, nuts, whole grains and fish, with generous amounts of olive oil, while limiting red and processed meats. For instance, one study of nearly 15,000 people in Italy found that a closer adherence to this dietary pattern correlated with reduced levels of inflammatory markers.

The secret isn't a single superfood, but rather the combined effect of the entire dietary pattern, says Rosa María Casas Rodriguez at the University of Barcelona in Spain. "We think it is the combination of different foods that, with different synergies, increases the effects."

We don't yet know about the impacts on the brain, but some other studies show that adhering to a Mediterranean-style diet is associated with a reduced risk of depression, and further large-scale trials are under way.

The benefits of an anti-inflammatory diet may even extend to shielding the brain from dementia. A 2024 study of data from more than 84,000 older adults with pre-existing conditions such as heart disease or type 2 diabetes who participated in the UK Biobank study found that those eating the most anti-inflammatory diet had a 31 per cent lower risk of developing dementia.

To delve into the mechanisms of these effects, Nagpal and his colleagues conducted a small, randomised trial of older adults with mild cognitive impairment. They found that, compared with controls, following a Mediterranean diet that was also ketogenic (very low in carbs and high in fat) for six weeks increased the production of beneficial short-chain fatty acids, particularly butyrate, which is known to be neuroprotective and improve gut barrier health. These changes in the gut microbiome were associated with improvements in Alzheimer's disease biomarkers, such as amyloid plaques, in the participants' cerebrospinal fluid.

Of course, diet isn't the only lever we can pull. What about regular physical activity? ›

Although higher-intensity exercise can cause a normal, temporary spike in inflammation for muscle repair, there is evidence that, in the long run, physical activity dampens chronic inflammation. It is also clear that a lack of exercise is linked to chronic inflammation. One study from earlier this year of nearly 16,000 people found that sedentary behaviour is correlated with chronic systemic inflammation – which the study's authors called a "sedentary disease". The less you move, the greater the risk.

Sedentary behaviour is also a risk factor for obesity, which has strong associations with chronic inflammation (see "Quenching the fire"). Age is another risk factor, as well as chronic stress, which has a direct impact on the body's inflammatory state by triggering the sustained release of the hormone cortisol. While cortisol normally acts as a potent brake on inflammation, prolonged exposure can lead to a condition where immune cells become less sensitive to anti-inflammatory signals, triggering a cascade of inflammatory cytokines that can disrupt neurotransmitter metabolism and exacerbate depression. To combat this stress response, there is evidence that mindfulness and meditation can help, but Nagpal's advice is to find an activity you genuinely enjoy, as "happiness is one of the key components that can directly reduce stress".

"Happiness is one of the key components that can directly reduce stress"

And then there are medications. In the past decade or so, Miller, Khandaker and others have tested anti-inflammatory drugs typically used for conditions such as rheumatoid arthritis to treat depression, and they have generally found a positive impact. However, perhaps unsurprisingly, these medications have by far the greatest impact on those for whom persistent, low-grade inflammation is driving their illness – perhaps up to 1 in 4 people with depression. "The most pressing question in our field right now is how to identify this group," says Khandaker. This isn't straightforward, because there isn't yet a standard biomarker to measure chronic inflammation, which is a complex process involving a range of different immune substances and cells.

Miller argues that a common blood test for C-reactive protein, a general marker of inflammation, is the "lowest-hanging fruit" for identifying people who might respond to anti-inflammatory treatments, and that this approach is already being trialled in clinics.

But perhaps the most talked-about new approach involves drugs that mimic the satiety hormone GLP-1, such as semaglutide (sold as Ozempic and Wegovy), best known for their dramatic effects on weight loss. While these drugs were originally used to treat diabetes and then obesity, their ability to combat inflammation has put them at the centre of research into cognitive decline and mental health conditions.

Several large observational studies link the use of these drugs to a reduced risk of dementia, depression and anxiety, though, so far, the findings from clinical trials are more of a mixed bag. But all eyes are on the results of two large-scale phase III trials, evoke and evoke+, which are investigating whether semaglutide can modify the course of early-stage Alzheimer's disease, with results expected later this year.

A key question is whether the anti-inflammatory effects of GLP-1 drugs are mainly due to weight loss and better blood glucose control, both of which dampen inflammation, or via a direct effect on the immune or nervous system. Studies presented at the Society for Neuroscience meeting in Chicago last October by the research company Neurofit in Strasbourg, France, show that in mouse models of Alzheimer's, GLP-1 drugs improve cognitive deficits even in healthy-weight animals. "This demonstrates that the beneficial effect occurs directly in the brain, rather than being a secondary consequence of weight loss," says Emile Andriambeloson at Neurofit.

All this highlights how there is still a way to go before we have a full understanding of how inflammation messes with our minds – but the research is already beginning to translate into tangible clinical progress. The other good news is that, for the majority of us who may be unknowingly experiencing long-term low-level inflammation, there are many lifestyle factors that can help simmer down the heat burning within. ▮

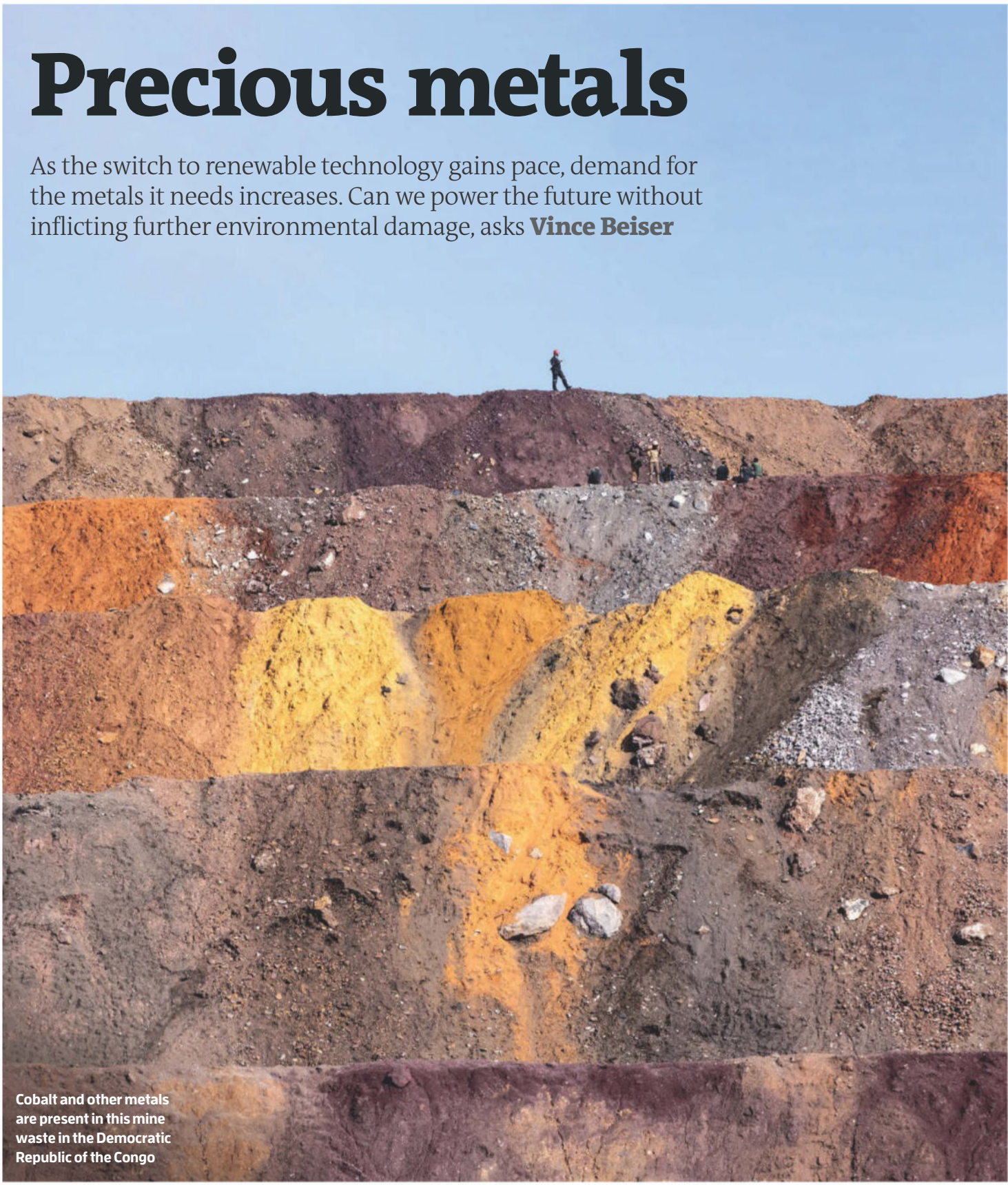
REUTERS/CARLOS JASSO

Exercise is another way to dampen down inflammation

Manuela Callari is a freelance science writer

Precious metals

As the switch to renewable technology gains pace, demand for the metals it needs increases. Can we power the future without inflicting further environmental damage, asks **Vince Beiser**



Cobalt and other metals are present in this mine waste in the Democratic Republic of the Congo

PASCAL MAITRE/PANOS PICTURES

FRIGID, remote and mostly uninhabited, Greenland isn't a place that usually attracts much attention. But the autonomous Danish territory has been making headlines this year, with US President Donald Trump bellowing about acquiring it. Why is he interested in such an unassuming place? Perhaps there's a clue in the recent economic deal he cut with Ukraine and his talk of making Canada the 51st state. Those nations all hold vast amounts of what may be the 21st century's most important natural resources: metals.

The world is shifting, however belatedly, away from fossil fuels and towards renewable energy. That is good news for the climate, but there's a catch. Manufacturing all the wind turbines, solar panels, batteries and electric cars we need for a renewable-powered future – as well as all the digital electronics we are already so dependent on – will require huge amounts of lithium, cobalt, nickel, copper, rare earth elements and other minerals. As a result, demand for this set of what are often called "critical minerals" is soaring.

Yet, despite what you may have heard, there is no shortage of these materials. "The Earth has everything we need," says Simon Jowitt, Nevada's state geologist. "Getting them out of the ground is the challenge." Finding commercial-scale deposits and mining them profitably is difficult – and often inflicts enormous damage on people and the planet. Nevertheless, scientists are rising to this challenge. They may not be able to help with geopolitical wrangling over resources, but with innovative technologies and an environmental mindset, they are finding cleaner, more sustainable ways to obtain the metals we need to power the new Mineral Age.

As I discovered while researching my book, *Power Metal*, the market for critical minerals is gargantuan: hundreds of billions of dollars' worth will be needed by 2040. For instance, the International Energy Agency estimates that by 2050, demand for cobalt from the makers of electric vehicles alone will nearly quadruple. Their hunger for nickel will be nine times what it was last year, and for lithium it will be almost 12 times. Or take copper: over the many centuries in which humans have mined this metal, we have pulled 700 million tonnes of it out of the ground. To meet the projected demand, we will need to do the same again within the next two decades.

"Earth has all the materials we need. Getting them out of the ground is the challenge"

Key minerals

Today, the world relies on surprisingly few sources for most of the critical minerals we use. Chile is the biggest producer of copper, providing a quarter of the total supply. It also sits atop what is probably the world's biggest deposit of lithium, a key ingredient in the batteries for electric vehicles and electronic gadgets. Indonesia has rapidly ramped up mining in recent years and now produces nearly 60 per cent of all nickel, another battery metal. And some three quarters of the world's cobalt – yet another metal used in batteries – comes from the Democratic Republic of the Congo.

Then there are rare earths, a set of 17 obscure elements with tongue-twisting names like yttrium and praseodymium, which are used for electric car motors, wind turbines and many medical and military technologies. Despite their name, they aren't rare at all. They can be found mixed in low concentrations with other minerals all over the world. Nevertheless, digging them up and separating them out is difficult and expensive. There are relatively few places where rare earths are sufficiently concentrated to make mining them feasible. Greenland is one, and there has been very little mining there to date. China is another. It holds perhaps the single largest deposit of the metals, at the Bayan Obo complex, north-west of Beijing, and it has capitalised on this natural bounty to become by far the world's top rare-earths miner, digging up nearly 70 per cent of the global supply.

Given the soaring demand, it is no surprise that there is a planet-wide scramble under way to find more of these metals. In fact, some people are even looking beyond our planet. Starry-eyed entrepreneurs are eyeing the million or more asteroids orbiting the sun, some of which are jam-packed with metals. Google co-founder Larry Page and *Avatar* film-maker James Cameron invested in a couple of asteroid-mining start-ups back in the 2010s, both of which fizzled out. Now, a handful of ›

new enterprises are taking a shot.

Leading the pack is California-based AstroForge, which launched an uncrewed asteroid explorer earlier this year. The craft disappeared into the void before reaching its target, however. That underscores just how difficult the whole project is. You need to send a craft millions of kilometres into space, land it on an asteroid, have it extract metals and then bring them back – all at a cost below what you can get from selling those metals.

Still, this isn't a complete pipe dream. The Japanese and US space agencies have managed to extract material from asteroids in recent years. The boom in private space companies like SpaceX has made it easier and cheaper than ever to launch a lander. And new research suggests a slightly more feasible possibility: commercial quantities of platinum could be obtained by mining craters on the moon created by metallic asteroid impacts.

Deep-sea bonanza?

There is another potential non-terrestrial source a little closer to home: the bottom of the ocean. Parts of the seabed are carpeted with fist-sized rocks, known as polymetallic nodules, which contain what could be hundreds of billions of dollars' worth of nickel, cobalt, manganese and other critical minerals. Companies and governments have long wanted to harvest them.

Technology isn't the problem here – in recent years, underwater nodule-mining robots have been successfully trialled on the floor of the Pacific Ocean. The main obstacle is that, under international law, any commercial-scale sea mining requires permission from the UN-affiliated International Seabed Authority (ISA). The ISA has so far said no to all comers, largely because of fears of environmental damage. Those fears are shared by at least 33 countries, as well as hundreds of scientists, companies and organisations, all of which have called for a moratorium or outright ban on sea mining.

Things may change very soon, however. The US never signed the treaty that established the ISA, and Trump has called for the US to develop deep-sea mining capabilities. Earlier this year, The Metals Company essentially sidestepped the ISA and applied to the US government for a license to start industrial-scale mining. The application is currently under review, but the move has sparked outrage.

ULET IFANSASTI/GETTY IMAGES; PHILIPPE PSAILA/SCIENCE PHOTO LIBRARY

Above: Nickel mining in Sulawesi, Indonesia, has led to the destruction of rainforest

Left: Lithium extraction in Chile is straining water supplies

"There is no provision in international law for what they are proposing," says Duncan Currie, a legal advisor at the Deep Sea Conversation Coalition. "It's just the US saying: 'We'll do what we want.'"

Proponents of deep-sea mining argue that it will be less harmful than the terrestrial version. Although that is contested, it is undeniable that mining and processing metals on land often wreaks havoc.

Mines destroy landscapes, devour resources and excrete waste on a colossal scale. Around 35 kilograms of ore must be wrested out of the ground to get the metals required to build a single iPhone. In just one area of the Indonesian island of Sulawesi, more than 85 square kilometres of rainforest – the equivalent of 12,000 football pitches – has been wiped out to make way for nickel mines and related infrastructure. In Chile's arid north, copper and lithium mining is straining water supplies, imperilling rare animals and millennia-old Indigenous communities.

Chemical run-off and toxic waste from mines and refineries often foul the nearby air and water. Almost half the rivers in the western US have been polluted in this way, and those Indonesian nickel mines emit a carcinogenic toxin that has seeped into drinking water in some areas.

In China, rare earth mining and refining has turned the area around Bayan Obo into one of the most polluted places on Earth. Baotou, the region's main city, used to be surrounded by fields of watermelons, aubergines (eggplants) and tomatoes. Now things are very different. "These days, the soil can no longer support crops, the livestock has died off," writes Aaron Perzanowski, a law professor at the University of Michigan in his book *The Right to Repair*. He also reports that local people are experiencing a range of illnesses that seem to be connected with the mining.

In some parts of the world, mining is carried out by enslaved people and children. According to a US Department of Labor report, there is evidence of forced labour in the supply chains of Indonesian nickel and Chinese silicon and aluminium, as well as child labour in the supply chain of South Korean indium. In the Democratic Republic of the Congo, thousands of children work in cobalt mines under often brutal conditions. In Bolivia, adolescents dig for silver, a key ingredient in solar panels.

"Children as young as age 13 work inside mines, where they haul heavy loads of ore,

"Around 35 kg of ore must be mined to get the metals required for a single iPhone"

work in narrow tunnels at risk of collapse, are in close proximity to explosives, inhale toxic fumes and dust, and generally lack protective equipment," notes the report.

There is also a major geopolitical concern that can be summed up in a single word: China. By plundering its own huge reserves and aggressively investing in mining operations around the world, the country has come to dominate the supply chain for critical minerals.

Revisit, refine, recycle

Regardless of where minerals are dug up, most will be sent to China for refining and processing. The country has more than half the world's refining capacity for lithium, cobalt and graphite (another battery ingredient), while for rare earths, the figure hovers at around 90 per cent. All of which gives China not only a commanding economic position, but powerful political leverage, which it isn't shy about using. Earlier this year, for example, China restricted exports of rare earths and other metals in response to Trump's trade tariffs.

Although science can't help much with international relations or trade negotiations, researchers are making good progress in addressing the technical and environmental issues.

Some are looking at ways to clean up mining. A US team, for example, has found that pumping carbon dioxide into rocks deep underground releases nickel and cobalt, with the potential to make extraction carbon negative. Another group in China is developing an approach called electrokinetic mining, which uses electric currents to shake rare earths loose from soils, reducing the need for toxic chemicals. And several research groups are trialling techniques to extract lithium directly from underground brines, reducing the huge amount of water that is currently used. Improvements are also coming in refining critical minerals – the stage of the production process that generates the most greenhouse gases.

What could have an even greater impact than these innovations, though, is a growing movement to reduce, reuse and recycle. There are vast quantities of critical minerals hidden in the hundreds of billions of tonnes of mining waste all over the world – elements that weren't in demand when the original mines were operating, or that were too difficult to extract with the technology of the time. Now, researchers are looking at ways to obtain resources from that trash. "Half the problem is already solved: you've got the metals above ground," says Scott Dunbar, professor of mining engineering at the University of British Columbia in Canada.

One approach is to use plants called hyperaccumulators that suck up tiny specks of metals through their roots and concentrate them in their sap, stems or leaves. Researchers in the UK, Australia and Albania are experimenting with a range of these, putting them to work pulling metals out of mining waste or polluted soil. If plant-based metal harvesting, known as phytomining, can be made to work at scale, it could offer a double win: cleaning up poisoned ground while simultaneously providing new supplies of critical minerals.

A technique devised by scientists at the University of Missouri promises similar benefits. They have figured out a way to use a compound made from ground-up shrimp shells to draw neodymium – one of the most in-demand rare earth elements – from iron mine waste. Meanwhile, in West Virginia, researchers have found that they can extract rare earths from coal mine run-off by lowering the acidity of the water. Mining giant Freeport-McMoRan is trying to pull copper out of waste rock at one of its Arizona mines. And in Europe, several companies are extracting manganese and rare earths from tailings – leftover materials – at old mines.

Our discarded electronic gadgets are also full of recyclable metals, yet less than a quarter of the 62 million tonnes that people throw out each year is properly recycled. That is a colossal waste of energy and leads to more greenhouse gas production, since recycling metals incurs a far lower greenhouse gas cost than mining fresh ones. It is also a waste of money because these products contain more than $62 billion worth of metals.

One reason why so few old electronics get recycled is that sorting and separating out all their component metals and other materials is difficult and costly. Advances in technologies like X-ray fluorescence sorting, which can identify elements in e-waste, and AI-driven sorting systems could help. So could more efficient methods of recovering metals from used batteries, using techniques like microwaves to extract lithium, selective leaching and plasma arc recycling.

Advances in the design of products made from critical minerals could have huge effects too. For example, most electric vehicle batteries in use today are made of cobalt and nickel, but so-called LFP batteries replace those metals with iron and phosphate – materials that are much more abundant and have less troublesome supply chains. LFP batteries are rapidly gaining market share, particularly in China.

From the Stone Age onwards, humanity has relied on a succession of different materials to achieve progress. One way or another, we will get our hands on the metals we need to power our renewable future. The challenge is to make sure we don't trash the planet in the process. ▮

HU XIAOFEI/VCG VIA GETTY IMAGES

Electric cars use metals like lithium in their batteries

Vince Beiser is a journalist based in Canada. His latest book is *Power Metal: The race for the resources that will shape the future*

IN JUNE, at a conference set in the picturesque Italian town of Campagna, south-east of Naples, two physicists in a seemingly endless argument over a long-sought theory of fundamental reality caught my attention. From the sidelines, an unassuming figure politely interrupted them.

"I've got a slide that might help. Can I put it up?" asked Frank Wilczek. The slide, concisely describing the realms in which this theory may act, swiftly ended the dispute. Among the many luminaries jousting in Campagna, I realised, perhaps only Wilczek had the breadth of expertise to untangle their confusion.

Wilczek is one of the most original physicists alive today, whose achievements seem too numerous for a single mind. He revealed the true workings of one of the four fundamental forces of nature. He proposed the axion, a leading candidate for dark matter. He also predicted bizarre particles called anyons and a state of matter called a time crystal.

These landmarks fall within a familiar pattern. Wilczek immerses himself in something entirely new, makes a major contribution and then moves on, led by his curiosity. Now, at the age of 74, he is still finding new obsessions, such as gravitational waves and artificial intelligence. Though these may seem like disparate forays, they all serve Wilczek's desire to uncover hidden layers of reality.

"The way the world works is a boundless, continuing joy and a revelation to me," says Wilczek. "The deeper I look, the more I feel rewarded, the more I see new things to investigate, but also new things to just appreciate."

So, on a terrace in the shadow of the Picentini mountains, we sat down to look back at his career and cast one eye to the future.

The conference was held in an Augustinian convent that underwent an expansion in the 16th century and is now a working town hall. It was an unusual venue for a physics conference: posters about black holes and new kinds of elementary particles were plastered beneath medieval frescoes. The gathering was partly to celebrate how much progress there has been in quantum mechanics since the theory arose a century ago, and partly to work out how to approach the many puzzles that remain in fundamental physics. "The framework [of quantum mechanics] has gone from triumph to triumph – far beyond what the founders anticipated," says Wilczek.

Now a theorist at the Massachusetts Institute of Technology, Wilczek has done more than most to flesh out this skeleton theory with concrete descriptions of what reality is made of. Incredibly, he made his first major contribution when he was only 21. At the time, the standard model of particle physics – our best description of the elementary particles and forces of nature – was still being forged. For decades, physicists had grappled with how the strong nuclear force holds together protons and neutrons inside an atomic nucleus. Then, in 1972, the fresh-faced Wilczek stepped in with an idea he called asymptotic freedom, which says that as you pull apart quarks, which are the building blocks of protons and neutrons, their attraction grows stronger, but if you move quarks closer together, the force grows weaker. This observation formed a pillar of what is now called quantum chromodynamics, or QCD, which is itself a pillar of the standard model.

Inspiration strikes

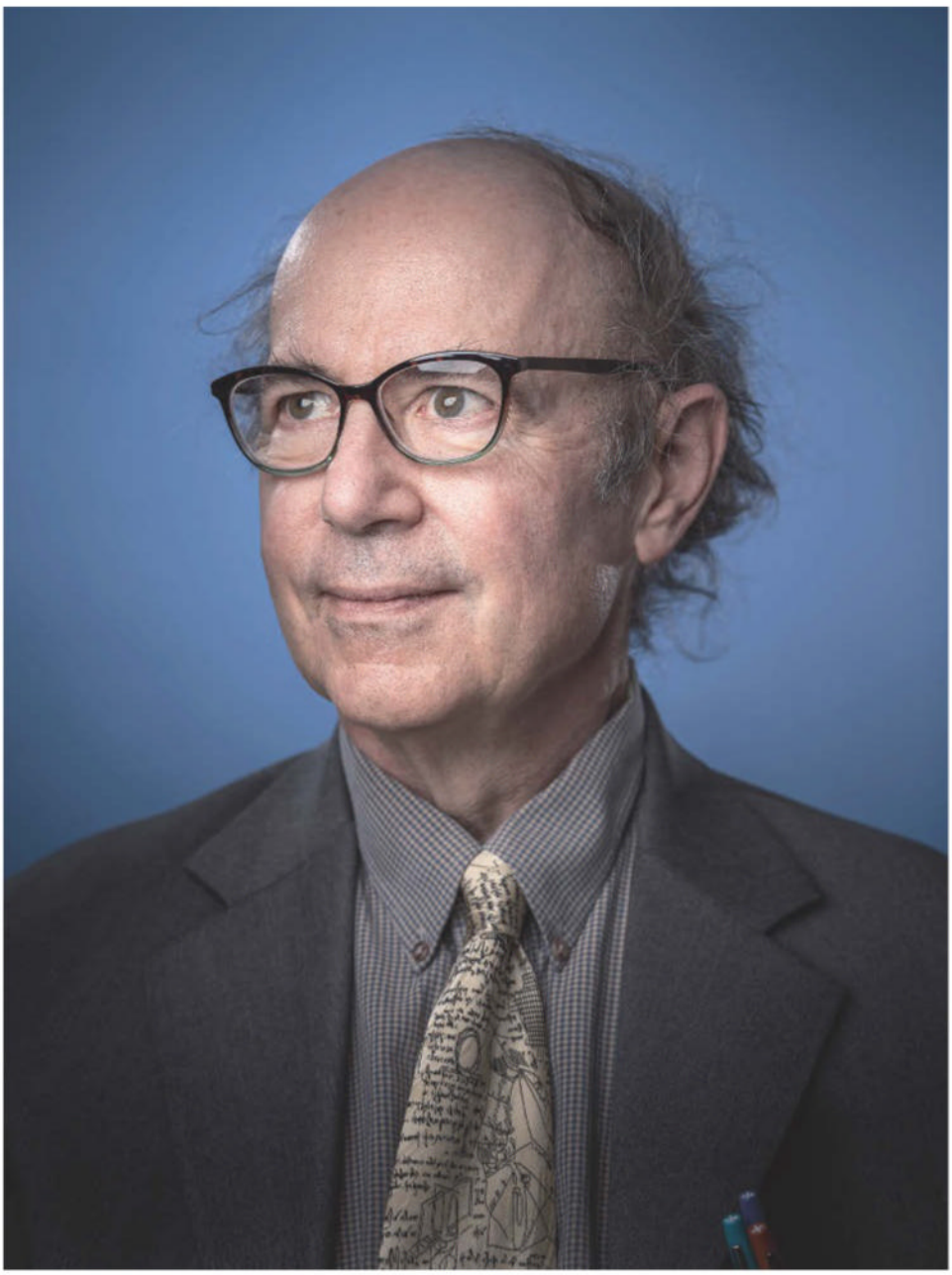
Although Wilczek later won the 2004 Nobel prize in physics for this insight, which he shared with David Gross and David Politzer, he has one regret about this period: asymptotic freedom is, by anyone's estimation, a bad name for a good idea. "I learned this very early the hard way," he says. "Because we didn't have a good name, other people kind of glommed onto it and grabbed different pieces. We didn't wrap up the package and establish our ownership in the way we should have."

It was a lesson that Wilczek took to heart. A few years after initially outlining the theory of QCD, he realised it was pointing towards the existence of a novel, ghostly fundamental particle. What could he call it? Wilczek's mind wandered to an earlier shopping trip with his mother while he was home from university. "I saw [a washing powder called] Axion up on the shelf, and I said, 'Gosh, that really sounds like a particle.'"

Since then, the axion particle has come ›

"The way the world works is a joy to me"

One of the most brilliant and original minds in theoretical physics, **Frank Wilczek** came up with the idea of time crystals among much else. Alex Wilkins met him to find out where his curiosity is taking him next



MICHAEL CLARK PHOTOGRAPHY

DESY

Above: The HERA particle detector verified Wilczek's theory of quantum chromodynamics

Below: A prototype of a device to detect axions, a hypothetical particle Wilczek named after a cleaning brand seen on a shopping trip (bottom)

JÓN GUDMUNDSSON/UNI OF ICELAND/STOCKHOLM UNI

AMEN23207/SHUTTERSTOCK

into its own. Although axions haven't been detected, they are a leading candidate for dark matter – the unknown substance that seems to bind galaxies together. Multiple experiments around the world are now searching for axions, which could be hundreds to billions of times smaller than the tiniest particles that we know exist. One of these detectors, which is being designed by Wilczek and his collaborators at Yale University, is called the Axion Longitudinal Plasma Haloscope, or Project ALPHA. The experiment consists of a fine-tuned wire frame capable of acting like dense plasma that should be able to detect an axion in the act of turning into a photon of light. When Project ALPHA switches on next year, it will home in on the range of masses where dark matter may still be hiding. "That should happen on the timescale of five to 10 years," says Wilczek. "Unless something goes terribly wrong."

Wilczek has many reasons to be optimistic about the search for axions, not least because he calls the theoretical motivations for it "profound". But he is under no illusions about how difficult it might be and is humble about the possibility of failure. "People believe all kinds of things," he says. Indeed, he is quick to point out to me that his conception of axions has evolved since the 1970s because it originally implied very massive particles that conflict with the observed properties of stars in our galaxy.

This humility was on display throughout the Campagna conference. Everywhere Wilczek went, he carried a small collection of coloured notecards, and many times I noticed him bending over to scribble reams of equations for a professor or student who had asked him something they didn't understand.

His eagerness to get stuck into the topic was also tied to his urge to carefully think things through, whether it was by himself or out loud, as he peppered speakers of every background – string theorists to gravitational wave experimentalists, Nobel prizewinners to recent graduates – with questions to help improve his own understanding. Such was the respect from his fellow physicists that, whatever the subject, whenever Wilczek spoke, they patiently listened.

Wilczek's thoughts are evidently worth listening to. It is hard to ignore the impact and relevance that QCD and axions continue to have, half a century on from their conception. The same is true of another of Wilczek's youthful divinations: a new kind of particle that, in 1982, he christened the anyon. Technically, anyons are collective vibrations that behave as if they are particles, called quasiparticles, which can result in some unique behaviours. Elementary particles are usually indistinguishable: if you imagine swapping two particles of the same type, it would be impossible to tell that the exchange ever happened. Anyons, on the other hand, keep track of where they have been in physical space, with each swap fundamentally altering how they vibrate.

Though anyons were a theoretical oddity at first, experiments performed by other researchers soon after indicated to Wilczek that they really might exist in some quantum systems. "I thought to see this kind of behaviour should be relatively straightforward and would only take a few months," says Wilczek. In fact, it took almost 40 years before anyons were shown to exist. Now they are an active area of research in quantum computing because each particle's ability to keep track of its past can be used to build computer memory. "A lot of effort has gone into designing materials or implementing the ideas in other kinds of hardware," he says. "It's a beautiful thing to see."

Another of Wilczek's triumphs could further transform quantum computing: the exotic-sounding time crystal. This peculiar state of matter contains repeating patterns that are found not in their physical structures, as with normal crystals, but in the way their structures arrange themselves through time.

Crystals in time

In this case, Wilczek tells me between bites of an Italian biscuit on the terrace, it was his wife who coined the term during a holiday walk in the English countryside in the early 2010s. "She asked me, 'What are you thinking about?' And I told her about this stuff – spontaneous breaking of time-translation symmetry. Well, she said, 'Can you make it a little more vivid?' And I said, 'Well, it's like a crystal, but in time.' She said, 'Oh, a time crystal. You have to call it that.'" This name "catalysed interest", says Wilczek, so that, within a decade, researchers had made real time crystals in the lab.

All of Wilczek's insights are rooted in quantum mechanics, and he is one of the theory's great champions. But having dedicated his career to extending and working within the field, he is also keenly aware of its shortcomings – not least in how little progress has been made in reconciling it with gravity to

"The deeper I look, the more I feel rewarded, the more I see new things to investigate"

MICHAEL CLARK PHOTOGRAPHY

reach a deeper layer of reality. "To conquer the rest of the territory is tougher because we've succeeded so much," says Wilczek. "The low-hanging fruit has all been picked and the easy experiments have been done."

New methods are emerging, though, that may help us to make inroads. This is thanks in no small part to the understanding of quantum materials spearheaded by Wilczek. "I'm very gratified that it gives us new tools for accessing subtle behaviours that we couldn't have dreamed of accessing before," he says. No one knows what lies beyond the frontier of quantum mechanics, but Wilczek is sure that it will be "even more beautiful and surprising".

One promising approach, he tells me, is to pay close attention to gravitational waves, which we have been measuring with increasing sensitivity since their discovery almost a decade ago. In the same way that the field of quantum optics has thrived in distinguishing the different forms that light can take, from high-energy lasers travelling through exotic materials to everyday light emitted from a light bulb, Wilczek hopes that we can tease out whether there is some hidden structure to gravitational waves that might imply a quantum nature.

Recently, an idea from the 1960s called a Weber bar has been resurrected to search for this structure. In their original conception, Weber bars were metre-high aluminium cylinders designed to resonate when gravitational waves of certain frequencies passed through them. New experiments that use quantum technologies to control and measure the bars' vibrations with far greater sensitivity could find the subtle imprints of hypothetical quantum particles called gravitons. "This would transcend this whole question of whether gravity is quantum mechanical," says Wilczek.

Wilczek is also buoyed by the possibilities of artificial intelligence and has been experimenting more and more with chatbots running on large language models as part of his scientific process. For instance, he used ChatGPT to help him design a better antenna for Project ALPHA, and even appears to be striking up a friendship with the chatbot. "Every day, I try to have a meaningful conversation with ChatGPT about science – and I've learned new things and had good answers to very technical questions," he says earnestly.

This might seem like an about-turn from the open letter he penned in 2014, along with physicists Stephen Hawking and Max Tegmark, which warned of the "incalculable benefits and risks" of AI. Yet Wilczek says he hesitated before signing the final draft of the letter because it had strayed from his typically optimistic stance. "I'm not alarmist. What worries me is not so much artificial intelligence, but natural stupidity," he says. Namely, he is concerned about AI being used for military purposes. "That's almost the same concept as doomsday machines, where you just hand over responsibility to processes you don't understand or control, and it's very dangerous because you only have to make one mistake."

Wilczek's natural optimism has recently been shaken by the large-scale cuts to US science funding enacted by the Donald Trump administration. While obvious technological spin-offs such as quantum computing and artificial intelligence have retained government support, the wider research ecosystem is being dismantled. "This is really killing the goose that laid the golden egg," says

Frank Wilczek has long been at the vanguard of theoretical physics

Wilczek. "It's being done very thoughtlessly, just like a kid playing with matches."

Wilczek is also angry at the tech CEOs who have benefited from the scientific research that has enabled their technology empires, but have mounted no opposition to the cuts. He puts down his coffee and looks at me seriously. "People like Elon Musk, Mark Zuckerberg, Jeff Bezos are conspicuously silent. We should call them out," he says.

Yet even with the promise of AI and quantum technologies, Wilczek has an acute sense of how much there still seems to do – and how little time there is to do it. Aside from quantum gravity, he reels off a long list of scientific puzzles that he is toying with: dark energy, dark matter, cosmic inflation, figuring out what's inside a neutron star. "It's like climbing Mount Everest," he says, smiling. "You've got to do it because it's there."

After a lifetime of climbing mountains, Wilczek's view is nothing short of sublime. "A human lifetime is very limited in time and space, compared to the universe," he says. "In a way, it is humbling, but it's also a relief to know that there's a larger structure of which we're a part that is so grand. Our imperfections, our struggles, our travails, when you put them in perspective, they somehow don't seem so traumatic." ▮

Alex Wilkins is a news reporter at *New Scientist*

Dear David

Taken for granted

Research reveals that bosses tend to exploit their most loyal employees. **David Robson** has some advice for a frustrated reader

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

Further reading

Vanessa Bohns's book *You Have More Influence Than You Think* (W. W. Norton) explores the psychology and ethics of compliance, including many strategies to become more assertive.

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

Next week

Stargazing at home

"I'VE always prided myself on my can-do attitude," a reader told me this month. "Recently, however, I've started to feel resentful of the amount of work my boss puts at my door compared to colleagues. The more I do, the more he seems to expect of me, and I now feel that I'm cracking under the stress."

Our reader's frustration is surely justified. A good work ethic should be one of the most highly prized – and rewarded – qualities in an employee. Everyday experience, though, reveals this is rarely the case. Indeed, according to studies by Matthew Stanley at the National University of Singapore and his colleagues, a pernicious bias can lead managers to exploit the very people they should be prizing.

In one experiment, a group of managers were asked to read about a fictional employee named John, whose company was facing financial difficulties. They had to decide how willing they would be to give John extra hours and responsibilities without any extra pay. The researchers found that the managers were far more willing to do so if they learned that John had proved to be a loyal member of the team – compared with someone who was known to be more detached from their work.

Further studies confirmed that small displays of loyalty encouraged managers to take this attitude: the more "John" gives, the more his managers will take. As Stanley and his co-authors note, this could create a "vicious cycle" of suffering – while less loyal workers manage to escape the sacrifices. But before you start viewing your boss too harshly, it is worth noting that Stanley and his colleagues don't believe that the managers are conscious of their behaviour, instead regarding this as a form of "ethical blindness".

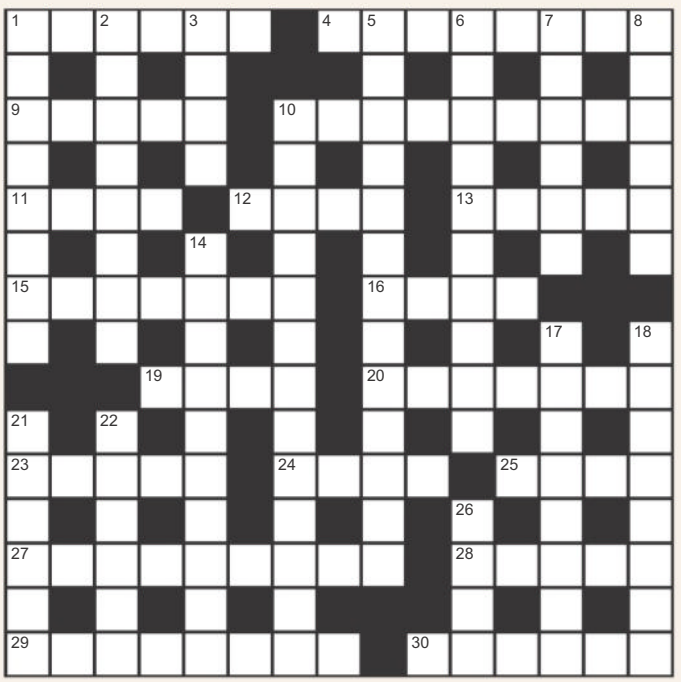
FERRAN TRAITE SOLER/GETTY IMAGES

This may be compounded by the fact that many of us struggle to turn down extra responsibilities for fear of seeming disagreeable. If we are to break free from that pattern of behaviour, we need to learn how to say no. Research by Vanessa Bohns at Cornell University in New York state suggests it is easier to do so by email than in voice-to-voice or face-to-face conversations. If the request comes in person, or on the phone, I have found that it helps to ask whether you can check your schedule before agreeing. That small delay should prevent a knee-jerk "yes", and if you want to refuse, it gives you time to formulate a polite response. Try to use assertive language. Saying "I don't have time" is more persuasive than "I can't make time", for example, since it is simply reflecting the reality of your situation, rather than apologising for your inability to create more hours in the day.

But I can't help think the onus should be on our managers to change their behaviour. A little self-awareness about their tendency to exploit their hardest workers might lead them to rethink how they reward that loyalty. ▮

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

Quick crossword #190 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Insect that might be annual or periodical (6)
4 Wading birds also known in the UK as peewits (8)
9 Bronze or steel, say (5)
10 Super-dense astronomical object (5,4)
11 Finely drawn metal (4)
12 Chance, in gambling (4)
13 Heartbeat (5)
15 Cd (7)
16 Skin (4)
19 Late clinical stage of infection with HIV (4)
20 Lachrymatory agent (4,3)
23 Surrounded by (5)
24 That being the case (2,2)
25 Concerning the mouth (4)
27 Suitable for further investigation (4-5)
28 Reasoning (5)
29 Rupture of an organ or blood vessel (8)
30 Nerve cell (6)

DOWN

1 James ___, Nobel-winning English physicist (8)
2 Compound of Cl (8)
3 24-hour periods (4)
5 Put under (13)
6 Online encyclopaedia editor (10)
7 Bicycle brake-cable guide (6)
8 Home country of the Nobel prizes (6)
10 Value derived from a person's height and weight (4,4,5)
14 Deep-sea submersible (6,4)
17 Preparation used to contain culture media, in microbiology (4-4)
18 Psychedelic found in some mushrooms (8)
21 RAF military transport plane (6)
22 Largest citrus fruit (6)
26 Primary colour (4)

Our puzzles are now solvable online
newscientist.com/games

Quick quiz #316
set by Corryn Wetzel

1 What is the primary structural component of cell walls in land plants?

2 What year was the iPhone first released?

3 What is the longest muscle in the human body?

4 Who is credited with the discovery of X-rays in 1895?

5 What is the term for a person's unique fingerprint?

Answers on page 47

BrainTwister
set by Sophie Maclean
#87 Seating mix-up

Three passengers are boarding a three-seat train, and each has their own assigned seat. The first passenger has lost their seat allocation and sits in a random seat. (They are equally likely to choose any of the three seats, including their own.) After that, everyone sits in their own seat if it is available, or a random one otherwise.

What is the probability that the final passenger to board sits in their own seat?

If five passengers board a five-seat train with the same situation, what is the probability that the final passenger finds themselves sitting in the seat that was assigned to the second passenger to board?

If there were 100 passengers and 100 seats, what is the probability the final passenger gets to sit in their own seat?

Solution next week

Cathartic cry

I recently lost my dog and good friend, Milou, to old age. I cry a lot for him, and wonder why crying helps us so much?

Randolph R. Cornelius
Professor Emeritus, Vassar College, Poughkeepsie, New York, US
Scientists have discovered that crying, by which we mean shedding tears, happens for a number of reasons and that it, indeed, helps us – often a great deal.

Shedding emotional tears, sometimes called weeping, evolved in humans – we appear to be the only animals that do this – to elicit help from those around us.

In infants, crying, which is initially a vocalisation that can develop into full-scale weeping, serves the purpose of alerting the infant's caregivers that the child is in need of something, whether it be nourishment, warmth or ridding it of pain.

Tears are an unmistakable signal that something is wrong in the infant's experience. As such, those who study tears regard it as an "attachment signal", an

"Tears are an unmistakable symbol of how much the loved one, human or otherwise, meant to us"

idea promoted by the English ethologist and developmental psychologist John Bowlby.

Attachment signals not only help bring us much-needed aid and comfort when we are young. Studies in the past 25 years have found that the tears of adults signal to other adults that the weeping person is in need. Thus, when we weep, others are likely to help us. But what about the kind of tears the questioner seems to be describing: tears that may appear when we are alone?

Although the answer has been difficult to pin down, it looks as if – as many of us who are frequent weepers know from our own experience – weeping indeed has an intrapersonal function, as well as the interpersonal function I described previously. Shedding tears has the effect of decreasing the physiological "arousal" that accompanies emotions like sadness or mourning. That term might seem odd, but while we may not feel like doing anything when we are saddened by the death of a beloved dog or cat, our bodies are in a state of physiological arousal. Letting tears of sadness or remembrance fall may indeed give us some solace.

Tears are also an unmistakable symbol of how much the loved one, human or otherwise, meant to us. This, in itself, may help us achieve a sense of closure. Note that the two explanations of emotional tears, the interpersonal and the intrapersonal, aren't mutually exclusive. At the same time that our tears bring about a change in our physiological arousal level, others may see that we are in need and offer us hugs and consoling words.

Ad Vingerhoets
Professor Emeritus, Tilburg University, The Netherlands
We conducted a worldwide study in which we asked approximately 5500 participants many details about their most recent crying episode, including how they felt after having cried. Exactly 50 per cent reported a mood improvement, 40 per cent reported feeling no change in mood, and the remaining 10 per cent felt worse. This made us realise that the better question – instead of the question of whether crying is beneficial – is: "For whom, and in which conditions, does crying make us feel better?" We found three crucial factors.

First is the mental condition of the crier. Surprisingly, those who tend to cry more often seldom report the beneficial effects of crying. Thus, those who need it the most don't benefit!

The second factor is the nature of the antecedent – what happened to elicit crying? We distinguished between uncontrollable events – such as the passing away of a significant other – and controllable events – such as an argument. We found that crying mainly makes people feel better after controllable events, and helps much less after uncontrollable ones.

Third is how bystanders react to the tears. If they respond with understanding and support, then you feel better. However, if they ridicule you or become mad and you feel shamed, then it is less likely that you will feel better.

Another factor that may play a role is that we often cry when we are in a deep, low mood. This means that after some time, by definition, we feel better (a return to baseline). That return to baseline might be misinterpreted as an increase in mood.

On the internet and in popular magazines, one can often read that the beneficial effect is likely to result from either an increase in the brain levels of substances like oxytocin or endorphins; the removal by tears of toxic substances and stress hormones from the blood; or an increase in parasympathetic activity, which results in relaxation.

However, regarding the first point, this is just a hypothesis. We did a study in which we measured the effects of crying on pain perception. If substances like

PM IMAGES/GETTY IMAGES

Does my petrol lawn mower emit more carbon than my grass captures?

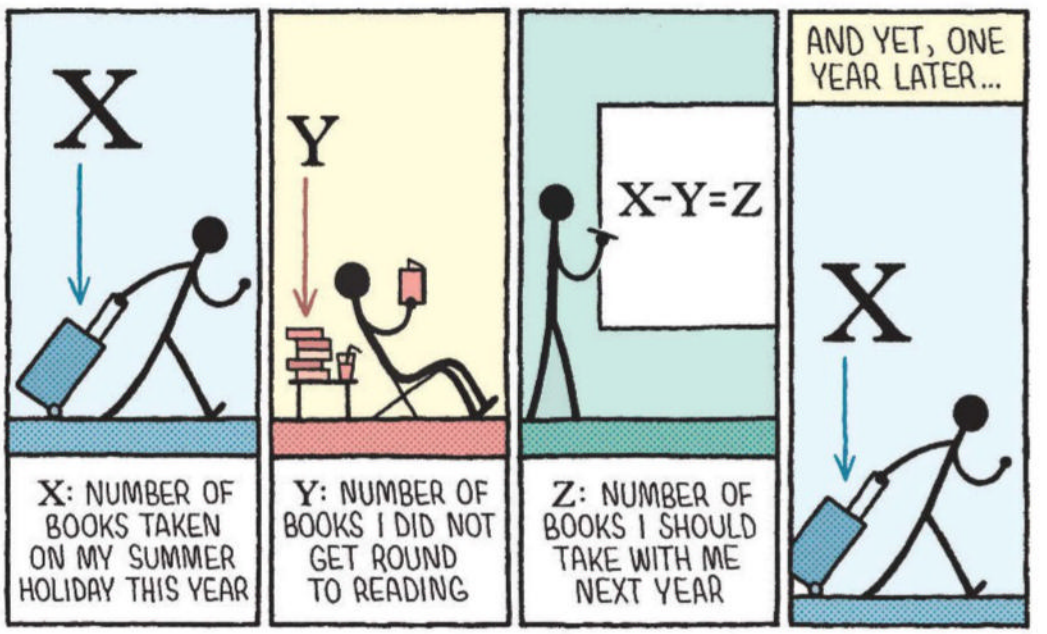
This week's new questions

Gas or grass? **I use a petrol lawn mower – does it emit more carbon than the grass captures?** ***John Fredericks,*** *Theydon Bois, Essex, UK*

Mug melody **Heat a ceramic mug of water in the microwave, tap it with a steel spoon, and the pitch is higher than before it went in. Why?** ***Francis Westfield,*** *Stoke-on-Trent, Staffordshire, UK*

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld
for New Scientist



endorphins or oxytocin were involved, one would expect a reduced pain perception, but that wasn't the case.

Regarding the second point, this claim doesn't make scientific sense. Yes, like saliva, tears are distilled from the blood, which implies that blood levels of certain hormones and other substances can be represented in the levels in tears. However, that doesn't mean that these substances are actively removed from the blood by this route.

Finally, regarding the increase in parasympathetic activity, the initial problem is that we cannot determine what comes first: is the increase in parasympathetic activity followed by the onset of crying, or is it the other way around? While there is no evidence in support of the idea that crying makes us feel better via changes in neurobiological processes, there is strong evidence that the sight of tears makes bystanders more empathic and more likely to provide support and comfort, which has a positive impact on the well-being of the crier.

"Squirrels have a highly flexible subtalar joint, allowing the foot to rotate independently of the leg"

Going vertical

Why can squirrels run straight down trees? And could my cat do the same thing if it had to?

Mike Follows
Sutton Coldfield, West Midlands, UK

Only a few animals possess the specific adaptations that allow them to move head first in a controlled way down a tree trunk, including squirrels.

Squirrels have a highly flexible subtalar joint – the joint between the talus (ankle bone) and calcaneus (heel bone). In most terrestrial mammals, this joint is flat and tightly interlocking, limiting side-to-side movement and stabilising the joint. However, in squirrels, the articular surfaces are rounded and obliquely angled, making the joint more mobile, allowing the foot to rotate independently of the leg.

Birds such as nuthatches can also walk head first down trees, searching for insects in crevices that other creatures miss. They have strong legs and large hind toes with curved claws that allow them to gain purchase on the bark, and they use their tails for balance.

Geckos have special toe pads with setae – microscopic hairs – that allow them to use electrostatic forces to grip vertical and inverted surfaces, so running down a tree poses no difficulty for them.

Some monkeys are also capable of moving head first down trees. While they lack the specialised foot rotation of squirrels, they rely on strong grasping hands and feet, excellent balance and agility. Tamarins, in particular, have claw-like nails that improve grip on vertical surfaces, allowing them to descend in a controlled way. ▮

Answers

Quick quiz #316 *Answers*

1 Cellulose
2 2007
3 Sartorius
4 Wilhelm Röntgen
5 Dactylogram

Cryptic crossword #168 *Answers*

ACROSS 1 Pupa, **3** Obsolete, **9** Surgeon, **10** Ichor, **11** Obese, **12** Ermine, **14** Embryo, **16** Pollen, **19** Sudoku, **21** Torso, **24** Radio, **25** Thicken, **26** Sure-fire, **27** Asia

DOWN 1 Pushover, **2** Per se, **4/18** Bunker buster, **5** Opium, **6** Ethanol, **7** Earp, **8** Celery, **13** Insomnia, **15** Bounder, **17** Outwit, **20** On-off, **22** Rakes, **23** Ores

#86 Travelling around *Solution*

The angle you turn plus the angle inside the triangle add up to 180 degrees, so you would turn 130 degrees at that corner. The sum of the angles inside a triangle is also 180 degrees: this makes the last angle 60 degrees and means we have turned through 130, 110 and 120 degrees to return to where we started, for a total of 360 degrees. This holds for any triangle: we always turn 360 degrees, which is one full rotation. For a quadrilateral like a rectangle or trapezium, the same is true. It is even still the case for quadrilaterals with an indent, you just turn left by a negative number of degrees at that corner. If the sides of the quadrilateral cross over, the sum of angles turned, positive and negative, is zero degrees.

In out in out

It's well-known that the internet is about 60 per cent cats and 35 per cent automated bots, so a cat-themed bot was inevitable.

Hence @PepitoTheCat, the X (Twitter) account of a black cat called Pépito who lives in France. His owner, Clément Storck, is an engineer with a fascination for automation, so he created a system that posts to X whenever Pépito goes in or out of his cat flap.

The account is not, on the face of it, thrilling reading. Every post is either "Pépito is out" or "Pépito is back home", with the time marked to the nearest second. These are accompanied by a black-and-white photo of Pépito and a short video showing him coming in or out.

And yet @PepitoTheCat has more than 860,000 followers (of whom a surprising number live in Brazil). What's more, they are attached. In June 2017, Pépito went out and did not come back for 22 hours, and, as BuzzFeed put it, "basically all of Brazil freaked out". Storck had to create an actual written post, explaining that Pépito had come back in through the "human's door", so his return hadn't registered on the system.

Feedback would just like to say: 22 hours? That's nothing. One of Feedback's felines routinely disappears for a day or so at a time. Worse, one of Feedback's former felines once disappeared for six weeks, only to be discovered up a tree several hundred metres from where she was supposed to be.

Pépito is surprisingly tenacious: the account has been going for 14 years, and Pépito turns 18 in September and is seemingly hale and hearty. However, the account has now entered more contentious territory, with the news that Pépito's owner is selling a Pépito-themed cryptocoin. Dude: we just liked the cat.

On track

Feedback empathises with the people who spend all their pocket money on Hornby model railways, even if we ourselves never got heavily into the hobby. We were therefore delighted when Alan Edgar drew our attention to a press release from Northern Rail, one of the UK's privatised rail firms (at the time of writing). In November 2024, the firm announced it had hired a new commercial and customer director to lead its "drive for growth": one Alex Hornby. The company's managing director was quoted as saying that Hornby has "a brilliant track record".

While we're on names, Ian Gammie came across a 2019 report about greenhouse gas emissions by the US military. Apparently, "the US military is one of the largest climate polluters in history, consuming more liquid fuels and emitting more CO_2e (carbon-dioxide equivalent) than most countries". This was according to research by UK academics, which seems about right – after all, you wouldn't catch any US academics writing something like that now. Ian was pleased to see that the report's authors included Patrick Bigger and Oliver Belcher.

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

You just lost

In March, Feedback discussed Roko's Basilisk: a particularly stupid thought experiment about artificial intelligence. It supposes that, in the future, there will be an all-powerful AI. This AI will create computer simulations of all the people alive today who didn't help bring it into existence and endlessly torture them as a means of ensuring that we all get in line right now and help build the AI. If that sounds confusing, it's because it doesn't make a lick of sense.

Our colleague Jacob Aron recently reviewed a novel called *Basilisk* by Matt Wixey that plays with similar ideas. That led reader Finn Byrne to look up "cognitohazards": the idea that some forms of knowledge are inherently dangerous. In the case of Roko's Basilisk, simply knowing about the future AI seemingly puts you in danger of an eternity of torment, because the AI is going to torture only people who knowingly refused to contribute to its existence.

Then something bad happened. As Finn browsed the Wikipedia page for cognitohazards, aka information hazards, he lost The Game. And then he wrote to Feedback to tell us about it, and then we lost The Game, too. At this point, you too have just lost The Game.

As Finn explains, The Game is "a very simple game played constantly by all of humanity". It has only three rules: "1) You are playing The Game. 2) Every time you think about The Game, you lose. 3) Loss of The Game must be announced." There is, of course, a website for it: losethegame.net.

The Game is something Feedback played a lot when we were a student and allegedly had time on our hands. On many occasions in pubs, watching TV or in science practicals, one of our friends would spontaneously announce: "Just lost The Game." We had forgotten about it for quite some time, but now we are going to lose a lot.

Finn goes on to discuss strategies for The Game. You can't win, except by developing permanent amnesia or dying, both of which seem like overkill. But you can make other people lose. "The website includes a page for avid players to donate to the worthy cause of the words 'LOSE THE GAME' being written 'over New York City in letters the size of the Empire State Building'," says Finn. If you're less keen to splash cash, you can leave hidden notes in strategic places.

Finally, there are awards for "making an outstanding number of people lose the game". Finn says that these have often been awarded to "people who have mentioned The Game in newspapers or magazines".


WATERLOO
SPARKLING WATER
WATER DOWN NOTHING
O SUGAR
WATERLOO
SPARKLING WATER
GUAVA BERRY
0 CALORIES
SUGAR
SWEETENERS
SODIUM
NON GMO Project VERIFIED
nongmoproject.org
WHOLE 30 approved
CERTIFIED GLUTEN FREE
GFCO.ORG

THE GREATEST CHALLENGES OF OUR TIME

THROUGH THE EYES OF THE GLOBAL HERO WHO CHANGED THE COURSE OF HISTORY

HISTORIC EVENT

AN EVENING WITH PRESIDENT

LECH WALESA

NOBEL PEACE PRIZE WINNER AND FORMER PRESIDENT OF POLAND

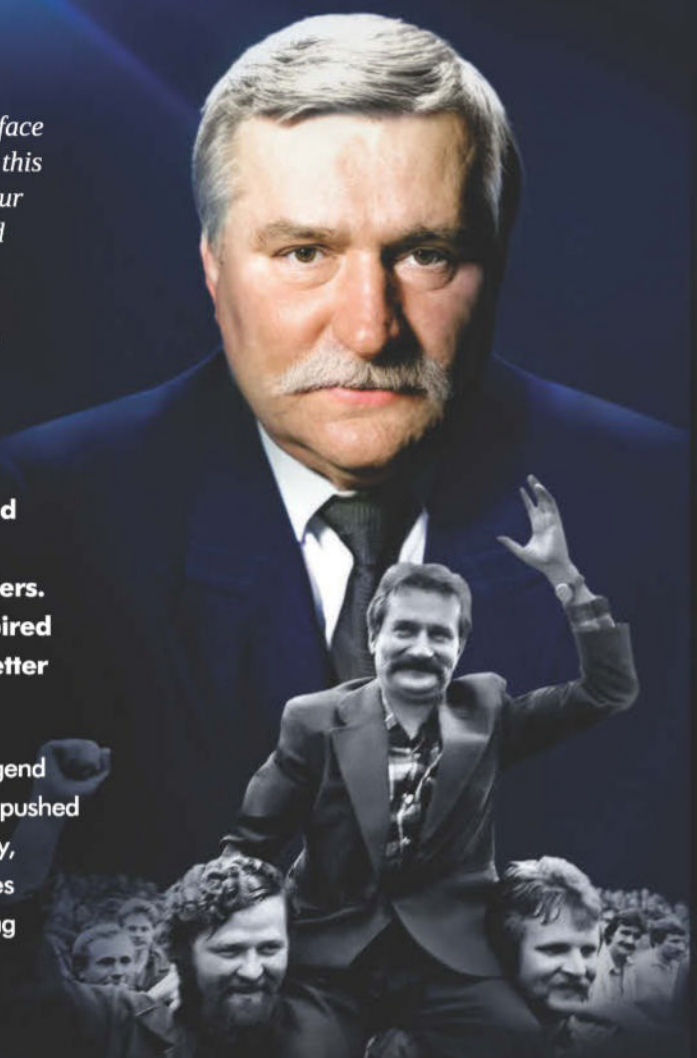
USA & CANADA GRAND LECTURE TOUR | AUGUST 31 – OCTOBER 30, 2025

"

We, the people,

live in challenging times and face a turning point in history. On this lecture tour, I will reflect on our past, confront our present and offer ideas for a better future. Join me for this historic conversation. Together, we can create the change we need.

Lech Walesa



Meet the man who defended freedom and became one of the world's greatest leaders. His courage and vision inspired millions to believe that a better world is possible.

Now, Lech Walesa, the living legend who defeated communism and pushed the world toward democracy, will take you behind the scenes of one of history's greatest turning points – and into the future we must build together.

Aug 31	Los Angeles, CA
Sep 2	Phoenix, AZ
Sep 4	San Diego, CA
Sep 6	Oakland, CA
Sep 8	Seattle, WA
Sep 12	Denver, CO
Sep 14	Houston, TX
Sep 18	Austin, TX
Sep 20	Dallas, TX
Sep 22	Atlanta, GA
Sep 24	Columbus, OH
Sep 26	Pittsburgh, PA
Sep 27	Baltimore, MD
Sep 28	Cleveland, OH
Sep 30	Minneapolis, MN
Oct 2	St. Louis, MO
Oct 4	Chicago, IL
Oct 5	Milwaukee, WI
Oct 9	Miami, FL
Oct 11	Orlando, FL
Oct 13	Boston, MA
Oct 15	Charlotte, NC
Oct 17	Philadelphia, PA
Oct 18	New York, NY
Oct 24	Montreal, QC
Oct 25	Toronto, ON
Oct 26	Detroit, MI
Oct 30	Vancouver, BC

HISTORY EXPLORER

PEACE AND LEADERSHIP | THE FIGHT FOR FREEDOM AND HUMAN RIGHTS | CHALLENGES TO DEMOCRACY
THE SOLIDARITY MOVEMENT | THE FALL OF COMMUNISM | RUSSIA AND UKRAINE | OUR VALUES
NEW SOLUTIONS FOR A NEW WORLD

REGISTER NOW for lessons from the past and inspiration for tomorrow

www.HistoryExplorer.com contact@historyexplorer.com +1 917-722-5050