

# New Scientist

WEEKLY April 6-12, 2024

HUNTING THE ZOMBIE FUNGUS WORTH MORE THAN GOLD

MATHEMATICIANS BATTLE OVER CONTROVERSIAL PROOF

COULD BONE MARROW TRANSPLANTS SPREAD ALZHEIMER'S?

SPECIAL ISSUE

## ANXIETY

Where anxiety comes from

Why the condition is on the rise

How to calm an anxious mind



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### Particle physics: Revealing the mysteries of matter

In 2012, the Large Hadron Collider found the Higgs boson, the supposed final piece in the standard model of particle physics. But is the model complete or are there other particles and forces at much higher energies? And might cracks in the theory offer a way through? Join six experts at London's Conway Hall on 13 April to find out everything we know about what stuff is made of.

[newscientist.com/events](https://www.newscientist.com/events)

## Tour

### Human origins in south-west England

Immerse yourself in the early human periods of the Neolithic, Bronze Age and Iron Age on this gentle walking tour. Join Emily Wilson, former *New Scientist* editor, as you explore hillforts and ancient stone circles, including Stonehenge, Old Sarum, Avebury and Maiden Castle. This five-day tour starts on 15 July and costs £1795.

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## Podcast

### Weekly

The team discuss a new high-resolution image of our galaxy's black hole and learn why unexploded weapons from the second world war might be getting more dangerous. Hear how not getting enough sleep can make you feel older than you are. Plus, why being a therapy horse can be quite stressful.

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## Tour



JUSTIN BLACK/SHUTTERSTOCK

**Stonehenge** Learn the human story behind these iconic rocks

## Instant Expert



CAVAZZA/MARINACERN

**DUNE detector** Elusive neutrinos could unlock particle physics

## Video

### Massive gravity

Claudia de Rham has spent much of her life dedicated to exploring the limits and true nature of gravity. So, *New Scientist* took her indoor skydiving and asked her why gravity still isn't fully understood and doesn't fit into the mould of the other fundamental forces. For her part, de Rham reckons thinking about hypothetical particles called gravitons offers a way forward.

[youtube.com/newscientist](https://www.youtube.com/newscientist)

## Newsletter

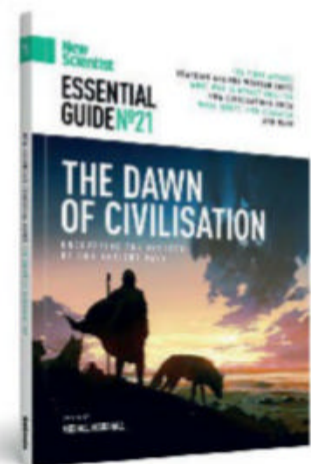
### Launchpad

Space reporter Leah Crane revels in the total solar eclipse that will pass across Mexico, the US and Canada on 8 April. Find out what to expect on the big day and hear how solar eclipses across the ages – as well as being awe-inspiring spectacles – have helped us to understand our place in the cosmos.

[newscientist.com/launchpad](https://www.newscientist.com/launchpad)

## Podcast

**“Horses that gave their consent to being petted were less stressed”**



## Essential guide

Where are the origins of humanity? When did civilisation begin and what does the future of society hold? Uncover the secrets of the past in this *New Scientist Essential Guide* covering all that we know about the arc of human ingenuity. Now available to read in the app or buy in print from our online shop.

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# Discovery Tours NewScientist

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having spent the winter in warmer tropical waters. During this time, the tundra and hillsides are in bloom as the ice melts away and endemic flowers begin to blossom.

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# Smokescreen

Blaming young people's problems on smartphones is easy – but is it true?

PANIC is spreading – in the press and the playground – about the impact of social media and smartphones on children.

There are many questions around what modern technologies are doing to young minds. Some claim that when we first gave children smartphones, it was the largest uncontrolled experiment humanity ever performed on its own children. That young brains are being rewired, and that social media is responsible for an alarming rise in childhood anxiety.

There has indeed been an increase in anxiety in young people, as we report in our special issue, starting on page 30. Given this rise seems to correlate with the arrival of smartphones and social media in the 2000s, it feels intuitive that they are to blame.

A backlash is now under way, as many parents seemingly long for the pre-smartphone days. In England, the government has issued new guidance to encourage schools to go phone-free and a UK-wide petition is calling for smartphones to be banned for under-16s.

**“There are things that can be done, like proper regulation of social media companies”**

Meanwhile, there is a campaign to delay giving young people a smartphone until eighth grade (aged 13 to 14) in the US.

And yet there is surprisingly little solid evidence that this technology is the cause of the rise in anxiety. Other research points to factors such as social inequality

and fears about climate change. The way therapy culture has started infiltrating our lives may also play a role.

None of this means that social media and smartphones are off the hook, but we must follow the evidence – and for now, unfortunately, it is inconclusive. This is no time for moral panic, and banning phones in an attempt to return to the simpler childhoods of the past isn't the answer.

But there are things that can be done, most notably proper regulation of social media companies, which claim that their platforms aren't for children and yet are widely used by them. It is also easier for governments to focus on phones rather than attempting to address the problems we know are causing anxiety in the young: climate change and poverty. ■

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## CONTACT US

[newscientist.com/contact](http://newscientist.com/contact)

### General & media enquiries

**US** 600 Fifth Avenue, 7th Floor, NY 10020

**UK** **Tel** +44 (0)203 615 6500

9 Derry Street, London, W8 5HY

**Australia** 58 Gipps Street, Collingwood, Victoria 3066

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## Lunar gardening

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## Keeping time

Atomic clock can tick for 40 billion years without error **p16**



## Astronomy

### On the hunt for young stars

The Hubble Space Telescope captured this stellar nursery using its ultraviolet camera. At its centre, you can see a host of blue stars, which are younger than our sun, while at the same time being more massive and hotter. The nursery sits within the Tarantula Nebula, itself part of the Large Magellanic Cloud, which orbits our own Milky Way galaxy.

NASA, ESA, STSCI, FRANCESCO PARESE (INAF-IASF BOLOGNA), ROBERTO CONNELL (UVA), SOC-WFC3, ESO

### Could you get Alzheimer's disease from a bone marrow transplant?

A study in mice adds to hints that this condition could be passed on, but we are a long way from saying the risk applies to people, says **Clare Wilson**

MEDICAL orthodoxy says Alzheimer's disease is caused by a build-up of proteins in the brain, rather than being transmissible between people. But a controversial idea posits that occasionally those proteins can be passed from one person to another through measures such as bone marrow and organ transplants, or even blood transfusions.

Now, this view has been bolstered by experiments in mice where the animals developed symptoms of Alzheimer's after bone marrow transplants. Critics say this isn't yet definitive proof of this route of transmission. So, what does this mean in practice?

The mainstream view is that Alzheimer's is caused by the build-up of two proteins, beta-amyloid and tau. While the exact mechanism is unclear, this idea has been strengthened by the recent success of two new medicines that clear amyloid specifically from the brain, although their effects on slowing memory decline are modest.

Some genetic mutations that cause people to get Alzheimer's in middle age, relatively early in life, directly cause a build-up of amyloid. For almost everyone else, the condition is seen as something that effectively strikes at random, with little that can be done to prevent it, except possibly keeping to a healthy lifestyle to boost general brain health.

The claim that Alzheimer's can sometimes be contagious emerged from studies of people who had received growth hormone injections in childhood between the 1950s and 1980s. The hormone had been obtained from dead people's brains.

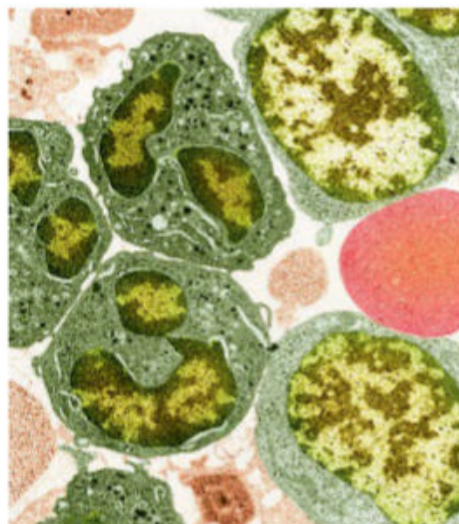
In the UK, where more than 1800 children were given the hormone in this period, some treatment samples were in storage. These were examined to see if they contained a misfolded form of amyloid, which is thought to possibly be involved in triggering amyloid build-up.



BSIP/IGU VIA GETTY IMAGES

**Above: Blood samples from bone marrow donors are analysed for compatibility. Below: Blood cell precursors in mouse bone marrow**

**"This is evidence that bone marrow transplants in mice can transfer Alzheimer's disease"**



DR GOPAL MURTHY/SCIENCE PHOTO LIBRARY

Recent research has revealed eight people had misfolded amyloid in their growth hormone injections. They had all either been diagnosed with Alzheimer's or had memory problems or signs of the condition on brain scans. But with only some samples available, it is difficult to judge how commonly this occurred. It is also unclear if the individuals' childhood treatments were responsible, because memory deterioration is common in older age and most members of the group have now died.

The latest development is an attempt to use animal research to shed light on the question. Chaahat Singh at the University of British Columbia in Canada and his colleagues took bone marrow from mice that had been genetically altered to have high amyloid levels in their brains, which cause them to develop memory problems early in life, then injected it into the blood of normal mice. These also developed cognitive impairments at a young age and had amyloid build-up in their brains (*Stem Cell Reports*, doi.org/mpfh).

The researchers say this shows that Alzheimer's disease can be

passed on by medical procedures, at least in mice. "The dogma states it is amyloid that is brain-derived that leads to pathology," says Singh. "This is evidence that bone marrow transplants can actually transfer disease."

Singh's team is calling for people donating bone marrow or an organ for transplantation to be genetically tested to make sure they don't have an inherited form of Alzheimer's that is the human equivalent to the genetically altered mice's version. This should even be considered for people donating blood, says Singh.

But some researchers are sceptical that the findings should change medical practice. A key issue is that it is unclear just how well these genetically altered mice exemplify the process that causes Alzheimer's in people. "While studies like this are important, differences in the physiology, anatomy and metabolism of mice mean this early-stage research cannot be reliably applied to humans," says Robert Danby at UK stem cell transplant charity Anthony Nolan.

On a practical level, it can already be hard to find a suitable bone marrow donor genetically similar enough to the recipient. Adding genetic screening for Alzheimer's could put potential donors off.

David Curtis at University College London says the inherited form of Alzheimer's is very rare and so any risk to bone marrow recipients seems low. Doctors seeking a bone marrow donor for a particular person have to weigh up multiple factors, he says. "I would put the risk of transferring dementia relatively low down on that list."

The latest study certainly isn't conclusive proof that this form of dementia can be passed on by medical procedures, but it is another step along the road to answering the important question of whether Alzheimer's is indeed transmissible. ■

## Climate change

# Heatwaves now last much longer than they did in the 1980s

Michael Le Page

AN ANALYSIS of all the heatwaves that occurred around the world between 1979 and 2020 has found that they are now persisting for 12 days on average compared with eight days at the start of the period.

As the planet continues to heat up, they will persist for even longer, says Wei Zhang at Utah State University. “Based on the trend, it could double to 16 days by around 2060,” he says.

Zhang’s team found that heatwaves are not only persisting for longer, they are also becoming more frequent and moving more slowly, meaning that specific places have to endure heatwave conditions more often and for longer.

While heatwaves are usually thought of as events affecting one region, the area affected by extreme heat changes as the weather systems responsible for the hot conditions move.

The speed at which heatwaves move has slowed from about 340 kilometres per day in the 1980s to some 280 kilometres per day now, the team found. What’s more, the rate of slowdown is accelerating.

Because heatwaves are persisting for longer, they are travelling further despite their slower average speeds, with the total distance rising from around 2500 kilometres to about 3000 kilometres. This means a larger area is being affected.

The study didn’t look at the causes of these trends. But the shift towards more frequent, slower-moving and longer-lasting

**Toulouse, France, saw temperatures in excess of 40°C (104°F) in 2019**



ALAIN PITTON/NURPHOTO VIA GETTY IMAGES

heatwaves as the planet warms will lead to ever more devastating impacts on societies and nature unless more is done to prevent further warming, the team warns.

To look at how heatwaves move, Zhang’s team divided the world into a grid. A heatwave was defined as one or more grid squares having temperatures well above the 1981 to 2010 average – specifically, higher than 95 per cent of temperatures in that period – for more than three days.

The team found heatwaves tend to move in certain directions

due to prevailing conditions. For instance, in Australia there is a strong tendency for heatwaves to move towards the south-east, whereas in South America they tend to move north-east (*Science Advances*, doi.org/mp2x).

The calculated numbers for heatwave persistence depend on how a team defines a heatwave, says Andrea Böhnisch at the Ludwig Maximilian University of Munich, Germany. With different definitions, the overall trends would remain the same but the numbers could vary substantially. “This should be considered when looking at the precise numerical values,” she says.

Other studies have shown that hurricanes are also moving more slowly, says David Keellings at the University of Florida.

“So this means that these incredibly dangerous events are going to spend longer over any one location, and that impacts will be felt more. Generally, the longer a population is exposed to heatwave conditions, the greater the rate of hospitalisation and death,” he says. ■

## Space

# Artemis astronauts will try to grow plants on the moon

NASA has selected the first three science experiments that astronauts will bring to the moon as part of the Artemis III mission. This mission, currently planned for 2026, will mark the first time humans have walked on the lunar surface since the Apollo 17 mission in 1972.

The first experiment is called Lunar Effects on Agricultural Flora (LEAF). In this experiment, astronauts will grow plants on

the surface of the moon, observing their ability to photosynthesise and grow, and how they respond to the stress of lower gravity and space radiation.

This won’t be the first time plants have been grown in space – astronauts have been growing vegetables on the International Space Station for a decade, and China’s Chang’e 4 mission sprouted seeds on the moon in 2019. Those seeds didn’t last long, though, so if all goes well, LEAF will give us our first glimpse of the full growth cycle of plants on the moon.

The second experiment is the

Lunar Environment Monitoring Station (LEMS), a seismometer to measure moonquakes near the lunar south pole. Characterising how the ground moves during quakes will help us understand the underground structure of the area.

The final experiment, called the Lunar Dielectric Analyzer (LDA), will measure how electrically conductive the soil is. Ice bound to dust particles increases the ability

**“The Artemis programme’s goal is to lay groundwork for long-term human presence on the moon”**

of the soil to conduct electricity, so the LDA will help the hunt for deposits of frost and measure changes in the soil as the sun rises and sets over the lunar surface.

“These three deployed instruments were chosen to begin scientific investigations that will address key Moon to Mars science objectives,” said NASA’s Pam Melroy in a statement. The Artemis programme’s goal is to lay the groundwork for long-term human presence on the moon, which will, in turn, teach us how to prepare for crewed missions to Mars. ■ Leah Crane

Cosmology

# Our black hole's magnetic swirls

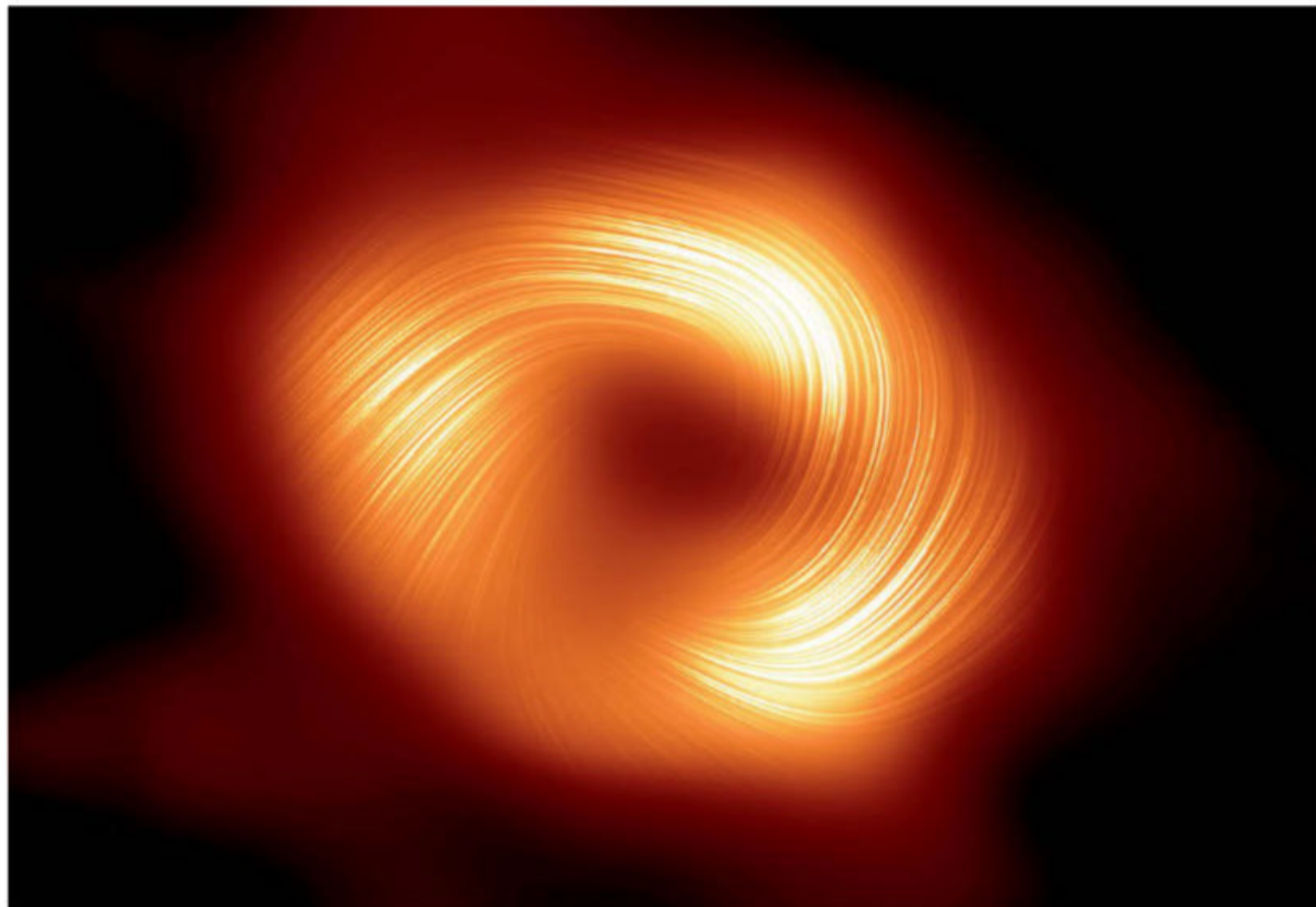
New view of the black hole at the heart of the Milky Way reveals its curling magnetic fields

Alex Wilkins

THIS is the supermassive black hole at the centre of our galaxy as we have never seen it before. The image reveals the swirling magnetic fields around Sagittarius A\* (Sgr A\*) and hints that it may be producing a jet of high-energy material.

The picture was taken by the Event Horizon Telescope (EHT). In 2022, the EHT produced the first image of Sgr A\*, revealing light coming from whirling hot plasma set against the dark background of the black hole's event horizon, where light can't escape its extreme gravity.

Now, EHT researcher Ziri Younsi at University College London and his colleagues have revealed how this light is polarised, creating this stunning picture (*The Astrophysical Journal Letters*, [doi.org/mpdg](https://doi.org/mpdg) & [doi.org/mpdh](https://doi.org/mpdh)). The image is very similar to one of another black hole, M87\*. Given that M87\* fires out high-energy jets, the similarity implies that Sgr A\* could too. ■



EUROPEAN SOUTHERN OBSERVATORY

Archaeology

# Ancient symbols carved near dinosaur footprints

MYSTERIOUS rock carvings found next to dinosaur tracks in Brazil suggest that ancient people discovered the footprints thousands of years ago and viewed them as meaningful.

The Serrote do Letreiro site in Paraíba state features the footprints of theropod, sauropod and ornithomimid dinosaurs from the Early Cretaceous Epoch, between 145 million and 100 million years ago. Near these are rock carvings, or petroglyphs, predominantly circular with radial lines and other abstract motifs.

Leonardo Troiano at Brazil's National Institute of Historic and Artistic Heritage and his colleagues surveyed the site on

foot and using drones. They discovered new dinosaur footprints and more than 30 petroglyphs surrounding them (*Scientific Reports*, [doi.org/mpdf](https://doi.org/mpdf)).

Little is known about the makers of these petroglyphs. "They were nomadic or semi-sedentary groups that lived in north-eastern Brazil," says Troiano. "They used stone tools and survived by hunting and gathering available natural resources. Considering the dates obtained from the few dated sites in the region, we speculate that the petroglyphs were made between 3000 and 9000 years ago."

Troiano says there is a special relationship between the

petroglyphs and the footprints, but we can't know how these people interpreted the prints. "Determining the motives behind these depictions is a truly complex

**Dinosaur footprints and carvings, highlighted by dashed lines, at the Serrote do Letreiro site, Brazil**



LEONARDO TROIANO/IPHAN, BRAZIL

thing," he says. However, he says the artists may have thought the prints were giant bird tracks.

Edward Jolie at the University of Arizona points out that Indigenous oral traditions offer a rich window into how people interpreted their world, including extinct creatures. "For example, some scholars have pointed out the impressive Thunderbird of traditional narratives – that are depicted in rock images across North America – may well be representations of *Teratornis*, a genus of massive birds of prey that went extinct by the Late Pleistocene [around 12,000 years ago]," he says. ■

Soumya Sagar

## Environment

# Some bamboo toilet paper contains hardly any bamboo

Madeleine Cuff

**ECO-FRIENDLY** toilet paper brands are selling bamboo loo roll containing as little as 2.7 per cent bamboo, according to UK consumer group Which?.

Unlike the trees that usually go into toilet paper, bamboo is a grass that can grow quickly even in poor soils, so harvesting it does less damage to the environment. For that reason, bamboo-based paper is thought of as an eco-friendly alternative to regular loo roll.

**“Only Who Gives a Crap and The Cheeky Panda contained 100 per cent grass fibres”**

Which? assessed the grass fibre composition of loo rolls from five popular UK brands that claim their products are made from “bamboo only” or “100% bamboo”.

Samples from Bumboo contained just 2.7 per cent grass fibres, Naked Sprout paper had 4 per cent grass fibres and Bazoo had 26.1 per cent. Instead of bamboo, the toilet paper was mainly made from virgin hardwoods including eucalyptus and acacia, Which? found.

Only two of the brands the firm tested, Who Gives a Crap and The Cheeky Panda, contained 100 per cent grass fibres.

Bumboo, Naked Sprout and Bazoo say they use bamboo certified by the Forest Stewardship Council (FSC), meaning it comes from responsibly managed forests.

In response to the findings, Bumboo said the tests revealed a “fibre error” in its supply chain, affecting a small amount of stock. It said rolls are now tested from every production run. Bazoo said a batch of its paper was “contaminated” with wood in November 2023, and it is implementing stricter controls. Naked Sprout said it was “incredibly disappointed” and stressed its entire supply chain is FSC certified. ■

## Mathematics

# Bitter divisions over controversial maths proof

Alex Wilkins

AN ATTEMPT to fix problems in a controversial mathematical proof has itself become mired in controversy, in the latest twist in a saga that has been running for over a decade and has seen mathematicians trading unusually pointed barbs.

The story began in 2012, when Shinichi Mochizuki at Kyoto University, Japan, published a 500-page proof of a problem called the ABC conjecture. The conjecture concerns prime numbers involved in solutions to the equation  $a + b = c$ , and despite its seemingly simple form, it provides deep insights into the nature of numbers.

Mochizuki published a series of papers claiming to have proved ABC using new mathematical tools he collectively called Inter-universal Teichmüller (IUT) theory, but many mathematicians found the initial proof baffling and incomprehensible.

## \$1 million prize

While a small number of mathematicians have since accepted that Mochizuki’s papers prove the conjecture, other researchers say there are holes in his argument and it needs further work, dividing the mathematical community in two and prompting a prize of up to \$1 million for a resolution to the quandary.

Now, Kirti Joshi at the University of Arizona has published a proposed proof that he says fixes the problems with IUT and proves the ABC conjecture (arXiv, doi.org/mpc9).

But Mochizuki and his supporters, as well as mathematicians who critiqued

Mochizuki’s original papers, remain unconvinced, with Mochizuki declaring that Joshi’s proposal doesn’t contain “any meaningful mathematical content whatsoever”.

Central to Joshi’s work is an apparent problem, previously identified by Peter Scholze at the University of Bonn, Germany, and Jakob Stix at Goethe University Frankfurt, Germany, with a part of Mochizuki’s proof called Conjecture 3.12.

The conjecture involves comparing two mathematical objects, which Scholze and Stix say Mochizuki did incorrectly. Joshi claims to have found a more satisfactory way to make the comparison.

Joshi also says that his theory goes beyond Mochizuki’s and establishes a “new and radical way of thinking about arithmetic of number fields”.

The paper, which hasn’t been peer-reviewed, is the culmination of several smaller papers on ABC that Joshi

has published over several years, describing them as a “Rosetta Stone” for understanding Mochizuki’s impenetrable maths.

Neither Joshi nor Mochizuki responded to *New Scientist’s* request for comment, and,

# 500

**Number of pages in Shinichi Mochizuki’s ABC conjecture proof**

indeed, the two seem reluctant to communicate directly with each other. In his paper, Joshi says Mochizuki hasn’t responded to his emails, calling the situation “truly unfortunate”. And yet, several days after the paper was posted online, Mochizuki published a 10-page response, saying that Joshi’s work was “mathematically meaningless” and that it reminded him of “hallucinations produced by artificial intelligence algorithms, such as ChatGPT”.

Mathematicians who support Mochizuki’s original proof express a similar sentiment. “There is nothing to talk about, since his [Joshi’s] proof is totally flawed,” says Ivan Fesenko at Westlake University in China. “He has no expertise in IUT whatsoever. No experts in IUT, and the number is in two digits, take his preprints seriously,” he says. “It won’t pass peer review.”

Mochizuki’s critics also disagree with Joshi. “Unfortunately, this paper, and its predecessors, does not introduce any powerful mathematical technology, and falls far short of giving a proof of ABC,” says Scholze, who has emailed Joshi to discuss the work further. For now, the saga continues. ■



Environment

# Saharan dust descends on Europe

Drought and changes in wind patterns seem to be boosting the spread of desert dust

James Dinneen

DUST blown from the Sahara desert is regularly carried into the sky above parts of Europe, with harmful impacts on air quality. But recently, there has been an eightfold increase in these dust intrusions and researchers are concerned they are becoming more common.

“In 2024, we are having these extreme events again,” says Sara Basart at the World Meteorological Organization, pointing to several dust intrusions over the Canary Islands and the western Mediterranean in recent months.

The Sahara desert is the source of more than half of all dust in the atmosphere, and during the warmer months of the year it is common for plumes of it to reach Europe, with a few each year reaching as far north as the UK.

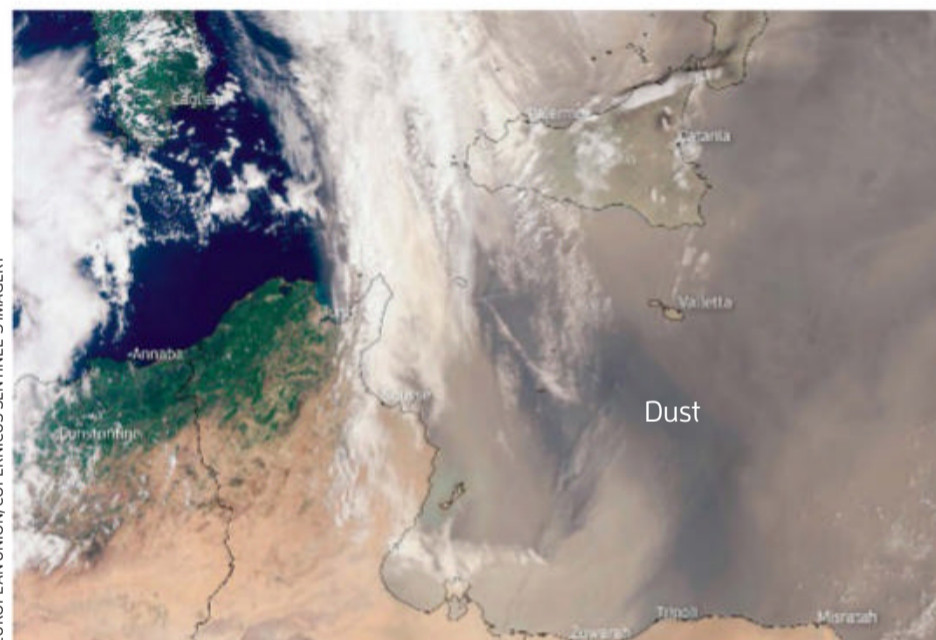
However, over the past four years, there have also been a series of intense dust intrusions in the northern hemisphere winter, from January to March, which is far more unusual, says Basart.

In February 2020, two exceptional dust events swept over the Canary Islands, resulting

in hundreds of cancelled flights. Dust intrusions of record intensity also hit western Europe in early 2021 and 2022. “It was unbelievable in Spain,” says Basart. There were fewer abnormal dust clouds in 2023. But the dust is back this year.

To understand what’s going on, Basart and her colleagues compared the unusual events

## Dust being carried from the Sahara desert over the Mediterranean in March 2024



between 2020 and 2022 with a satellite record of atmospheric dust extending back to 2003. She says the recipe for dust intrusions is straightforward: “The ingredients are soils that can be uplifted and enough wind.”

The researchers link the intrusions to ongoing drought in the Maghreb region of north-west Africa, which is increasing the amount of dust. They also identify an area of anomalous heat in the western Mediterranean, as well as

a jet stream “blocking” pattern that results in more winds blowing north from the Sahara (*EGU Sphere*, doi.org/mpcn).

“There was a change in the typical circulation patterns for wintertime,” says Basart, but it isn’t clear if this is a temporary anomaly or a longer-term trend.

Pedro Salvador at the Centre for Energy, Environmental and Technological Research in Spain says the change could be part of a longer-term increase in Saharan dust transport since the 1940s.

Data on the dust intrusions doesn’t extend that far back, but he and his colleagues recently found that atmospheric factors that make the intrusions more likely have increased since then.

He says desertification in the Sahara due to land use and climate change has also contributed to the volume of dust, with measurable consequences for air quality.

However, it is still unclear how climate change may be altering the circulation patterns behind dust intrusions, says Claire Ryder at the University of Reading in the UK. ■

Technology

## Robot predicts when you’re going to smile and smiles first

A HUMANOID robot can predict if someone will smile a second before they do, and match the smile itself. Its creators hope the technology will make interactions with robots more lifelike.

Although artificial intelligence can now mimic human language to an impressive degree, interactions with physical robots often fall into the “uncanny valley” and feel unsettling, in part because

robots can’t replicate the complex non-verbal cues and mannerisms that are vital for communication.

Now, Hod Lipson at Columbia University in New York and his colleagues have created a robot called Emo that uses AI models and high-resolution cameras to predict people’s facial expressions and try to replicate them. It can anticipate whether someone will smile about 0.9 seconds before they do, and smile itself in sync. “I’m a jaded roboticist, but I smile back at this robot,” says Lipson.

Emo consists of a face with cameras in its eyeballs and flexible

plastic skin that has 23 motors attached to it by magnets. The robot uses two neural networks: one to look at human faces and predict their expressions and another to work out how to produce expressions on its own face.

The first network was trained on YouTube videos of people making faces, while the second network was trained by having the robot watch itself make faces on a live camera feed. “It learns what its

**“I’m a jaded roboticist, but I smile back at this robot”**

face is going to look like when it’s going to pull all these muscles,” says Lipson. “It’s sort of like a person in front of a mirror, when even if you close your eyes and smile, you know what your face is going to look like.”

Lipson and his team hope that Emo’s technology will improve human-robot interactions, but they first need to broaden the range of expressions the robot can make. They also hope to train it to make expressions in response to what people are saying, rather than simply mimicking another person, says Lipson. ■

Alex Wilkins

## On the trail of the world's most valuable fungus

Prized in traditional medicine, the harvesting of yartsa gunbu is big business – with an ecological impact to match, finds Adam Popescu



THE hunt for a fungus that is worth more than its weight in gold as a traditional medicine is transforming the Himalayan landscape on which it grows. To learn more, I have come to the Sowa Rigpa Institute of Traditional Medicine in Kathmandu, Nepal, where I am watching the preparation of a tea made from yartsa gunbu, a “cure-all” fungus that may be the world’s most expensive natural resource.

Tsultrim Rabssel grinds and mixes the fungus with 16 rare herbs and medicinal plants. He hands a tea sachet to Tashi Tsering, who carefully places the grinds within. “Medicine’s ready,” he says.

# \$11bn

Estimated global market value for yartsa gunbu

These men are amchis, a Tibetan term that loosely translates to doctor. They specialise in traditional Tibetan medicine, a field that mixes science and belief and uses rare ingredients for spiritual and health tonics.

While its price and scarcity means yartsa, or *Cordyceps sinensis*, hasn’t been studied much in the West, researchers in China, Nepal and India have found potential therapeutic benefits for people receiving dialysis and for liver, kidney and cardiovascular disease, as well as possible antioxidant, anti-inflammatory and antiviral effects. It has also been hailed as an aphrodisiac – sometimes dubbed Himalayan Viagra – and there are real links to increased physical stamina (although other claims, like it curing cancer, are flat-out false).

To many who take yartsa, this mix of belief and benefit is what makes it worth more than its weight in gold, selling for around

\$150,000 a kilogram in China.

Globally, the market is worth an estimated \$11 billion.

“Why is it attractive? Because of the idea that it’s wild and pure,” says Tashi Dorji, a specialist in Himalayan economies at the International Centre for Integrated Mountain Development. “There is truth to the science, not all, but enough to make people believe. Belief is key.”

That belief is aided by yartsa’s unusual origins. It is produced when larvae of ground-dwelling ghost moths are infected with the parasitic *Cordyceps* fungus, which encases the caterpillars with its root-like mycelium, hence another of its names: caterpillar fungus. When the caterpillar surfaces to die, the fungus blooms with a needle-like stalk. The life cycle of the *Cordyceps* genus inspired the zombie-like humans in the video game and TV show *The Last of Us*.

The high price of yartsa – which only grows in high pastures in India, Nepal, Bhutan and China – makes harvesting it the main income for many impoverished

**Harvesting yartsa gunbu provides an income for many people in Nepal**



RIGHT: ADAM POPESCU; BELOW: JITENDRA RAI/BAJRACHARYA/ICIMOD



**Tashi Tsering with a handful of yartsa gunbu fungus (also seen above)**

communities here. Booming demand has improved living standards, but it is also having a huge ecological impact on a region that is already warming at double the global average rate.

Yartsa takes years to grow and is being harvested unsustainably. Using a pickaxe to remove the mycelium strips away the soil that the moths need from the hillside, speeding up erosion caused by climate change. Research also shows that yartsa harvests pollute rivers and result in deforestation.

Warming also has a direct impact, as less snow means less yartsa, since it needs moisture to grow. One study suggests the

fungus is migrating to higher altitudes to avoid the heat. (In Bhutan, mean winter temperatures have increased by 3.5°C to 4°C across most of yartsa’s habitat.)

Demand, habitat deterioration and climate change all contributed to the International Union for Conservation of Nature labelling yartsa as vulnerable in 2020, stating the fungus had declined by at least 30 per cent over the past 15 years due to overharvesting.

“It’s too important to local economies to stop,” says Dorji. Even counterfeit yartsa and bad batches can’t stop the trend. “It’s a luxury item,” he says.

At the institute, the amchis show me pieces of yartsa that go for \$10 each. Tsering offers me a steaming cup containing a mud-brown mixture that smells slightly putrid, a yartsa infusion called a chulen. “You can take it, it will affect your body,” he says, before I ask how. “Longer sex. More energy.”

I down the drink, which tastes like cinnamon and nutmeg. But I don’t feel an energy boost or a libido surge. Not long after, I am asleep in my hotel room. But is that because this “cure-all” isn’t all it is cracked up to be or because I was so exhausted from running around Kathmandu looking for it? Maybe it is a touch of both. ■

## Weapons

### Unexploded old bombs are getting more dangerous

Michael Le Page

A STUDY of unexploded shells from the second world war has shown that one of the explosives they contain is becoming more sensitive to impacts. This substance, called amatol is still found in some ammunition in the war in Ukraine.

“Based on our findings, we can say that it’s relatively safe to handle, but you can’t handle it as like TNT,” says Geir Petter Novik at the Norwegian Defence Research Establishment. Unlike TNT, it can easily go off if it is dropped, he says.

There are millions of tonnes of unexploded ammunition around the world, some in old ammunition dumps and some in shells and bombs that failed to detonate



Unexploded German artillery projectiles and rifle grenades from the second world war

after being fired or dropped. There is a widespread misconception that the projectiles become less dangerous over time, says Novik.

Now, he has tested the impact sensitivity of five samples of amatol from unexploded WWII bombs found in Norway. The test involved dropping weights on small samples to see what it takes for them to explode. All five samples were more sensitive to impacts than expected for amatol, with one being four times more sensitive (*Royal Society Open Science*, doi.org/mn6c).

The findings will change how Novik’s team handles unexploded ordnance, for instance by transporting smaller quantities at a time. Novik now plans to try to find out why the impact sensitivity is increasing. “We suspect that it’s the formation of sensitive crystals or salts,” he says. ■

## Technology

### AI forecaster can predict the future better than humans

Alex Wilkins

AN ARTIFICIAL intelligence can predict election results or economic trends with an accuracy that matches groups of human forecasters.

People are notoriously bad at predicting the future, at least on an individual level. But websites called prediction markets, where people can bet on the outcome of events, have shown that the wisdom of crowds leads to better guesses. The average, crowdsourced predictions, which take into account many people’s forecasts, tend to be much more accurate than those of one person alone.

Now, Danny Halawi at the University of Berkeley, California, and his colleagues have developed an AI to replicate this process. They found it can predict future events better than the average human and, in some cases, better than the crowd.

“[Forecasting] requires a human to sit down and really gather a lot of sources, figuring out which sources to trust and how to weigh all these things,” says Halawi. “A language model can just do this very quickly.”

To train the model, Halawi and his team started with an existing large language model, OpenAI’s GPT-4. They gave it

# 71.5%

The AI’s average accuracy at predicting events

additional training, a process called fine-tuning, using tens of thousands of accurate crowdsourced forecasts from prediction markets.

When the system is given a new prediction task, a separate language model breaks down the task into sub-questions and uses these to find relevant news



SPENCER PLATT/GETTY IMAGES

#### Buy or sell? An AI can forecast future economic trends

articles. It reads these articles to answer its sub-questions and feeds that information into the fine-tuned GPT-4 to make a prediction.

Halawi and his team found that their system could predict events much better than individuals and almost as well as the crowdsourced answer, achieving an average accuracy of 71.5 per cent, compared with the human group’s 77 per cent, on a set of test questions.

The system performed best, sometimes even outperforming the crowd, on “uncertain” questions, those that had a wide range of possible answers (arXiv, doi.org/mn6j). But it struggled when predictions contained little uncertainty, such as forecasting whether or not the stock value of a large, publicly traded company might go to 0 next year. This is because GPT-4 prefers to hedge its answers as a safety feature, says Halawi.

The system could be an

additional useful data point for economic and political analysts who use different information sources to make decisions, says Richard Saldanha at Queen Mary University of London, but it is unlikely to be better than many custom models and algorithms for scenarios like financial modelling. “For a discretionary asset manager, somebody who makes their own decisions by synthesising information, I think it’s an additional input,” says Saldanha.

“In the future, political decision-makers may consult the AIs on what actions would most likely bring about desired outcomes,” says Dan Hendrycks at the Center for AI Safety in California. He also suggests that prediction-making models could address future dangers created by AI. “Forecasting bots would help us anticipate and steer clear of these risks,” says Hendrycks.

However, the model currently isn’t public, and running it costs about \$1 per question asked, which is more expensive than most queries to AI chatbots. ■



## Health

# Immune systems made young again

Antibody therapy rejuvenates defence network in old mice, helping them fend off infection

Grace Wade

AN EXPERIMENTAL treatment rejuvenates the immune systems of older mice, improving their ability to fight infections. If it works in humans, the therapy could reverse age-related declines in immunity that leave older adults susceptible to disease.

These declines may be due to changes in our blood stem cells, which can develop into any type of blood cell – including key components of the immune system. As we age, a larger proportion of these stem cells become predisposed to producing some immune cells over others, says Jason Ross at Stanford University in California. This imbalance impairs the immune system's defences. It also fuels inflammation, which accelerates ageing and increases the risk of conditions like heart disease, cancer and type 2 diabetes.

Ross and his colleagues have developed a treatment using

antibodies, which are proteins that recognise and attack certain cells, to target these biased stem cells. They tested the treatment in six mice between 18 and 24 months old, which is roughly equal to an age of 56 to 70 years in humans.

**“Rejuvenating or improving immune function could really help us fight off infections”**

A week after receiving an antibody injection, the mice had about 38 per cent fewer of these aberrant stem cells than six rodents of the same age that didn't receive the treatment. They also had greater amounts of two types of white blood cells crucial for recognising and combating pathogens, as well as lower levels of inflammation.

“You can think of it as kind of turning back the clock,” says Ross. “We're making the proportion of

these [immune] cells more similar to [those of] a younger adult mouse.”

To test if the changes resulted in a stronger immune system, the researchers vaccinated 17 older mice against a mouse virus. Nine of these mice had received the antibody treatment eight weeks earlier. The researchers then infected the rodents with the virus. Two weeks later, they measured the number of infected cells in the animals and found that nearly half of the treated mice – four out of nine – had cleared the infection, compared with only one of the eight untreated mice (*Nature*, doi.org/mn9m).

The findings indicate that the antibody treatment rejuvenates the mouse immune system. Since humans, like rodents, also see aberrant blood stem cells increase with age, a similar antibody therapy may reinvigorate our immune systems, says Ross.

Such a possibility is still a long way off, says Robert Signer at the University of California, San Diego (UCSD). For a start, we need to better understand potential side effects of the treatment. In an article accompanying the work, Signer and Yasar Arfat Kasu, also at UCSD, suggest that depleting stem cells could heighten the risk of cancer. On the other hand, “a better immune system is going to be better at surveying for cancers. So we just don't know exactly what will happen yet,” says Signer.

Still, these findings are very promising, says Ross.

Ageing is the number one risk factor for a broad range of diseases. “By rejuvenating or improving immune function in older people, that could really help with fighting off infections,” says Signer. “You might also have an impact on different types of chronic inflammatory diseases. That's what's so exciting here.” ■

## Space

# Mars may have captured a comet to create its two moons

THE two moons of Mars may once have been a single comet that was ensnared and split by the planet – and an upcoming mission could find out for certain.

How Mars got its two moons, Phobos and Deimos, is a mystery. They are small, 27 and 15 kilometres across, respectively, and orbit the planet's equator. Astronomers have suggested that they may have formed after a collision on Mars's surface, similar to how Earth's moon was created, or be asteroids that were captured by the planet's gravity.

Sonia Fornasier at the Paris

Observatory and her colleagues have a different idea. They say the moons may have formed from one or two captured comets, similar to comet 67P/Churyumov-Gerasimenko, which was visited by the European Space Agency (ESA) spacecraft Rosetta in 2014.

The researchers studied data on Phobos from ESA's Mars Express spacecraft, which has been orbiting Mars for more than 20 years. “We found a huge number of observations that were never published before,” says Fornasier.

The team's analysis of Phobos shows that the moon has similar visual properties to a comet, reflecting an amount and type of light that puts it more in line with comets like 67P than it does an asteroid (arXiv, doi.org/mn7w).



BURADAKI/AMY

This suggests that Phobos, and by extension Deimos, could have been part of a binary comet pair that was captured by Mars, or a single comet that broke into two pieces.

“Dynamically, it's very difficult to capture an asteroid and have two satellites in the equatorial plane of Mars,” says Fornasier. “What we are suggesting is maybe it's a binary comet that was captured by Mars.”

Mars has two small, irregularly shaped moons, called Phobos and Deimos

A Japanese mission called Martian Moons Exploration, set to launch in 2026, will attempt to bring samples of Phobos back to Earth in 2031. Any abundance of volatile elements such as carbon, oxygen or nitrogen in these would support the idea that Phobos was a comet. That could mean we get samples not just from a moon of Mars, but from a body that originated in the outer solar system. “It would be the first sample from a cometary nucleus,” says Fornasier.

Other planets may have captured comets too, such as Saturn, whose moon Phoebe seems to have come from the outer solar system. ■  
Jonathan O'Callaghan

Earth science

# Huge crater in India hints at major meteorite impact 4000 years ago

Joshua Rapp Learn

A POSSIBLE impact crater found in India may have been caused by the largest meteorite to strike Earth in the past 50,000 years.

The meteorite could have caused a fireball, a huge shock wave and wildfires that would have spread through an area inhabited by people from the Indus valley civilisation 4000 years ago.

“It would have been definitely equivalent to a nuclear bomb, but without the radioactive fallout,” says Gordon Osinski at Western University in Canada.

The Luna structure is 1.8 kilometres wide and has long been known to locals in Gujarat state. Researchers had examined it before in the belief it was from an impact, but nothing came of these studies. Now, K. S. Sajinkumar at the University of Kerala in India and his colleagues have returned to do more in-depth research.

Geochemical analysis revealed a high proportion of iridium in the soil, which suggests the impactor was probably an iron meteorite.

The team also identified other materials characteristic of meteorites, including wüsite,

## 1.8km

The diameter of the structure in Gujarat state

irschsteinite, hercynite and ulvöspinel (*Planetary and Space Science*, doi.org/mn58).

While the geochemical analysis appears to match, the team still hasn’t completely proved this is a crater, says David King at Auburn University in Alabama. To do this, the researchers would need to find super-heated rocks that melted due to the energy of the impact, he says. Such materials are difficult

to uncover, though – and the area where they would be in the Luna structure is usually underwater. Sajinkumar and his colleagues were only able to dig a trench during the very short dry season, but plan to search for shocked materials in future.

Despite the lack of these materials, Osinski is convinced that the Luna structure is an impact crater. “The authors have done a great job with the samples that they have,” he says.

Radiocarbon dating of organic material under the debris layer from the presumed impact showed the plant material to be about 6900 years old. But in ongoing work that isn’t yet published, Sajinkumar and his colleagues ran optically stimulated luminescence tests on the soil layer, which revealed the last time that the minerals

saw sunlight. These tests – on the presumed pieces of the meteorite – have refined the date to roughly 4050 years ago, says Sajinkumar. That would put the impact at about the end of the mature phase of the Harappan civilisation in the Indus valley.

The collision would have created a shock wave that reached about 5 kilometres away, says Sajinkumar, and ejected material could have created wildfires that spread much further.

“In the near vicinity, it would be a fireball, then complete decimation for kilometres,” says Osinski.

If there were people living in that area, there would have been serious casualties, says King.

Sajinkumar says that this might have been the only impact of such magnitude that complex civilisations on Earth have ever witnessed. ■

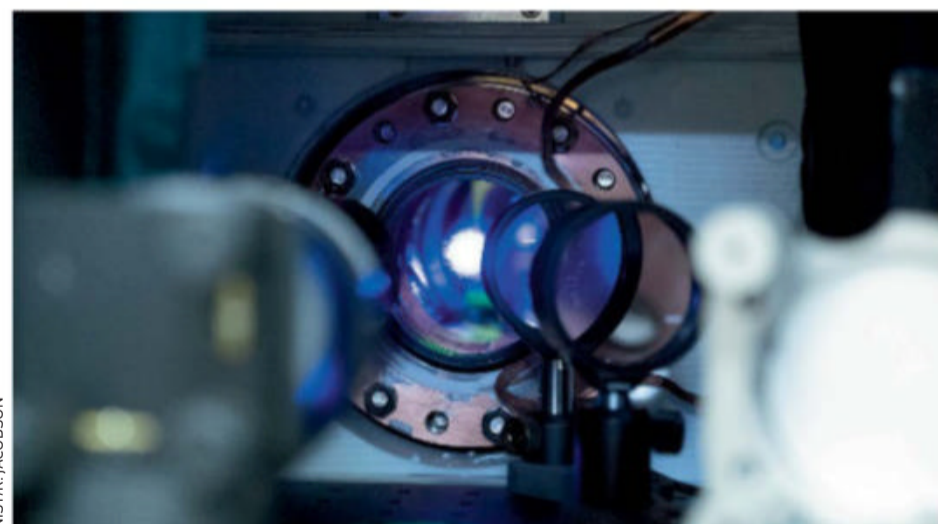
Physics

## Atomic clock can tick for 40 billion years without losing time

THE most accurate clock in the world will lose less than 1 second every 40 billion years, or around three times the current age of the universe. While we have no direct need for such extreme timekeeping, the clock could help investigations in multiple areas of physics, including detecting dark matter.

At the core of the clock, built by Alexander Aeppli at the University of Colorado Boulder and his colleagues, are about 40,000 strontium atoms, cooled by lasers to only about a hundred-billionth of a degree warmer than absolute zero.

The clock’s tick is provided by the electrons within these chilly atoms oscillating rapidly between two



NIST/J. JACOBSON

specific quantum states. To achieve this, the team shielded the atoms from outside interference, like room temperature objects in the lab, producing oscillations that Aeppli says are accurate to eight parts in a tenth of a billionth of a billionth, or less than 1 second in 40 billion years (arXiv, doi.org/mn6b).

“We’re playing a bunch of tricks to make it the most accurate clock we possibly can,” says Aeppli.

The new clock is twice as accurate as any previous atomic clock. “This is like when someone sets a new world record for [running] the mile or the marathon. It’s really, really impressive and it takes a huge

This atomic clock uses the oscillations of cold strontium atoms to track time passing

amount of work,” says Shimon Kolkowitz at the University of California, Berkeley. He says that while the new clock may not immediately lead to new discoveries, the researchers’ careful examination of all the possible sources of inaccuracy sets a standard for atomic clocks and will push the whole field forward.

Eventually, very accurate atomic clocks could play a part in detecting dark matter, making GPS satellites more precise and helping to spot tiny movements of tectonic plates. “Whenever you make better measurements of time, that opens up so many new things you can study in physics,” says Aeppli. ■  
Karmela Padavic-Callaghan

## Health

### A lack of sleep makes you feel old

YOU can feel years older than you really are after sleep deprivation.

Leonie Balter and John Axelsson at the Karolinska Institute in Sweden surveyed 429 people – aged 18 to 70 years old – to see how old they felt and how much they had slept in the past 30 days.

Each day of poor sleep added an average of 0.23 years to people's subjective age. Those getting sufficient sleep had a subjective age that was 5.81 years younger on average than their real age.

Sleep restriction tests on 186 more people revealed that those aiming to get 9 hours of sleep across two consecutive nights felt 0.24 years younger, but those restricting sleep to 4 hours for two consecutive nights said they felt an average of 4.44 years older than they were (*Proceedings of the Royal Society B*, doi.org/mn7c). **Chen Ly**



TOSHITAKA SUZUKI

## Technology

### Implanted battery is charged by the body

A BATTERY designed to run on oxygen from inside the body could last months or years before needing to be replaced, and might one day power everything from pacemakers to brain implants.

Xizheng Liu at Tianjin University of Technology in China and his colleagues have made batteries from a sodium-based alloy, because sodium reacts with oxygen to create electrical power.

The researchers implanted the batteries beneath the skin of rats. After two weeks of healing, blood vessels regrew around the battery, bringing oxygen close enough for the chemical reaction to occur. The batteries produced a stable voltage of 1.3 to 1.4 volts and the rats showed no ill effects (*Chem*, doi.org/mn76). The batteries don't yet produce a high enough current to power medical devices, though. **Matthew Sparkes**

## Zoology

### Japanese tits gesture to let their mates enter nest first

SOME birds seem to flutter their wings to tell their mates they should enter the nest first, suggesting that the animals may communicate with a variety of gestures.

Great apes commonly use communication signals like waving. To see if birds do similar things, Toshitaka Suzuki at the University of Tokyo and his colleagues installed hundreds of nest boxes in a forest populated with Japanese tits (*Parus minor*) near the town of Karuizawa.

Each box had a 7.5-centimetre-wide hole, just big enough for one bird to squeeze through at a time.

During breeding season, the team observed 321 nest visits across eight breeding pairs, with the tits often bringing food for their brood.

If a bird couple arrived at the nest together, each tit would perch on a nearby branch before entering. About 40 per cent of the time, the female fluttered her wings for a few seconds, with her chest facing the male. This was quickly followed by the male entering the nest first, then the female.

When neither bird fluttered its wings, which made up 44 per cent of nest visitations, the females usually entered first. Only one male was seen repeatedly fluttering its wings, which was followed by the female entering first. Wing fluttering wasn't observed at all when each bird arrived separately (*Current Biology*, doi.org/mn62).

"We can conclude that this wing fluttering conveys 'after you,'" says Suzuki. "This study is the first to demonstrate that birds can use wing movements to convey a particular meaning."

The findings hint that Japanese tits, and maybe other bird species, communicate in more complex ways than we thought. **CL**

## Really brief



KUTREDRIG/GETTY IMAGES

### AI can tell you how to make beer better

An artificial intelligence can predict how a beer will taste from the chemical compounds it contains and make suggestions on how to improve it. It could help people create alcohol-free beers that taste just like regular ones (*Nature Communications*, doi.org/mn7k).

### Tiny deer is named as a new species

A deer just 38 centimetres tall, about the size of a Jack Russell terrier, has been recognised as the first new deer species found in South America for over 60 years. The species, the newest member of a group of dwarf deer unique to the central Andes, has been named *Pudella carlae* (*Journal of Mammalogy*, doi.org/mn3d).

### Ergonomic chair boosts gamer skills

Gamers using the TITAN Evo gaming chair win more, according to a study in 33 adults. When they played online game *League of Legends* for 2.5 hours sitting in the chair, they had 25 per cent more wins than when on a standard office chair. They also had less back muscle stiffness (*medRxiv*, doi.org/mn7q).



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Chanda Prescod-Weinstein looks to the skies p20

**Aperture**  
Experimental green tech that harnesses microbes p22

**Culture**  
A complete archaeological history of music p26

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Jacob Aron plays the new *Final Fantasy VII Rebirth* p28

**Letters**  
Let the woolly mammoth rest in peace p29

## Comment

# A longevity revolution

With global life expectancy now exceeding 70 years old, we need to change how we age, not how long we age, says **Andrew Scott**

**T**ODAY, a child born in the UK has a greater than 50 per cent chance of living into their nineties. That is a remarkable testimony to medical, scientific and social progress, which has lowered mortality rates so we die later. It is a widespread trend: global life expectancy now exceeds 70, up from about 47 in 1950.

It seems that one longevity revolution is coming to an end. For the first time in human history, the most important health challenge is to age well. So begins a second longevity revolution – one focused on changing how we age, and slowing the ageing process so that lives aren't just longer but also healthier for longer. But this will require a transformation in our health system, careers and pensions as well as cultural norms and individual psychology. It also demands a shift in scientific focus away from individual diseases and towards a greater understanding of the biology of ageing.

Increasing life expectancy has changed the global burden of disease. The top 10 causes of death now include cardiovascular disease, pulmonary disease, dementia and diabetes. All of these have a common risk factor: age. If we could find a way to slow down biological ageing, we could potentially impact multiple diseases. This would unleash enormous welfare gains, with one study estimating that a one-year gain in life expectancy in the US would



SIMONE ROTELLA

be worth around \$38 trillion.

But achieving this requires changing how we think about ageing. It means accepting that the biology of ageing is a mainstream line of scientific inquiry, not a throwback to alchemy and promises of immortality.

Evidence that change is occurring is accumulating. Consensus is building around the key biological pathways of ageing, and researchers are making progress on pinning down how some of these pathways work, for instance in areas of stem cells. There are now methods for measuring biological age. With

a proliferation of journals focused on ageing, and billion-dollar funding flowing into geroscience, change feels firmly underway.

This shift also requires recognising that ageing is malleable, not inevitable or fixed. We too often draw a distinction between health and the consequences of ageing, assuming the latter are natural phenomena. That thinking reflects past success in treating diseases such as smallpox or typhus. For most of history, those were also seen as natural and inevitable. But no longer. We now need to translate that progress to tackling how we

age – and remember the words of French philosopher Michel de Montaigne that “to die of old age is a death rare, extraordinary, and singular, and therefore so much less natural than the others”.

A focus on ageing and ageing-related diseases also ushers in something unique – a virtuous circle that other diseases don't possess. When progress was made in treating infant diseases, infant deaths fell, so research moved on to the diseases of middle age. Breakthroughs there led to fewer midlife deaths, and so science shifted to focus on ageing-related diseases. But the better we get at ageing, the more older people there will be and the more valuable further gains will be. When we are ill in our 90s, living into our 100s has little appeal. But if we can be healthy 90-year-olds, then we want to live for even longer. A second longevity revolution focused on changing how we age thus opens up the possibility of living to ages far greater than ever before.

Where we end up depends on a battle between human ingenuity and human biology. But in a world where the young can expect to become very old, a longevity imperative sets a course for a new scientific terrain, and a dramatic change in how we live our lives. ■



Andrew Scott is professor of economics at London Business School and author of *The Longevity Imperative*

MATSMITHPHOTOGRAPHY.COM

## Field notes from space-time

**Star-gazing for beginners** As a particle astrophysicist, you'd think I would know what I'm doing when it comes to looking at the sky. I don't, but I'm learning, says **Chanda Prescod-Weinstein**



Chanda Prescod-Weinstein is an associate professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her most recent book is *The Disordered Cosmos: A journey into dark matter, spacetime, and dreams deferred*

### Chanda's week

#### What I'm reading

*I'm loving James Poskett's Horizons: The global origins of modern science.*

#### What I'm watching

*I've been quite enjoying the sci-fi television drama Constellation.*

#### What I'm working on

*Reading a lot about the history of human conceptions of space and time.*

This column appears monthly. Up next week: Graham Lawton

**O**N 8 APRIL, a total solar eclipse will be visible from various parts of North America. The path in which this will occur runs from Mexico, diagonally across the US and into the Atlantic region of Canada. Eclipses like this, where the moon moves directly between the sun and Earth and blocks out light, happen almost every 20 years. But our planet is a big place, and these events can't be seen everywhere. Only about once every 400 years is one visible from any given spot on Earth. Which is to say, those of us in or near the path of the eclipse are quite excited.

I have never seen a total eclipse, and that is unlikely to change this time, unfortunately. That is despite living in a place close enough to the strip that will be cast into total shadow that you might think we are lucky, as from here at least 90 per cent coverage of the sun by the moon will occur.

But unluckily for my community, there is a reason the region we are in is called New England, and it isn't just because the first settler-colonisers who came here were deeply uncreative in their naming scheme.

New England is also prone to a spot of English weather. On balance, I expect clouds on 8 April, not just where I live, but also along the path of total darkness, or totality, that is within driving distance, which is why I am not shelling out for the exorbitant hotel prices I have been seeing.

It feels strange to accept that I am likely to miss the astronomical experience of a lifetime – though it is possible I will throw caution to the wind and hustle up to Vermont at the last minute with visions of totality filling my head.

One would think that as a practitioner of astronomy – I am a professional particle

astrophysicist – that I would be first in line. I have two degrees in astronomy and everything!

But a quirk of a modern astronomy education is that you can have two or even three degrees in astronomy and astrophysics and know little to nothing about actually looking up at the sky with any kind of competence. Neither of my undergraduate lab projects required me to know anything about doing this, or knowing what equipment I might need to take a decent photograph of the stars.

I have even been on what is called an observing run at the twin Magellan telescopes at

**“You can have two degrees in astrophysics and still know little about observational astronomy”**

Las Campanas Observatory in the Atacama desert, Chile. I tagged along with a couple of observational astronomers on a 10-day trip in 2011.

My main takeaway was that a sky with no light pollution is absolutely stunning and, also, observational astronomy is too hard for me. Not least because you could spend 24 hours travelling and, on reaching your destination, have your allotted observing time completely ruined by clouds.

After that trip, I never saw myself going near a telescope, even though, as I like to joke with people, two of my best friends are telescope builders. I am all set with equations, I told myself and anyone who asked about it.

Turns out that I was full of it, and not just because I am playing a leadership role in the science definition of a proposed X-ray space telescope called STROBE-X

(which stands for “Spectroscopic Time-Resolving Observatory for Broadband Energy X-rays”) and also helped make the case for how the Vera C. Rubin Observatory will improve our efforts to understand the fundamental nature of dark matter.

Last year, I quietly began researching amateur astronomy, joined the related helpful online community called Cloudy Nights and invested in a telescope, mount and a specialty astrophotography camera.

In the past, I didn't feel strongly about clouds over my house. But now I feel extremely disappointed every time they ruin my night, which is a lot since, remember, I live in New England. But that only makes the nights and days when there are clear skies more magical. A clear sky is precious, especially as our weather systems respond to a warming planet and as LED lights that radiate across the visible spectrum make it increasingly difficult to see the universe beyond our atmosphere.

I have started posting the occasional astronomy image of my own making on my Instagram and making music videos out of them on TikTok. My favourite is one I captured of the sun, a close-up using a specialty filter (remember never to look directly at the sun or point a camera at it without an appropriate filter).

In the video, set to Megan Thee Stallion's music, you can see sunspots on our star. A view like this is accessible to anyone with binoculars and some solar filter paper. I might not get to see the eclipse, but I urge you to join me in looking up, not just on clear nights, but during clear days too. ■

For more of our coverage of the eclipse, see [newscientist.com/article-topic/solar-eclipse-2024](https://www.newscientist.com/article-topic/solar-eclipse-2024)

# HELP EXPLORE A NOVEL INTERACTIVE AI PARADIGM!

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We will work intensively with people who are not usually involved in AI discovery and innovation - people with lower socio-economic opportunities in the UK and those in Global South communities such as the informal settlements in India, Kenya, Brazil, and South Africa. Their lived experiences will be brought into the design and development process. In doing so, we aim to discover novel ways for people - everywhere, whatever their contexts and opportunities - to engage with AI systems.

We call this new trajectory for AI research, EVE

- everyone virtuoso everyday - to succinctly summarise the drive of the work. That is, we are interested in defining and evaluating a class of AI technology that enable expressive, individual, and masterful interactions, like a virtuoso musician who channels all their being - physical, mental, emotional, and even spiritual - through their instrument to help themselves and others make sense of the world.

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*For further details and to apply please go to:*

<https://cs.swansea.ac.uk/~csmatt/> Closing date : 8th April 2024

*To discuss your application informally, please contact Professor Matt Jones at [matt.jones@swansea.ac.uk](mailto:matt.jones@swansea.ac.uk)*

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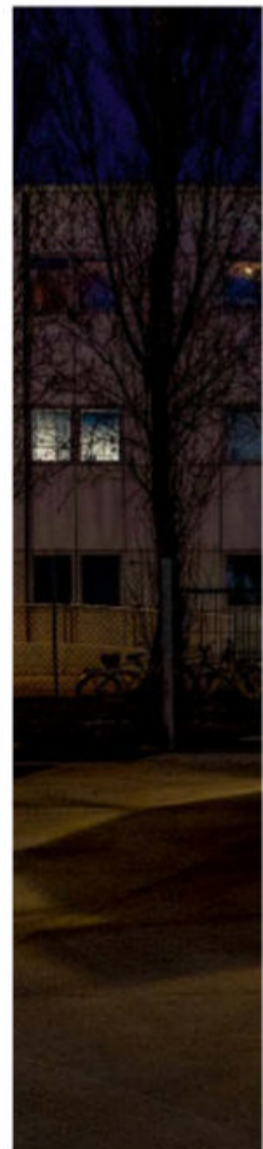
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## Green glow up



Photographer **Luigi Avantaggiato**

THESE curious experiments are products of the Green Propulsion Laboratory in Venice, Italy: a publicly owned research centre exploring new ways to rehabilitate the environment and generate energy. An unusual mix of scientists, engineers and psychologists at the lab have created prototypes that harness natural organisms to do useful jobs, often taking on a sculptural aspect as a side effect that attracts resident artists.

“Despite being objects of science, there is beauty,” says photographer Luigi Avantaggiato. He spent time cataloguing devices such as Purple-B (shown at far left), which uses a bacterium called *Rhodospseudomonas palustris*, commonly found in the Venice lagoon, to convert human waste into useful hydrogen. The experiment has been funded by the European Space Agency as it could provide a way to process astronauts’ waste in orbit and create usable fuel, but it could be of use on Earth’s surface too.

The bright green contents of several tanks in the lab (near left, top) are what is known as the Liquid Forest, a project in which tiny algae, such as *Chlorella*, capture the carbon dioxide that is warming our planet. Each tank contains 250 litres, and every cubic centimetre of that can hold around a billion algae.

Another shot (near left, bottom) shows a geodesic dome in which environmental engineers from a start-up called 9-Tech are working on new ways to recover silicon from obsolete solar panels.

The whole lab site was created by Veritas, which handles the waste and water supply for around a million residents and 50 million tourists in Venice and Treviso. ■

**Matthew Sparkes**



Advertising feature sponsored by



# The luxury developer protecting coral from climate change

Meet the high-tech tourism developer using robots and AI to bring coral back to life in the Red Sea

Heat repellent architecture at the Six Senses Southern Dunes resort

On the glittering Red Sea coast, there's a luxury tourist destination that has it all: white sands, impeccable accommodation, world-class yachting and – perhaps surprisingly – a cutting-edge laboratory that's protecting coral reefs from climate change.

AMAALA is a new kind of sustainable destination. It's not finished yet (the first guests will arrive in 2025) but the destination is one of the first by Red Sea Global (RSG), a Saudi Arabian developer whose ambition is to redefine what regenerative tourism can do.

Run with 100% renewable energy, AMAALA is one of two carbon neutral luxury destinations that RSG operates (the other, called The Red Sea, is also in Saudi Arabia). They're test beds for sustainable development and hubs for new technology and ecological research.

With two hotels already open and four more welcoming guests this year, RSG is building mangrove nurseries and experimenting with carbon negative concrete. But arguably its most ambitious project is to protect and regenerate corals, which are under extreme pressure from warming temperatures, in the Red Sea and beyond.

"Corals cover less than 1% of the Earth's surface but sustain 25% of all marine life," says John Pagano, Group CEO of RSG. "To protect and enhance the coral reefs under our guardianship we are using advanced technologies, such as remote operated vehicles and machine learning, to monitor coral cover.

"These innovations can produce 3D images and automatically analyse them, enabling our scientists to quickly identify

and respond to threats like coral bleaching and invasive species."

RSG researchers have created offshore coral nurseries to help sustain and grow rescued corals, while a coral nursery on dry land could supercharge the speed at which new coral can be nurtured.

The work forms RSG's 'coral commitment', announced at COP28 in Dubai last year. There, it signed a letter of intent with the Coral Research & Development Accelerator Platform (CORDAP), a body set up by the G20 to fast-track research into new solutions to save the world's coral from our rapidly changing climate.

As well as monitoring 300 reef sites in the Red Sea, RSG scientists are working on a Coral Gardening Pilot Project. Beginning in 2021, researchers established offshore

**"Corals cover less than 1% of the Earth's surface but sustain 25% of all marine life"**

nurseries to nurture and regrow rescued corals. The pilot achieved a 97% survival rate.

The nurseries are suspended from floating platforms, allowing researchers to provide the optimum conditions for coral to grow. "They're sheltered from predators, they've got good water conditions, and they are protected from sedimentation," says Dr Jess Bouwmeester, associate director of marine enhancement at RSG. "And because we have accelerated growth, we can transfer anything that grows above the normal rate to the reef."



RSG's scientists are also developing an onshore nursery, where corals are developed in controlled conditions. The idea is to boost the natural coral reefs when needed, says HH Princess Shaikha Al Saud, a marine conservationist on the team.

"We think of the land-based nurseries as a back-up system for the natural life cycle. If there's an issue with the reproductive cycle or a major stress event, we still have good stock to rely on."

The breeding programme helps scientists enhance corals and maintain genetic diversity, which can be an issue after mass bleaching events, Princess Shaikha says. But

it also helps with another issue: corals' narrow reproductive window.

"Corals spend six-to-nine months developing their eggs and sperm for everything to be released over just two hours a year. That's it," Bouwmeester says. "That's your only reproductive window."

That window usually begins around 10pm in the Red Sea, making it even harder for researchers to study. To make it easier, Bouwmeester intends to play a trick on mother nature.

"We're going to have four different systems where we trick the corals with the temperature cycles and the light cycles,"

she says. "If I can trick the corals to think it's night during the daytime and day during the night-time, I can get them to spawn at 11am, a time that works much better for me because I will be awake and have a functioning brain."

In the future, Bouwmeester will also get different corals to think it's spawning time at different times of the year. "So now my team and I can do four spawning events per year, not just one."

With time, she says this could mean an exponential increase in the number of new corals available to replace lost colonies or boost the coral community.

Soon, RSG will also begin testing 3D-printed materials to create artificial substrates for relocating coral colonies or growing new ones. Essentially, it means creating new reefs to support marine life. And the cool thing is, everyone's invited.

RSG's vision is for tourism, conservation and research to co-exist and sustain each other at its destinations. The marine life institute it is building at AMAALA, Corallium, will include visitor experiences alongside its laboratories and rehabilitation centres. Tourists will be encouraged to participate, play and learn.

"We believe that academic research and tourism can work together, for people and planet alike" says Pagano.

"The facility goes beyond any existing marine life attraction. It has 10 zones that provide everything from augmented reality experiences to night diving, as well as dedicated spaces for the scientific community to advance research projects."

Bouwmeester is looking forward to welcoming visitors, too. "We want to get them involved," she says. "As soon as people start learning about corals they tend to be a lot more protective of them. In terms of environmental awareness, getting the tourism sector involved is extremely important."

It's an optimistic, pragmatic approach to conservation. Hopefully, we can keep learning from the coral, Bouwmeester says. "Corals surprise us in a lot of ways," she says. "We know they're some of the most sensitive organisms in the world but they do have the ability to bounce back. What we want to do is support that resilience and boost it when we can."

**Find out more about Red Sea Global**  
[redseaglobal.com](https://www.redseaglobal.com)



## RSG & THE FUTURE OF REGENERATIVE DEVELOPMENT

**Coral protection is just one part of Red Sea Global's commitments to regenerative tourism. Here are three other innovative projects already underway.**

### THE MANGROVE NURSERY

**In the summer of 2023, RSG opened its first mangrove nursery as part of a commitment to plant 50 million mangrove trees by 2030. Mangrove forests can store as much as five times more carbon than tropical forests and they also sequester it 10 times faster.**

### THE CARBON-NEGATIVE CONCRETE

**RSG has partnered with Partanna, a company that claims to have created concrete that not only avoids carbon emissions but also removes carbon from the atmosphere. The companies will operate a pilot programme to install 11,000 carbon-negative paving stones.**

### THE CARBON SINK

**At the end of 2023, RSG announced a new 20-acre wetlands which double as a chemical-free way of treating wastewater. The wetlands are made of reeds that naturally absorb the water's nutrients and metals, and the treated water is used at RSG's landscape nursery.**

# The music of time

A new book promises to deliver the complete archaeological history of music for the first time. **Arwa Haider** listens in



Book

## Sound Tracks

Graeme Lawson

Bodley Head

DIGGING around for old instruments and the sounds of the past is a natural obsession of music lovers. It conjures up those countless hours spent happily scouring record stores or digital archives for treasures, building up a vinyl collection or rooting out rare gems for a playlist.

For archaeologist, multi-instrumentalist and historian Graeme Lawson, it takes on a more literal meaning as well as an impressively ambitious scope. The publicity for his new book, *Sound Tracks: Uncovering our musical past*, promises that it relates “the whole archaeological history of music for the very first time”. If that sounds overwhelming, Lawson appears immediately as a personable guide to reassure us that leisure is a fundamental premise of his book.

His chapters emerge like a series of vignettes, each composed around one or more musical finds. Before long, we have considered music’s bond with local traditions and imported materials (such as in the case of the Natchez Indigenous people of 18th-century southern Mississippi) and discovered examples of people everywhere repurposing daily objects like empty steel oil drums, discarded bones or clay pipes to make memorable sounds.

Lawson is an engagingly vivid narrator with a sharp eye and ear, and the breadth of his experience and expertise makes for a diverting perspective, whether he is recalling life as a young archaeology graduate, a live musician (and historian-



A SHMOLEAN MUSEUM OF ART AND ARCHAEOLOGY/HERITAGE IMAGES/ALAMY

performer) or instrument-maker. His tone is playful and persuasive, pitched to ensure that his meticulously detail is accessible – and crucially, relatable – to all curious readers.

At one point, Lawson wryly observes that “archaeologists are no strangers to disappointment”. He acknowledges the limitations

**“We discover people repurposing daily objects like oil drums or bones to make memorable sounds”**

of what can be preserved, whether it is an instrument’s physical form or its original sound (something he dreamily calls “the ghosts of a lost music”). Sometimes, music’s fragility is what captivates us. I was charmed by his description of sweet-sounding “tree-bark flutes”, simply crafted from springtime wood, yet deteriorating within days or even hours.

*Sound Tracks* isn’t much

concerned with the perennial, ultimately subjective argument of what distinguishes “music” from noise, or the more contemporary rhythm and flux of genres and trends. Rather, it draws parallels in terms of the importance of music in cultures across time and place – from heartfelt serenades to ritual sacrifice.

The geography of musical discovery is fascinating too, spanning sites such as that of the wreck of the Tudor warship the *Mary Rose* on the UK’s south coast to a car park in Zimbabwe where archaeologist Shadreck Chirikure located a tiny key from an mbira (a traditional thumb-piano), possibly dating to the 16th or 17th century.

The Western European colonial perspective that dominates many musical finds also places limits on understanding. A bronze trumpet taken from a Pharaoh’s tomb by 20th-century British archaeologist Howard Carter proves less robust than it looked: it falls apart years later during attempts to play it to mark Carter’s death. Elsewhere,

**Trumpets and a trumpet tube from between 4500 and 2800 years ago**

another British archaeologist, Leonard Woolley, is shown holding a Sumerian lyre from a site near Nasiriyah, now in southern Iraq. As a British Iraqi music journalist, I am dispirited rather than delighted that various Woolley “discoveries” are in the British Museum.

*Sound Tracks*, however, is more concerned with musicology than modern politics. As the book progresses, Lawson considers evidence that humans are “wired” for sound, observing: “At the first appearance of instruments around forty thousand years ago, their forms are if anything more elaborate and more coherent than those that succeeded them.” He leaves us asking what musical legacy we might want to gift future generations, or even other worlds: a truly elliptical end note. ■

Arwa Haider is a writer based in London

# Behind the algorithm

AI is already challenging our work and lives. A must-read book explores the human impact, finds **Chris Stokel-Walker**



**Book**  
**Code Dependent**  
Madhumita Murgia  
Picador

THE artificial intelligence revolution has overwhelmed us all since the release of OpenAI's ChatGPT in November 2022. But AI is far more than that, as a new book by Madhumita Murgia, AI editor for the *Financial Times*, explains.

Murgia has long been fascinated by data, writing a story for tech magazine *Wired* a decade ago that outlined how eager tech companies are to collect and analyse information about their customers. But in *Code Dependent: Living in the shadow of AI*, she chooses to focus on the humans who help make the technology work, or whose lives are affected by its decisions.

There are no mentions of Sam Altman, OpenAI's enigmatic CEO, in her book, but plenty of Sama, an outsourcing company used by many tech giants to label the data

In some sectors, workers are increasingly beholden to algorithmic decision-making

on which they train AI systems. Murgia trots the globe, but she studiously avoids the hotbed of the revolution. Her book is better for it.

She sites the action largely in the time before the release of ChatGPT, and this provides a useful primer for the world in which we now live. Her deftly told stories are those of the human annotators who, among other things, help train autonomous driving systems or pore through image classifiers and text, adding labels about what is and what isn't appropriate content.

We also ride alongside delivery drivers whose livelihoods are taken from them in an instant due to misfiring algorithms. And we sit in a doctor's surgery as patients are treated with the help of AI.

To judge by the meticulous detail in her book, Murgia has worked hard to win the trust of those she writes about in its 10 character-led chapters. She learns which flowers a beekeeper-turned-data worker (who escaped conflict in Iraq and ended up in a low-paid job training an algorithm) saw his insects feed upon. She eats alongside those she profiles, breaking bread with them while learning how they help power the tech we use daily.

Through these moments, we learn how precarious the work now being handled by algorithms is. One data labeller explains how a simple AI-guided change in shift patterns by her company lost her vast amounts of work – and how the bosses then banned her from working for them for a month for complaining.

We learn, too, how unreliable this data may be. Another data annotator works earnestly and hard. But he is labelling bones for medical AI without knowing human anatomy. He says that he enjoys labelling roads and traffic signs, hoping that, one day, he will be able to drive himself and so put that knowledge to use.

Other labellers admit that they sometimes have to guess at the least wrong answer, their decisions forever encoded into AI models.

Murgia also tells her own journey to bookend the narrative. In her introduction, she explains how she was a techno-optimist – perhaps understandably, given her career as tech journalist – but has since become more sceptical of the tech that is currently “altering the very experience of being human”, as she describes it.

However, she is no Luddite. To conclude, she offers a list of 10 questions designed to provoke thinking about how to better frame our relationship with AI, including who should be accountable for AI decisions in life-and-death, or life-altering, choices, and how people can opt out of being swept up in AI's dragnet.

Given the topic's ubiquity, it is refreshing when a new perspective comes along. And *Code Dependent* is just that, making it a must-read for those struggling to reckon with the AI revolution. ■

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



**Alison Flood**  
Culture editor  
London

As a big fan of world-ending dystopias in my fiction, I was delighted to be sent a copy of **The Book: The ultimate guide to rebuilding a civilization**. This 400-page coffee-table book does what it claims,



educating you about everything from how to make rope from willow bark to how to grow penicillin, complete with gorgeous illustrations. Created by Vsevolod Batischev and Timur Kadyrov, with Lewis Dartnell at the University of Westminster, UK, as its scientific and technical expert, **The Book** isn't cheap (it costs £99), but it is a thing of beauty and I will be grabbing it if any disasters come my way.

A family birthday also meant a trip to **SENSAS** (pictured) in London, a multi-sensory experience that saw us, sometimes in darkness, putting our senses to the test. We tried to identify foods (from crickets to chickpeas), darted through a laser maze and experienced “anti-gravity”. It was a lot of fun, despite the screaming when we had to put our hands into a box of slugs.



## The games column

**Saving the world** *Final Fantasy VII Rebirth* is the latest in an expanded remake of a classic eco-conscious game from 1997. In addition to gorgeous new graphics, the game's ideas now resonate even more strongly, says **Jacob Aron**



Jacob Aron is *New Scientist's* news editor. Follow him on X @jjaron



SQUARE ENIX

**Cloud Strife (centre right) joins a group fighting an evil power company**

rendered locales marred by industrial infrastructure.

It is worth examining mako, and how different interpretations alter its message. Both the name and appearance of mako reactors point to a nuclear analogue – driven home in *Rebirth* when you find a destroyed reactor near the home town of Barret, the most anti-mako member of the group.

Personally, I view nuclear power as incredibly safe and think it is a shame anti-nuclear sentiment has derailed efforts to tackle climate change by hobbling a carbon-free source of energy. After the 2011 Fukushima nuclear disaster, for example, which saw no deaths from radiation sickness, Germany mothballed its nuclear fleet. As a result, its annual CO<sub>2</sub> soared by 100 million tonnes, adding an estimated 1100 deaths a year from coal power-driven air pollution.

That is why I prefer to read mako as oil, a non-renewable liquid extracted from below Earth's surface and derived from the lifestream of all living things. Squint a bit and it isn't dissimilar to oil's ancient organic origins.

The *FFVII* world also features mako-derived "materia" that provides its people with magical powers, in the way that petroleum products make up many trappings of our world. During a visit to a Las Vegas-like amusement park, there is even a discussion on whether such a frivolous use of mako energy can be justified.

But whichever interpretation you choose, it is clear *FFVII* wants us to think about our impact on the planet. To do that while telling an epic story of magic, friendship and much more shows why the game deserves its classic status. ■



### Game

## Final Fantasy VII Rebirth

Square Enix  
PlayStation 5

## Jacob also recommends...

### Games

## Terra Nil

Free Lives

PC, Android, iOS

An anti-city-builder that I reviewed last year, in which you rewild landscapes by removing human-made infrastructure to restore natural habitats.

## Flower

Thatgamecompany

PC, PlayStation 3, 4 and Vita, iOS

Play as the wind as you whip up swirling petals in this delightful meditation on the natural world.

IN 1997, the world's nations met in Japan to sign the Kyoto protocol, the first global agreement on reducing greenhouse gas emissions. But this wasn't Japan's only big contribution to the environmental movement that year, as 1997 also saw the release of *Final Fantasy VII*, a game that wears its eco-consciousness on its sleeve and is widely regarded as one of the best ever made.

For the uninitiated, *Final Fantasy* spans 16 "main" games to date, each set in its own fictional universe and accompanied by a dizzying array of spin-offs. But don't let that scare you off, as you can ignore the numbering and treat each game on its own merits.

*FFVII* follows the story of Cloud Strife, a spiky-haired mercenary with an improbably large sword. He joins an eco-terrorist group called Avalanche that is fighting Shinra, an evil power company (also Cloud's former employer). Shinra's goal is to exploit "mako", a form of energy derived from the spiritual essence of the planet. We aren't exactly dealing with subtle metaphor, but for hordes of fans,

it was an introduction to ideas that resonate even more strongly now.

I never played the original, as I didn't own a PlayStation, but the game is so loved that its developer, Square Enix, has been remaking it as an updated and expanded trilogy. The first, *Final Fantasy VII Remake*, released in 2020, covers the exploits of Cloud and co. in

**"Debates about exploiting resources hit harder running around beautifully rendered locales"**

a city called Midgar. The group bombs a Shinra mako reactor and flees in pursuit of Sephiroth, Cloud's former commander, out to take control of the mako.

The latest game, *Final Fantasy VII Rebirth*, picks up the story and sees you on a mission to find and stop Sephiroth. This focus on exploration reinforces the game's environmental theme, as debates about exploiting natural resources hit much harder when you are running around beautifully

## Editor's pick

### Please let the woolly mammoth rest in peace

16 March, p 12

From Christine Duffill,  
Southampton, UK

I read about the plan to bring back the woolly mammoth with dismay. How can anyone theorise about any environmental benefits of such an endeavour without looking at both animal welfare and ecological impact? What would these introduced animals eat? If there isn't enough food, they will starve and lead a miserable life. If there is enough, they may outcompete other species that rely on it and wreak havoc with the local ecology.

Introducing an extinct large herbivore is so obviously a recipe for disaster that I can't believe this is seriously being considered. We have seen what happens when alien species enter a new environment.

### You're gonna need a bigger carbon extraction set-up

16 March, p 36

From Nigel Tuersley,  
Wardour, Wiltshire, UK

I'd say the scale of direct air capture (DAC) of carbon dioxide to deal with climate change must exceed the 80 megatonnes a year in your article. Leaving aside contributions via offsetting, restoring climate stability this century would, at a minimum, involve reducing CO<sub>2</sub> levels in the atmosphere to around 320 ppm. That would mean extracting about 1600 gigatonnes of CO<sub>2</sub> in the decades ahead. If just half was met by DAC, it would require thousands of plants that can each capture 1 million tonnes a year, even more if you consider their limited lifespan.

If we are serious about avoiding climate chaos, we need to face up to the magnitude of the challenge.

From Andrew Taubman,  
Sydney, Australia

A solar power station in space would make a potent weapon,

one that is essentially impossible to defend against. With solar and wind generators spread widely enough on the ground, plus cheap long-term power storage, we don't need space solar.

### The flexitarian approach to bringing back the wolf

16 March, p 29

From John Kitchen, Kettering,  
Northamptonshire, UK

The idea that wolves could be reintroduced successfully into modern Britain, given today's lack of wild spaces, is laughable. However, should everyone choose to cut their meat and dairy consumption by 90 per cent so that the UK could rewild half its farmland, then wolves probably could be given a new home. I have cut my intake of meat and dairy by 90 per cent. Will you?

### I need that no-cake-for-breakfast feeling all day

16 March, p 15

From Phil Eden, Sheffield, UK

New weight-loss treatments all seem to concentrate on making you feel full. For a couple of hours after I wake, despite being hungry, the thought of eating chocolate or cake is very unappealing. Come late morning and for the rest of the day, even when full, I can crave these foods. Can anyone invent a pill to maintain this first-thing-in-the-morning feeling all day?

### Not yet persuaded of the merits of space miso

9 March, p 13

From Sam Edge,  
Ringwood, Hampshire, UK

I was interested in your piece on miso fermentation on the International Space Station.

However, I'm not sure any conclusions can be drawn by comparing one jar fermented in space with two on Earth.

Different results from two identical preparations fermented in the same facility aren't uncommon, the same as with home-made beer and wine.

### Friends may be imperfect, but they always trump AI

9 March, p 32

From Gerard Buzolic, Coolumb Beach, Queensland, Australia

Empathetic artificial intelligence would be like virtual reality for the emotions. As it learns, no doubt it would say just the words I need to hear. As lives get busier, the quick fix offered by such an AI would become more tempting.

While my real friends may ring me at inconvenient times, talk about things I am only moderately interested in, are sometimes infuriating, give wrong advice, say the wrong thing and occasionally waste my time, I wouldn't trade them for a custom-made AI version. Like gardens and real streams in real forests, I love them for their sake, not just mine.

Name and address supplied

Amanda Ruggeri's very fine article focuses on the quality of empathy that can be delivered by AI compared with the gold standard of human empathy. Having been recently diagnosed with terminal cancer, I have experienced an outpouring of empathy from friends, family, nurses and physicians, some in person, some over the telephone and some through emails and cards.

I can attest to the huge range of effectiveness of these attempts at empathy. My experiences tell me that the comfort I attain from any

such interaction is determined solely by the strength of our mutual love. As Ruggeri concludes, call a friend. It is the best.

### Covid brain may have another explanation

9 March, p 18

From Robert Masta,  
Ann Arbor, Michigan, US

Since the measured average drop in IQ for those who have had a covid-19 infection was small, according to the study you report on, one has to wonder how much was due to a possible correlation between lower IQ and incidence of infection. Lower IQ tends to lead to the kind of jobs in which it is harder to avoid exposure.

### On the threat to African penguins

9 March, p 10

From Anthony Forbes,  
Durban, South Africa

There is no evidence that an apparent reduction in great white sharks off the south coast of South Africa has resulted in a rise in seal numbers and greater predation of or competition with penguins.

The African penguin is in a well-documented catastrophic decline following decades of guano harvesting and egg collection, both now fortunately no more. The biggest documented threat at this stage is competition with the fishing industry, whose activities in areas around island breeding colonies were curtailed, but have now been restored following industry pressure. ■

### For the record

■ In "To leap or not?" (16 March, p 32), we should have said snowy albatrosses nest on Possession Island in the Southern Ocean.  
■ It was the use by King Louis XIV of France of estiquettes (small cards) to advise on rules of behaviour that led to the word etiquette (9 March, p 21).



### Want to get in touch?

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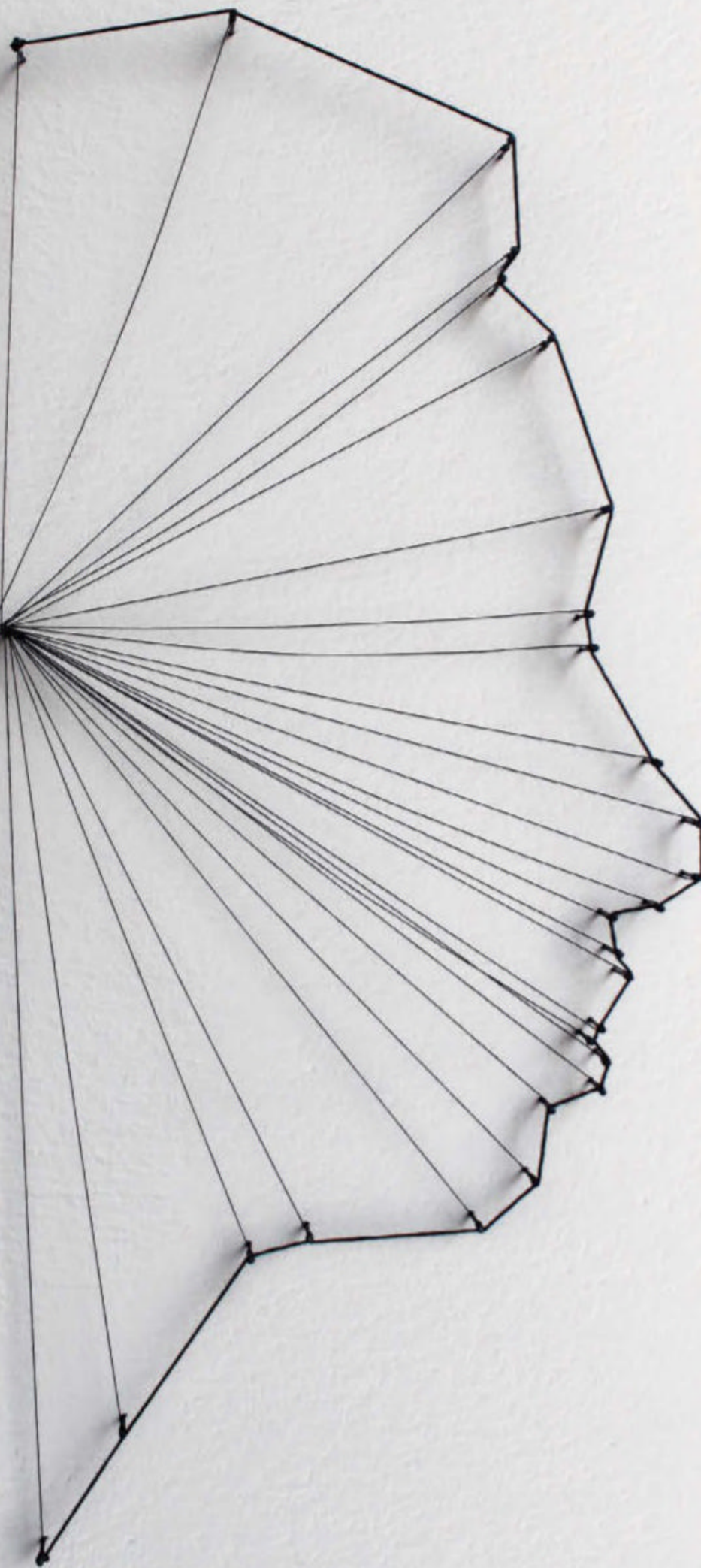
Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

# ANXIETY

We have all felt it at some point in our lives, a nervous energy that flutters through our body and mind, perhaps as a deadline approaches or an interview looms. But recently, fears have grown that a larger number of people, especially children, are experiencing anxiety more often and to a greater extent.

Over the next nine pages, we take a deep dive into the latest findings about this common yet mysterious emotion. We will explore what happens in the brain and body when you feel anxious and look at the reasons why some people are more prone to anxiety than others. We will investigate whether it really is becoming more common, and some of the possible reasons for that, including, you guessed it, the covid-19 pandemic and the climate crisis. Finally, we will examine some surprising benefits to being anxious, from creativity to problem-solving, and discover some science-backed ways to beat it.

ATELIER PAMELA CAMPAGNA, WWW.PAMELACAMPAGNA.COM





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## WHAT IS ANXIETY?

WHEN I was asked to write this article, my heart started beating faster, my hands started shaking and my thoughts went into overdrive coming up with what felt like hundreds of objectively sensible reasons why I couldn't do it. I could tell you that as chief subeditor at *New Scientist* I don't often get a chance to write. But the truth is I rarely write because I am very anxious about it. What if the people I contact don't respond? What if I write something stupid? What if I am stupid? What if, what if, what if.

Clearly, I chose to write this article, partly because I am stubborn and hate that these anxious feelings hold me back from doing things I might enjoy, and partly because I find that doing the things that make me anxious helps me overcome that feeling (see "Five scientific ways to ease anxiety", page 38). But my main motivation was to answer questions that have been

bothering me for years: what exactly is anxiety and what is happening in my body and brain to cause this feeling?

Answering that first question is difficult, in part because there is no one way to feel anxious. "I'd say there's as many types of anxiety as there are people in the world," says Oliver Robinson, head of the Anxiety Lab at University College London.

We do know everyone experiences anxiety – it helps prime us to be ready in possibly risky situations. Consider walking home alone in the dark, where that feeling of being on edge and alert may help you to react if the unexpected happens. Where it becomes more of a problem is if you still feel like that when you are safe at home. "Anxiety is a threat response in the absence of a threat-inducing stimulus," says Sahib Khalsa at the Laureate Institute for Brain Research in Tulsa, Oklahoma.

We don't know exactly what is

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There are  
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people in  
the world

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happening in the brain when you are anxious, says Robinson. However, one area that has had a lot of attention is the amygdala, as it deals with fear-related memories and is involved in detecting danger and helping conjure involuntary emotional responses.

When it has picked up a potential external threat, the amygdala sends signals to the prefrontal cortex, the region at the front of the brain that deals with complex functions like emotional regulation. Then, two sections of this region step in: either the dorsomedial prefrontal cortex tells the amygdala to pay attention to these signals or the ventromedial prefrontal cortex dampens them. We think that, in an anxiety disorder, this normally helpful process goes awry, so that you experience anxiety at inappropriate times or too intensely, says Robinson (See "Anxiety vs anxiety disorders", left).

But potential threats that spark anxiety don't only come from external sources. "There could be a change within your body and you then have a threat perception," says Khalsa. This is due to something called interoception. Often referred to as our sixth sense, interoception is how our brain keeps tabs on what is happening within the body, subconsciously monitoring things like muscle tension and carbon dioxide levels in the blood. "Oftentimes, anxiety is a misinterpretation of a [physiological] signal," says Khalsa. Becoming aware of a change in heart rate, for example, could induce anxiety by making you think you are having a heart attack.

Evidence that higher interoceptive awareness may contribute to feelings of anxiety came when 24 women with generalised anxiety disorder (GAD) were given 0.5 micrograms of the drug isoproterenol to increase their heart >

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### Anxiety vs anxiety disorders

**Anxiety is a feeling of fear or unease that is often accompanied by physical symptoms, such as sweating or a rapid heartbeat. While being anxious can be a normal response to stressful situations, when this emotion is triggered excessively, becomes difficult to control or is felt without a specific cause, it may be symptomatic of an**

**anxiety disorder. These include a variety of conditions, such as phobias, social anxiety disorder and generalised anxiety disorder, and their effect on a person's life can be debilitating. Around 4 per cent of people globally have an anxiety disorder and up to a third will have one at some point in their life.** Bethan Ackerley

## WHY ARE SOME PEOPLE MORE PRONE TO ANXIETY?

rates. They experienced larger changes in the response of their brains to heartbeat, thought to be a measure of cardiac interoception, than 24 controls without the condition. Prior to taking isoproterenol, the women with GAD also had a higher measure of cardiac interoception than the control group.

Given anxiety seems to depend on this connection between mind and body, where does the initial trigger start, in the brain or in the body? “We don’t know,” says Khalsa. “Some would say that the two are happening simultaneously. It is close enough in time that, for all intents and purposes, it doesn’t matter.” What seems clear is that both parts play a role in anxiety. “If you think about it in evolutionary terms, having this feedback loop is probably useful, because it means that you’re able to adapt and update your perceptions,” he says.

So, did learning about what happens when I feel anxious help when writing this article? A little. I have no plans to switch careers, but the next time I am asked to write about something I am interested in, I plan to take control of my overactive anxiety response and say yes without hesitating. **Eleanor Parsons**

**30**  
per cent of the  
variation in  
generalised  
anxiety  
disorder  
is attributable  
to genetics

WE ALL know that person, the one who, when faced with what looks like an overwhelming problem, shrugs their shoulders, comes up with a solution and moves on without so much as a furrowed brow.

To someone with even a fleeting relationship with anxiety, it can seem staggering how others go through life with such aplomb. Why are some protected, while others are more prone to experiencing it? Like most aspects of our behaviour, genetics play a part, as do environmental pressures and lifestyle choices. Thankfully, a better understanding of how they interact is helping us find new ways to minimise the problem.

Let’s start with your genes. Studies show that about 30 per cent of the variation of generalised anxiety disorder in the general population is attributable to genetics. This isn’t due to a particular gene, but rather to a host of interacting genetic factors.

For some people, it may be genes associated with the hormone serotonin, which passes messages around the brain. One study in marmosets found a causal relationship between the animals’ perceived level of anxiety and genes responsible for the proteins that mop up serotonin in a brain region called the amygdala, which deals with fear-related memories. When serotonin was blocked from being taken up by cells in the amygdala, the animals’ anxiety seemingly decreased.

This suggests that some people might have a genetic predisposition to absorb too much serotonin into their cells in this region. As a result, less serotonin passes between neurons, disrupting the messages that help us

monitor and process threats, which then leads to anxiety. Drugs that block serotonin uptake, called SSRIs, are often the first medication offered to treat generalised anxiety disorder.

The spotlight has also turned to genes associated with a protein called brain-derived neurotrophic factor (BDNF), which helps neurons grow. Casey Guillot at the University of North Texas and his colleagues have found links between variants of BDNF genes and an individual’s vulnerability to anxiety. BDNF is intimately involved in how our brain matures, and altered levels are thought to affect how fear circuits in the hippocampus, prefrontal cortex and amygdala develop during early adolescence. Putting it all together, “it’s reasonable to speculate that variations in BDNF genes have effects on brain signalling that result in greater vulnerability to anxiety”, says Guillot.

We can’t place all the blame on our genes, though. While some of us have a genetic susceptibility to anxiety, environmental factors can help or hinder its expression. For instance, a study of more than 41,000 people found that stressful events such as loneliness amplified the effects of a genetic susceptibility to anxiety.

Your gut microbiome may play a role, too. Last year, Mary Butler at University College Cork, Ireland, and her colleagues compared the gut bacteria of 31 people with social anxiety disorder – which is a fear around social situations – and 18 people without it. They found several differences between the groups. For example, those with social anxiety disorder had more of the species *Anaeromassilibacillus sp An250*, while those without the condition had more *Parasutterella excrementihominis*.

Butler says that “attempts are under way” to work out how these interact with the body and brain, which could lead to treatments. There is reason to be hopeful. For instance, research has shown how manipulating gut



microbes can help with drug-resistant depression (see “Five scientific ways to ease anxiety”, page 38).

There is another way your diet could affect your anxiety levels. One meta-analysis found a correlation between caffeine intake and elevated risk of anxiety, especially when people had more than 400 milligrams of it, or around five regular cups of coffee, a day. The reason isn't clear, but it may be because high volumes of caffeine increase heart rate, which could trigger anxiety via “interoception”. It has been shown that people who are overly aware of internal sensations, like their heartbeat, may be at higher risk of experiencing anxiety (see “What is anxiety?”, page 31). The positive news is that interoception can be modified: when people are taught ways to better interpret physiological sensations, they are able to decrease their anxiety.

So, while you can't change your genes, if you have been dealt a genetic predisposition towards anxiety, and want to overcome it, switching to decaf and developing a more accurate perception of bodily sensations may not be a bad place to start. **Helen Thomson**

HERA FOOD/ALAMY; JEFF MITCHELL/GETTY IMAGES



## IS ANXIETY ON THE RISE?

OVER the past few years, I have noticed an increasing number of people sharing their experiences of feeling anxious, whether it is celebrities opening up in interviews or friends chatting over a drink. This got me thinking: are more people feeling anxious these days or are they just more willing to talk about it?

This apparent uptick seems to be seen in studies of anxiety prevalence – but dig into the details and the picture isn't so clear. As for what is behind this possible rise, the covid-19 pandemic is an obvious cause, yet it isn't the only one: economic and political factors may also play a role.

Let's look at the pandemic first. “It was a phenomenon that none of us had experienced, a global issue that understandably caused a huge amount of stress,” says David Smithson at the charity Anxiety UK. “Who wouldn't be worried?”

Levels of anxiety rose at the start of the pandemic, with the World Health Organization reporting a 25.6 per cent increase in anxiety disorders in 2020 as lockdowns and other restrictions were brought in and people grappled with an unknown virus and its ➤

### Why did anxiety evolve?

Given that feeling anxious is a universal part of being human, it must have evolved for a reason. The most established idea is that it was to help us look out for danger, in particular to avoid the predators that would have hunted our ancestors. By being anxious about the prospect of meeting a big cat, for example, our ancestors may have adapted their behaviour, such as travelling in groups, to increase their chance of survival and having offspring.

This suggests that anxiety may be felt by all prey animals. However, it is hard to tell whether an animal is feeling anxious. In humans, the only way to know for sure is to ask – and we can't

do this with animals. Instead, we can see if their behaviour resembles that of a human who feels anxious, says Sahib Khalsa at the Laureate Institute for Brain Research in Tulsa, Oklahoma. Mice, chimpanzees, dogs and horses, among others, are all thought to exhibit behaviours related to anxiety.

However, Jeffrey Mermelstein, a psychologist based in Albuquerque, New Mexico, thinks there is a second aspect to the evolution of anxiety in humans. He suggests that another form of anxiety evolved from our predator fear response – a social anxiety related to group cohesion and loyalty – leaving us with two broad types of anxiety. EP

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One study  
found a  
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and elevated  
risk of anxiety

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impact on their lives. But this rise didn't persist, according to a review of 177 studies looking at people in high-income countries, with levels falling as the pandemic continued.

This chimes with Smithson's experience. "We saw that rise through demand for our support services from the start of the pandemic for about two years," he says. "We have seen, in the last 12 months or so, that demand has dipped down and it's back now at pre-pandemic levels."

But anxiety levels had been rising before the pandemic started. In the UK, diagnoses of generalised anxiety disorder rose in people aged 18 to 44 between 2014 and 2018, for example, with the largest increases seen in women and young people (see "Are children becoming more anxious?", right). In the US, self-reported feelings of anxiety rose in adults aged 18 to 49 from 5.1 per cent in 2008 to 6.7 per cent in 2018, with greater increases again seen in the youngest.

One explanation for this is that people may be more willing to seek support following campaigns encouraging individuals to talk about their mental health. However, while stigma about mental health conditions in general decreased up until the early 21st century, there is some evidence that this trend has now stalled.

"Over the short term, the past 10 years or so, there is no evidence that willingness to admit to these issues has increased," says Ronald Kessler at Harvard University. "As a result, evidence for increased reports in trend surveys are likely due to genuine increase in prevalence."

Short-term and situational anxiety, which could be related to things like economic and political stressors, is the type that is rising, he says. "There is little evidence for increases in the early-onset chronic type of serious anxiety that is likely to be influenced heavily by biological factors."

Yet this increase isn't global. One study, based on data collated in 2022

by the Global Burden of Disease project, looked at the prevalence of anxiety disorders in 204 countries around the world. It found that Portugal had the highest rate, at 8671 cases per 100,000 people, followed by Brazil, Iran and New Zealand.

Europe and the Americas were the regions with the highest rates, while Africa and Asia had the lowest. The study suggests this increased incidence in higher-income countries could be due to a range of different factors, such as diet, lower levels of physical activity and a more individualistic culture.

Other possibilities for these

# 25.6

per cent rise  
in anxiety  
disorders  
was seen  
worldwide in  
2020, at the  
start of the  
pandemic

variations include methodological differences, for example studies based only on the records of those seeking treatment can't account for those who don't or can't access healthcare. Conversely, self-reported surveys can sometimes struggle to differentiate between everyday feelings of anxiety and clinically significant anxiety (see "Anxiety vs anxiety disorders", page 31), so may overestimate levels in a population.

Whatever the reasons behind the increase, it does seem to be present – at least in some countries. It looks like we may be having this conversation for a while yet. **BA**



# ARE CHILDREN BECOMING MORE ANXIOUS?

CHILDHOOD can be a time of great anxiety. It is when we learn how to make friends and cope when those friendships go sour, when we first feel the pressures of school work and exams, and when the difficulties of puberty kick in.

But recent research suggests that childhood anxiety is on the rise, with more children feeling anxious today than even just a few years ago. As researchers start to investigate why this might be, a complicated picture is emerging, encompassing everything from the covid-19 pandemic to social media. Thankfully, there are ways to help children to ensure the potential long-term effects are limited.

Evidence for high levels of anxiety in children comes from an analysis of 29 studies that were published between 2020 and 2021 that included 80,000 young people from around the world. It found that 20.5 per cent of children had clinically significant anxiety symptoms, with girls and older adolescents particularly affected.

Of course, 2020 and 2021 were defined by the covid-19 pandemic, when many people of all ages felt increased anxiety (see “Is anxiety on the rise?”, page 33). However, prior to the pandemic the generally accepted prevalence figure for young people was 11.6 per cent, from a study that surveyed 37 per cent of Finnish adolescents aged 14 to 18 in 2015. Signs that anxiety diagnoses were rising in younger people even earlier come from a survey of the parents of around 60,000 households as part of the National Survey of Children’s Health in the US, which found that the proportion of children who had ever been diagnosed with an anxiety disorder increased between 2007 and 2012, from 5.5 per cent to 6.4 per cent.

One cause of the rise in childhood anxiety seems to be climate change (see “What is eco-anxiety?”, page 36). Another possible driver is that today’s young people are the first generation to grow up with social media and

smartphones. The constant exposure to bad news made possible by such tools may play a role, says Jennifer Wild at the University of Oxford. “If you’re getting a lot of notifications, you are primed to threatening situations, and that can increase anxiety.”

Outcomes may depend on how these platforms are used. When Rebecca Anthony at Cardiff University, UK, and her colleagues examined 38,700 survey responses by 11 to 16-year-olds living in Wales, they found that, for most of them, time spent talking to their close friends online was linked to better well-being. “However, speaking with strangers was associated with poorer well-being,” says Anthony. “This was particularly true for girls.”

## School environment

More research is needed before we can draw solid conclusions about the impact of social media and smartphones on young people, says Wild. It may be that anxiety causes excessive use of social media, for example, not vice versa.

School and the interactions that take place there may also have an effect. “When you look at studies that ask children what they worry about, the most common things that they talk about relate to experiences and the environment at school,” says Cathy Creswell, also at the University of Oxford.

However, when Anthony and her colleagues investigated whether bullying could account for an observed increase in rates of emotional problems, such as feeling nervous, among 11 to 16-year-olds in Wales between 2013 and 2019, they found it couldn’t. Nor could the quality of friendships. Instead, the biggest risk factor was socioeconomic status. “When we looked at trends over time, the rise in symptoms was steeper for poorer families,” says Anthony.

“The average age of treatment for anxiety is around 35 to 40, but the average age of onset is around 13”

The good news is that there are effective treatments for anxiety in young people, such as cognitive behavioural therapy, or CBT (see “Five scientific ways to ease anxiety”, page 38). Creswell and her colleagues have been looking into the use of an online platform for CBT, led by parents but in conjunction with personalised phone support from a therapist once a week. In a study of 444 children with anxiety aged between 5 and 12, they found it was just as effective as regularly seeing a therapist for CBT in person. Given one of the main barriers to children receiving support is access to a therapist, this approach could help widen access, according to Creswell.

The key is early intervention. “The average age of treatment is around 35 to 40, but the average age of onset is around 13,” says Wild. “We want to be making interventions accessible for young people, because it’s much better to intervene before it becomes a way of life.” **BA**



## WHAT IS ECO-ANXIETY?

WILDFIRES, floods, droughts – over the past few years, more and more extreme weather events and natural disasters have been attributed to climate change. And things are only predicted to get worse.

Given this apocalyptic outlook, it is hardly surprising that some people feel overwhelmed by anxiety about our prospective future. But how widespread is this eco-anxiety, and what can we do to overcome it?

There is no formal definition of eco-anxiety, also sometimes called climate anxiety. The Climate Psychology Alliance – a collection of therapists and researchers interested in the psychological impact of the climate crisis – describes it as “heightened emotional, mental or somatic [bodily] distress in response to dangerous changes in the climate system”.

It is the anxiety that keeps on giving. “With ordinary anxiety, the expectation is that with some form of intervention, some form of support, you will recover,” says Caroline Hickman, an eco-anxiety specialist at the University of Bath, UK. “But the thing about eco-anxiety is that it is unresolvable, because the eco-crisis is not being resolved.”

The label “anxiety” is overly narrow, says Hickman. “We use it as an umbrella term to describe a range of emotional responses to environmental breakdown, which includes fear, grief, rage, despair, sadness and hopelessness.” For that reason, some have tried to rebrand it as “eco-distress”, but even that seems inadequate, says Hickman. “I think we should call it ‘climate terror’ or ‘climate oh-my-fucking-god’”

Recent research suggests that eco-anxiety is common, especially among young people. “It is endemic across the world,” says Hickman. In an international survey conducted in 2021 of 10,000 people aged 16 to 25, Hickman and her team found that more than half reported simultaneously feeling sadness, anxiety, anger, guilt,

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The thing  
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powerlessness and helplessness about climate change. More than 45 per cent said that these emotions negatively affected their daily life, including eating, sleeping and having fun.

This last number varies across the world, from 28 per cent of respondents in the UK to more than 70 per cent in India and the Philippines. That isn’t surprising, given that people in the Global South are on the front line of ecological breakdown and often have personal experience of the consequences, says Hickman.

There is no baseline to compare these numbers with, but Hickman says that her experience as a psychotherapist suggests a rising tide. Five years ago, four or five people a week came to her seeking help for eco-anxiety. Now, it is 25 to 30. “It’s increasing massively,” she says.

The symptoms may be the same as

anxiety, but the remedy is not. The American Psychological Association and similar bodies don’t recognise it as a medical condition. “Strong climate emotions and climate anxiety do not constitute mental illness,” says Lindsay Galway at Lakehead University in Thunder Bay, Canada.

It should stay that way, says Hickman. Pathologising eco-anxiety misses the point, she says: it isn’t a mental health condition in need of individual treatment, but a rational response to ecological breakdown. The people who don’t feel some level of eco-anxiety are the ones with a problem, she says. “If you’ve got eco-anxiety, you should be proud, because it’s an indication that you care about the planet.”

Indeed, eco-anxiety can be a strong motivator to demand change. Ironically, though, it may also be a root cause of climate denialism, according to the Climate Psychology Alliance, because dismissing the problem or electing people who do so can be a cosy security blanket.

Even if eco-anxiety cannot and should not be cured, there are measures people can take to cope, says Andrew Weaver at the University of Victoria in Canada. Research on other forms of anxiety shows that they are driven by the perception of uncontrollable personal risk. Ergo, eco-anxiety can be alleviated by identifying and controlling those risks. People who live in flood-prone areas, for example, can make a plan to safeguard their property and belongings, while those in areas at risk of drought may reduce their water usage and install more water storage.

Ultimately, the only solution is for people in power to do their jobs and sort out the mess, says Hickman. “Until we take forceful action on climate breakdown, eco-anxiety will keep going up. But if we stopped oil extraction and shifted to renewables, eco-anxiety would almost disappear overnight.” **Graham Lawton**





## ARE THERE ANY BENEFITS TO ANXIETY?

WHEN we are worrying about an upcoming deadline or feeling overcome before an exam, it can seem absurd, almost insulting, to imagine that this has any advantages.

There can be no doubt that extreme anxiety is highly debilitating. At moderate levels, however, our nervous feelings can make us smarter problem-solvers and fuel original thinking. Anxiety may even benefit our health.

To understand why, we can see anxiety as a kind of alarm bell. It draws our attention to a situation that requires action, and greater sensitivity to those signals helps us respond more rapidly. “The physiological arousal and worrying thoughts operate quicker than our conscious evaluation of how demanding a situation is and whether we have the resources to handle it,” says Todd Kashdan, director of the Well-Being Laboratory at George Mason

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decisions  
”

University in Virginia. “This heightened awareness helps us make more informed decisions.”

As evidence, Kashdan points to research that tested undergraduates’ anxiety levels before tricking them into believing that they had infected a computer with a virus. Those who were more anxious ignored distractions when on their way to tell the IT team about the problem.

Similar reasoning may explain why one aspect of the personality trait neuroticism – related to worry and vulnerability – was found in another study to be linked to lower mortality during the study period. If you are constantly worried about your health, you might be more likely to seek medical help at the first sign of symptoms, which allows you to receive more effective treatment.

How about performance anxiety – those nerves we feel before an

important event? “Anxiety can be the nudge we need to prepare for an upcoming presentation, or the push to have a difficult conversation we’ve been avoiding,” says Kashdan. “In this way, anxiety can be a catalyst for growth and improvement.”

Whether or not we experience those benefits may depend on the way that we “appraise” our own anxiety. Imagine, for example, that you are a designer and you have been asked to pitch a new product. The stakes are high. Your tension inevitably builds and your creativity drops as the deadline approaches.

There are two ways to interpret your feelings. You may assume that you can only function when calm and that feelings of nervous tension are a sign of imminent failure, fuelling further anxiety. You might begin procrastinating, feeling so helpless that you ignore the alarm.

Alternatively, you might accept that a certain level of anxiety is part of the creative process. You see your nervous feelings as a source of energy that keep you focused and looking for better solutions. Whenever doubts surface, you remind yourself of your previous successes and focus on the potential rewards.

There are good scientific reasons to take this positive mindset. Many of our anxious feelings are the result of “physiological arousal”, which can boost performance. A racing heart, for example, pumps more oxygenated blood to the brain, which could help fuel better thinking. People who recognise those benefits tend to do better under pressure.

Our appraisals are malleable. In one study, 113 people took part in a mock job interview involving a presentation followed by questions – an exercise that would make most people feel anxious. Afterwards, they took a standard test of original thinking that involved inventing unusual uses for a newspaper. Those who had been primed to see their ▶

## FIVE SCIENTIFIC WAYS TO EASE ANXIETY

nervous feelings as a potential resource before the interview tended to give more original answers.

Reappraisal can also benefit people who are anxious about exams. When students were taught that nervous feelings can energise the mind before taking a maths test, they had better results and lower levels of “maths evaluation anxiety” – which is when the mind goes blank during a maths test – than those who weren’t primed. First-year college students who had been taught to reappraise their feelings similarly got better results on their exams than those who hadn’t.

Learning to reappraise our anxious feelings may bring greater long-term resilience. A study of doctors and teachers found that those who viewed their anxiety as a source of information and energy were at a lower risk of exhaustion and burnout over the following 12 months. Once we have listened to the body’s alarm and acted on its message, we can take time to relax – and leave our worrying for another day. **David Robson**

“  
A racing heart pumps more oxygenated blood to the brain, which could help to fuel better thinking”

”

WHEN anxiety hits, how can you calm your whirring brain? For some people, worrying thoughts interfere with their daily lives, affecting their health and reducing their ability to maintain relationships. In these cases, the standard treatments are medications such as selective serotonin reuptake inhibitors (SSRIs) or a talking therapy like cognitive behavioural therapy (CBT). Alongside these, there are other techniques that may help. Here are five strategies that have the best evidence behind them.

### Confront your demons

Exposure therapy, a variation of CBT, encourages people to confront the sources of their anxiety. To cope with their worries, many people practise “avoidance”, which reduces short-term discomfort, but prevents them from learning how to deal with their fears. If a socially anxious person always backs out of engagements, for example, they will continue to believe that conversation with strangers is frightening, whereas if they attend, they might find that making small talk is easier than expected.

Virtual reality can help kick-start the process in a controlled environment. A meta-analysis of 22 studies involving 703 people showed that VR exposure therapy led to a significant reduction in anxiety for people with social anxiety disorder, and that this effect was still seen a year later. However, in-person exposure therapy had a stronger impact over the longer term. Multiple studies show that it is effective for many people with anxiety-related conditions, including post-traumatic stress disorder.

### Get moving

A wealth of research shows that aerobic exercise has numerous psychological benefits, including for anxiety. One meta-analysis of 13 studies, with a total of more than

75,000 participants, found that those who reported doing more physical activity had a significantly lower risk of developing anxiety. Another study found anxiety and fear responses to predictable and unpredictable electric shocks were reduced in women who had spent 30 minutes on a treadmill.

There are many potential mechanisms behind this effect. Aerobic exercise can help the body to release its own cannabinoids, compounds similar in structure to those found in cannabis, which can bind to the receptors of neurons involved in emotional processing and mute our responses to potential threats. On a purely psychological level, exercise may distract the mind and break ruminative thinking cycles, offering temporary relief from worries.

### Lift weights

In addition to aerobic activity, resistance training may also help. Exercises at moderate to low intensities – such as sit-ups, planks, squats and weightlifting – have been shown to reduce anxiety in the short and long term. One meta-analysis of 16 studies found this was the case for those with mental and physical illnesses, though the largest benefits were seen in those with no medical conditions. The sense of achievement associated with such training might increase someone’s self-esteem, which makes life’s challenges feel more manageable. It may also change the feedback that the brain receives from sensors within the body (see “What is anxiety?”, page 31); with stronger muscles, we may feel more physically resilient, which translates to improved mental well-being.

### Change your diet

The health of our gut can influence our thinking and emotions (see “Why are some people more prone to anxiety?”, page 32), so changing diet







## How to help a friend or relative

It is never easy to see a loved one overcome with anxiety. According to the mental health charity Mind, the best support we can provide is a listening ear – without judgement and without exerting pressure to change the person’s feelings or behaviour.

One approach is to help your loved one reappraise their situation. In her book *The Anxiety Toolkit*, clinical psychologist Alice Boyes recommends that you ask three questions:

- What’s the worst that could happen?
- What’s the best that could happen?
- What’s most realistic or likely?

This is a common exercise in cognitive behavioural therapy and helps to interrupt ruminative thought spirals.

If the other person is in the middle of a panic attack, you might encourage them to breathe slowly and deeply. You can also help them focus their attention on a structured, repetitive activity, such as counting aloud or stamping their feet on the spot. DR

may help with anxiety. In her book *Calm Your Mind With Food*, Uma Naidoo, a nutritional psychiatrist at Harvard Medical School, recommends eating complex carbs from vegetables or lentils, which favour a healthier gut microbiome, and increasing consumption of omega-3 fatty acids from fish, nuts or seaweed. “In many studies, dietary sources of omega-3s yielded better results than supplements,” she writes. Fatty acids form our neurons’ cell membrane and may influence cell signalling and neuroplasticity. They also reduce inflammation, which is linked to poorer mental health.

Sources of protein that are high in the amino acid tryptophan may also help, such as poultry, salmon, tuna, soya beans and chickpeas.

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The body can transform tryptophan into serotonin, which is an important neurotransmitter involved in emotional processing. One study of 25 people without an anxiety disorder found decreased levels of anxiety after they ate a diet high in tryptophan for four days compared with when they had a low-tryptophan diet for the same length of time.

### Be mindful

Mindfulness-based stress reduction (MBSR) encourages people to develop a non-judgemental awareness of their thoughts, feelings and bodily sensations. Whenever a worry crops up, they may simply observe it before drawing their attention back to the steady rhythm of their breathing, for

instance, or directing their attention to each part of the body in turn to notice their sensations.

A randomised controlled trial found that an eight-week course in MBSR was as effective as the SSRI drug escitalopram at treating people with various anxiety disorders. Not all studies find such consistent benefits, however, with one meta-analysis suggesting that mindfulness may be more effective when combined with elements of CBT.

Like all interventions, mindfulness won’t work for everyone. One alternative is to cultivate feelings of self-compassion, which has also been shown to ease anxiety. DR ■

Consult your doctor before making any changes to your treatment



MICHAEL RUNKEL/ROBERT HARDING/ALAMY

# Island bounty

It is one of the most isolated places in the world, but Pitcairn Island (population 47) has much to teach us about how to protect ocean biodiversity, discovers **Graham Lawton**

**A**FTER four nights at sea on a pitching and rolling ship, the announcement over the Tannoy is the sound of sweet relief. “Land ahoy!”

I get dressed and lurch out onto the foredeck. If it really is ahoy, I can’t see it. The sun is coming up and dazzling the point on the horizon where terra firma should be, due east of our position in the middle of the South Pacific. The ship rolls sickeningly and I retreat to my berth.

A couple of hours later, I re-emerge and am greeted by an awesome sight – a rugged green rock rising out of the ocean like something from the film *Jurassic Park*.

This is Pitcairn, one of the remotest inhabited islands in the world and part of a British overseas territory. I am here to find out how this isolated community is aiming to put its dark past behind it and reinvent itself as a paradigm of ocean conservation – and also if there are lessons to be learned more generally



**Pitcairn is one of the remotest inhabited islands in the world**

about how to protect marine biodiversity. But as always on this precarious outpost, there are squalls gathering on the horizon. How can Pitcairn's stellar conservation efforts continue when its already tiny population is dwindling?

Pitcairn is best known as the final destination of nine mutineers from the ship HMAV *Bounty*, who made landfall in January 1790 along with 11 Tahitian women and six Tahitian men they had persuaded to join them. After going ashore and deciding the island was a suitable hideout, they scuttled and burned the ship to avoid detection – mutiny was a capital offence. For the next few years, they scraped out an existence on the tiny but fertile island before turning on one another in an orgy of murder and suicide. Ultimately, just one mutineer, John Adams, was left standing. More recently, the island was engulfed in a sexual abuse scandal that necessitated the construction of a prison.

I hitched a ride to Pitcairn on the HMS *Tamar*,

one of a couple of Royal Navy patrol boats that occasionally drop by to assist the locals. It was the longest journey of my life: 19,000 kilometres by air from London to Tahiti (I offset it) and a 2180 km boat ride. The crossing took four days and traversed three time zones with nothing to see except blue sea, azure sky and the odd atoll on the horizon. I had hoped to spy an albatross or whale or two. No such luck.

Pitcairn is the only inhabited island in a group of four separated by hundreds of kilometres of open ocean, and with even vaster stretches of water between it and the

"The islands are home to a bountiful marine ecosystem above and below the waves"

next nearest settlement (see map, page 43). It is the southern half of a volcano that rose from the waves around a million years ago, built from lava gushing from a hotspot where the Nazca and Pacific tectonic plates are pulling apart. The northern half of the resulting island was blown to smithereens by an eruption; the capital, Adamstown, now nestles in the remains of the extinct caldera. Its nearest inhabited neighbour is the French Polynesian island of Mangareva, 540 km away. With a population of approximately 1200, Mangareva is a relative metropolis. Pitcairn's population is 47, the smallest of any sovereign state or dependency in the world, an order of magnitude less than the next smallest.

The other islands – Henderson, Ducie and Oeno – are uninhabited coral atolls. The first is a UNESCO World Heritage Site on account of its geological oddness: tectonic upheavals have elevated it several metres above the waves and it is now one of only two such raised coral atolls in pristine ecological condition, along with Aldabra in the Seychelles.

Of the outer islands, only Henderson has ever been inhabited. Archaeological evidence suggests that it and Pitcairn were colonised and then abandoned by Polynesian settlers long before the arrival of the *Bounty*. Ducie and Oeno are totally inhospitable.

The islands are, however, home to a bountiful marine ecosystem above and below the waves. There are 20 breeding species of bird – six of them found only on the islands, such as the Pitcairn reed warbler – and over 300 species of plant, including 10 endemic ones. The reefs are home to 70 species of coral, hundreds of species of fish, five shark species and two of the seven types of sea turtle – green and hawksbill. Three species of whale, including the critically endangered southern right whale, pass through these waters. All told, more than 1250 species have been recorded on and around the islands, many of them found nowhere else, according to Michele Christian, manager of the territory's Environmental, Conservation and Natural Resources Division.

On land and in the air, it is easy to see the biodiversity. But there are few obvious indicators that this is one of Earth's great marine biodiversity hotspots. However, the wildlife gradually reveals itself. There are flying fish, hoards of crabs and near-shore corals. On the second day of my visit, a group of islanders go fishing in their open longboats. Later, they return with a heaving catch, mostly grouper, but also an amberjack and a spectacularly large and impressively ugly triggerfish. When I go ➤

snorkelling in a lagoon called St Paul's Pool, I get a glimpse of what is out there: abundant corals teeming with fish.

The water is incredibly clear and blue, a patchwork of aquamarine and lapis lazuli. Even on the Tamar, which is anchored in 17 fathoms (31 metres) of water about half a kilometre offshore, it is possible to see the seabed. This incredible clarity is what allows coral to thrive as deep as 75 metres down, the world's deepest-known tropical reefs.

## Bumper biodiversity

Christian and her fellow islanders have big dreams for their biodiversity bounty. In 2016, after four years of surveys by the National Geographical Society and others, the UK government (which administers Pitcairn) designated the islands' exclusive economic zone (EEZ) – which extends 200 nautical miles from shore in all directions apart from where it butts up against French Polynesia's waters – as a marine protected area (MPA). At the time, it was the largest in the world, covering almost 842,000 square kilometres, about three-and-a-half times the area of Britain. The surveys revealed not just an abundance of wildlife, but also a completely intact marine ecosystem – something extremely rare in today's world, which Pitcairn's deputy governor, Alasdair Hamilton, says is the true value of the MPA.

MPAs are the ocean's nature reserves. Technically, they are free from the human exploitation that has blighted much of the rest of the seas, from industrial fishing to container shipping, mass tourism, hydrocarbon exploration and extraction, pipelines, undersea cables, wind farms, aquaculture, pollution and the looming threat of deep-sea mining. The Marine Conservation Institute in Seattle, Washington, lists 16,854 such areas globally, but their implementation and enforcement has been patchy at best. Only 1042 of the MPAs are ranked as "fully" or "highly" protected, collectively covering just 2.9 per cent of the ocean surface. That is a long way short of the 30 per cent by 2030 target agreed at the latest round of biodiversity negotiations in Canada in 2022.

These "paper parks" are one of the biggest obstacles to ocean conservation. "We create MPAs, but we don't enforce them," the US special envoy on climate change, John Kerry, told the One Ocean Summit in Brest, France, in February 2022. The UK is a serial offender: it has implemented 1286 MPAs within the 731,309 km<sup>2</sup> EEZ around Britain and Northern Ireland, but only a piddly 6.75 km<sup>2</sup> is classed as fully or

"It is one thing to designate a marine protected area, quite another to enforce it"

highly protected – those areas at Lundy, Lamlash Bay and Flamborough Head. Some "protected" areas allow bottom trawling, which is one of the most destructive forms of commercial fishing.

But the UK does have overseas territories, including Pitcairn, to make up for its domestic failings. Three of these are already surrounded by huge MPAs: South Georgia and the South Sandwich Islands; the British Overseas Territory of Saint Helena, Ascension and Tristan da Cunha; and, of course, Pitcairn. There are also pockets of strict protection around the overseas territories of the Falkland Islands, the British Virgin Islands, the Cayman Islands and the Turks and Caicos Islands. Together, these strongly protected areas total 2,282,456 km<sup>2</sup>, 39 per cent of the UK's EEZs. That makes the UK one of only two countries

**Pitcairn's seas (right) are a rare intact marine ecosystem, but plastic waste is a big problem, particularly on nearby Henderson Island (below)**



IMA/JENNIFER LAVERS HANDOUT/EPA/SHUTTERSTOCK

to have hit the target of protecting 30 per cent of its waters by 2030.

However, it is one thing to draw a boundary around a dot on a map and call it an MPA and quite another to enforce it. "There are some countries that are trying to check the boxes and have paper parks, areas that are just lines on a map, without conservation benefits, without proper management," says marine biologist Enric Sala, a National Geographic explorer in residence. "These areas are truly incompatible with conservation, so they should not count as marine protected areas."

And so I made my way to Pitcairn's new Marine Science Base to find out how to do it properly. The facility was opened in September 2023 and isn't fully operational yet, but has become the de facto HQ of the Pitcairn MPA and its planned research programme. "This will be a haven for researchers and conservationists and I think could be a hub for marine and climate science," says base manager Sid Gould.

Anecdotally, biodiversity has increased since the MPA was designated. "It was funny, but it seemed like as soon as we got that designation, things started happening," says Melva Evans, MPA officer at Pitcairn's Environmental, Conservation and Natural Resources Division. "We got more sharks. We got more whales. It's like they knew that this is safe territory."

Safer, anyway. The biggest threat to the MPA is illegal, unreported and unregulated (IUU) fishing. Islanders are encouraged to report anything that looks fishy, such as a vessel



ENRIC SALA



**At 540 kilometres away, Mangareva is Pitcairn's nearest inhabited neighbour**

moving slowly through the waters, or fishing gear floating in the sea or washed up on shore. The Royal Navy helps to patrol the waters when one of its boats is in the vicinity. But the bulk of the policing is done by satellites, which track the movement of ships in and around the MPA via their automated identification systems and flag up any suspicious activity.

## Patrols from afar

Judging from this data, there is little evidence of IUU, says Christian. "Everything is carefully monitored and tracked and if something looks suspicious, we're notified. The good thing is, since we've had the designation, they kind of keep their distance."

Data for 2022 from the UK's Marine Management Organisation shows industrial

tuna fishing vessels, mostly bearing Chinese and Taiwanese flags, massed around the outskirts of Pitcairn's MPA, but only a tiny number within it. "Pitcairn's MPA is doing its job," says Hamilton.

Thanks to satellite tracking, IUU fishing really is no longer worth the effort, says Evans, as the penalties are draconian. "They'd be stupid to risk that." Doubly so: it is well-known that MPAs are fecund nurseries for fish, which then disperse out of the area and fill the boots of waiting vessels in international waters. The islanders are allowed to take fish around the four islands and also from the vicinity of Adams Seamount, known locally as Forty Mile Reef, an active underwater volcano to the east of Pitcairn. Without this concession, the MPA would have been dead in the water.

There is still much to learn about the MPA's ecosystems. "We're still quite uncharted," says Christian. "The more research that happens, the more we're finding out. At the moment, we're concentrating on the outer islands to see what they've got and the condition of the corals. Later on down the track, it might be the deeper waters."

This knowledge gap of the deep isn't confined to Pitcairn. A recent research paper concluded that while coastal MPAs are very effective, not much is known about the benefits of oceanic MPAs, which are defined as covering water deeper than 200 metres.

Nonetheless, from what is known, Pitcairn appears to be getting the MPA process right. Last year, it was given a Blue Parks Platinum Award by the Marine Conservation Institute, recognising that it meets the highest science-based conservation standards. "I think this is the jewel in the Pacific," says Gould.

But, as with everything here, the situation is precarious. The islands may be remote, but they aren't immune from global change. "Plastic pollution is a major, major problem,

especially on Henderson, which is in the southern part of the Pacific gyre, so it gets massive amounts washed up on the beaches," says Pitcairn administrator Steve Townsend, referring to a vast system of currents that steers waste around the ocean.

An expedition to Henderson in 2019 collected 6 tonnes of plastic rubbish, most of it from the fishing industry, says Hamilton. The same effort estimated that there are 4 billion particles of marine microplastic on Henderson's eastern shore. Evans describes the island's litter problem as "heartbreaking". It is also unnecessary: most of the plastic bottles on Henderson were recently found to have been illegally dumped at sea by fishing vessels. Exactly how to solve this problem is a major conservation question.

Henderson also has issues with invasive rats, which eat ground-nesting seabirds and their eggs. A previous attempt to eradicate them failed. Another is planned in 2026. Climate change, ocean acidification and sea-level rise are further threats. Rainfall patterns are changing, too, with more frequent heavy downpours, which wash sediment into the sea and muddy the pristine waters. Sharks and many fish prefer clear water and will vote with their fins.

Perhaps most pressing of all, Pitcairn's population is ageing and dwindling – more than 70 per cent are over 65 and nobody has been born here since 2006. The school is empty. Mayor Simon Young, the first non-native to be elected to the post, wants to encourage immigration, but some islanders are hostile to that idea. If that means a slow extinction, then so be it, they say. There is a diaspora beyond the island, but moving to Pitcairn and integrating into its insular community is challenging.

In 2040, Pitcairn will celebrate the 250th anniversary of the mutineers' settlement. Whether anyone will still be living here to mark it is far from certain. If that comes to pass, who knows what will happen to the science base. But as long as the satellites remain aloft, the MPA itself should be fine. "It's an enormous area," says Evans. "It isn't possible to have patrol ships out there. It's the eye in the sky."

Long may it endure, even if Pitcairn's fate is to revert to an uninhabited rock in the vast southern Pacific. ■



Graham Lawton is a staff writer at *New Scientist*



## Puzzles

Try our crossword, quick quiz and logic puzzle **p45**

## Almost the last word

How do crows develop such distinct voices? **p46**

## Tom Gauld for *New Scientist*

A cartoonist's take on the world **p47**

## Feedback

Spilling the tea, plus chatty alligators and dietary ants **p48**

## Twisteddoodles for *New Scientist*

Picturing the lighter side of life **p48**

## The science of baking

# Turning orange

A dash of science makes it easy to bake a delicious vegan version of carrot cake, says **Karmela Padavic-Callaghan**



Karmela Padavic-Callaghan is a reporter for *New Scientist* in the US. The science of baking appears monthly.

## What you need

For one 9-inch/23-centimetre round cake:

**1 cup (110 g) grated carrots**

**1 cup and 2 tbsp (140 g)**

**all-purpose flour**

**1½ tsp baking powder**

**½ tsp baking soda**

**1½ tsp cinnamon**

**¼ tsp nutmeg**

**½ tsp ground ginger**

**½ tsp sea salt**

**¼ cup (62.5 g) apple sauce**

**½ cup (118 ml) almond milk**

**1 tsp vanilla extract**

**½ cup (100 g) white sugar**

**¼ cup (60 ml) vegetable oil**

## For the frosting:

**1 ½ sticks (170 g) vegan butter**

**2 cups (240 g) confectioners' sugar (icing sugar)**

**Zest of half a lemon**

**1 tbsp lemon juice**

**1 tbsp vegan yogurt**

**¼ tsp salt**

**1 tsp apple cider vinegar**

## Next week

60-second psychology

THIS winter, my local farm has been supplying me with carrots in all the colours of the rainbow. After a few chilly months of chopping them up for savoury dishes, I was delighted when the sun returned to New York and basically beckoned me to make a carrot cake (pictured) instead.

I didn't grow up eating carrot cake, but thick slices with cream cheese frosting are among the standouts in my early memories of American baking. As a vegan baker, I now make a carrot cake that is a different proposition: it brings out the natural sweetness and earthiness of carrots while foregoing eggs and dairy. And, unlike some sponges that require lots of fussing over, this cake is made vegan pretty easily, with no price paid in flavour.

First, I peel the carrots, then grate them on the finest part of my grater to ensure they meld with the batter during baking, making it a little denser but not less soft. I pack the shreds into a measuring cup or a bowl, squashing them down to squeeze out all the juice I can, to make sure I am not adding extra liquids to the cake and making it mushy. Next, I mix the dry ingredients in one bowl and the wet in another. This cake relies on both baking powder and baking soda for rise as it lacks eggs.

To account for the eggs' function as a binder, I use apple sauce – while I find it to be a poor universal substitute for eggs in baking, here its tangy flavour is a great addition. Its slight acidity also helps activate the baking soda



KARMELA PADAVIC-CALLAGHAN

and make the cake rise. I round out the flavour with some cinnamon, nutmeg and ginger.

While vegan butter is now widely available, I prefer to make this cake with vegetable oil. Because oil is liquid at room temperature, the cake stays moist and tender for longer. Oil also produces a finer crumb – most butters contain just enough water to strengthen the strands of the gluten proteins that form in the flour, and this leads to a more coarse and chewy texture.

I mix wet ingredients into dry until no streaks remain. I don't overwork the batter, again trying to prevent those pesky gluten strands becoming too strong, and fold in the carrots. Then, I pour the batter into a greased dish lined with parchment paper and bake

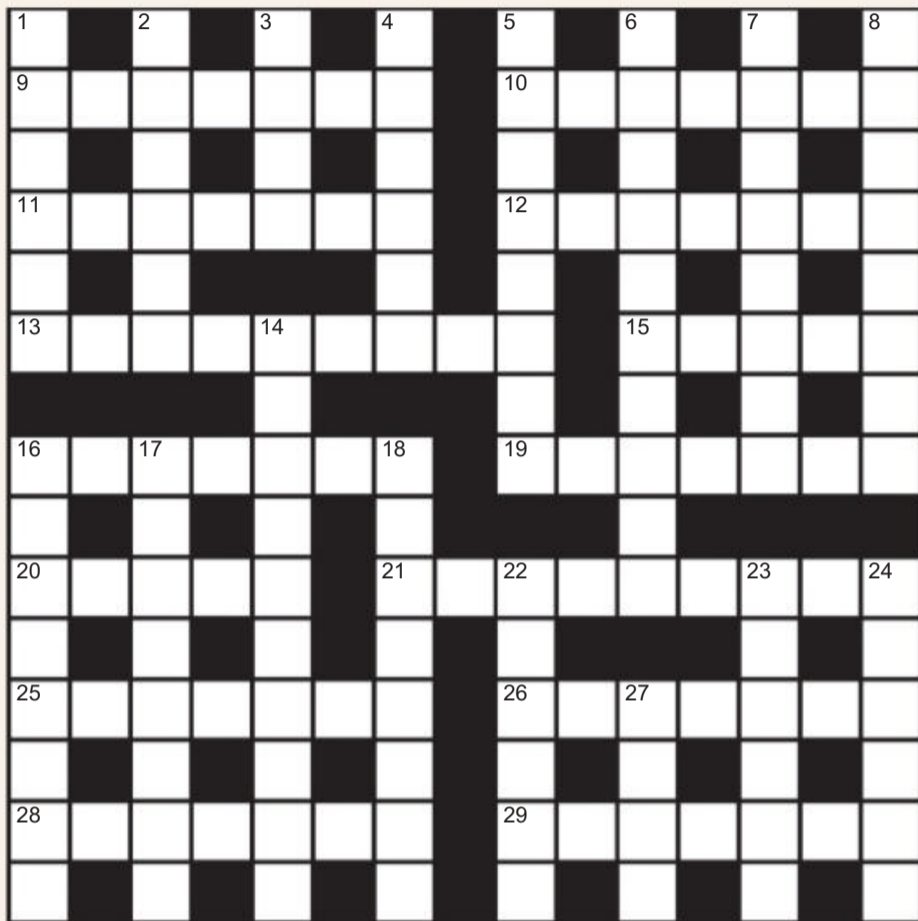
for 40 minutes at 180°C (350°F).

Once it is completely cool, I add toppings. A cream cheese frosting is traditional, but I often go for a tangy, lemony frosting made from vegan butter, confectioners' sugar, coconut yogurt and lemon, with dollops of raspberry jam. When it comes to vegan butter, it helps to pick a product with a low water content. Because water molecules are polar – they have electrically positive and negative ends – while oil molecules aren't, water and oil don't mix, so too much water could make the frosting separate as you beat it.

This cake is best consumed by a window, basking in the sun. ■

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

## Quick crossword #155 *Set by Richard Smyth*



**Scribble zone**

Answers and the next cryptic crossword next week

### ACROSS

- 9** F, Cl or Br, perhaps (7)
- 10** Former name of the element dubnium (7)
- 11** Of a time period, less busy or less expensive (3-4)
- 12** Berg (3,4)
- 13** Productive combination (9)
- 15** Molten rock (5)
- 16** Endpoints (7)
- 19** Quantity of electrical power (7)
- 20** Figure formed by two connecting lines (5)
- 21** Protein found in muscle tissue (9)
- 25** John James \_\_\_\_, US artist and naturalist (7)
- 26** Milk sugar (7)
- 28** To begin with (2,5)
- 29** Neither acid nor base (7)

### DOWN

- 1** Pulsates (6)
- 2** Alkene (6)
- 3** S-like curve (4)
- 4** Cobras and mambas, say (6)
- 5** Heavy-duty cutting tool (8)
- 6** Flattened steel or copper, perhaps (5,5)
- 7** Symmetrical paralysis of the body (8)
- 8** Measure of electric current (8)
- 14** University city after which an extinct hominin was named (10)
- 16** Reptiles endemic to New Zealand (8)
- 17** Stiffen (8)
- 18** Resistance to infection (8)
- 22** Connected to the internet (6)
- 23** Paintings, sculptures etc. that incorporate living processes (3,3)
- 24** Syringe (6)
- 27** Membrane that may cover a newborn's head (4)

## Quick quiz #246

*set by Bethan Ackerley*

- 1** How many types of adipose tissue are found in placental mammals?
- 2** Geometric objects with flat sides are known as what?
- 3** In which direction does Jupiter's Great Red Spot rotate, clockwise or anticlockwise?
- 4** Frogs and toads belong to which taxonomic order?
- 5** The two palaeontologists embroiled in the Bone Wars, a period of competitive fossil hunting in the late 19th century, were Othniel Charles Marsh and who else?

Answers on page 47

## BrainTwister

*set by Katie Steckles*

### #14 Factor graphs

To construct a factor graph, we dot numbers around a page and draw lines between pairs where one is divisible by the other. Start by writing the numbers 1 and 2, and join them with a line – since 2 is divisible by 1. Then write 3 and join it only to 1 (since 3 is divisible by 1 but not 2). The number 4 would connect to 1 and 2 but not 3, and so on. The connecting lines need not be straight.

Can you continue adding numbers and connecting them to their factors until you have all the numbers from 1 to 10, but without any of the lines crossing anywhere? (You may need to redraw if you get stuck.)

How many more numbers can you add before this becomes impossible?

If you don't include the number 1 in your graph and instead start from 2, how many numbers can you add without creating lines that cross?

Solution next week



Our crosswords are now solvable online

[newscientist.com/crosswords](http://newscientist.com/crosswords)

## Crowing about it

**How do crows develop such distinct and individual “voices”? I don’t hear this with other bird species in my garden.**

*Nicola Clayton and Francesca Cornero, University of Cambridge, and Valerie Dufour and Killian Martin, French National Centre for Scientific Research*

When you hear crows and other members of the corvid family, such as rooks, ravens, jays and magpies, you may notice that each bird has its own individually distinct voice. This is the case for many songbirds, but we find it easier to hear in crows because of how human hearing works.

We are better at detecting differences between low-pitched sounds than high-pitched ones, and crows produce loud vocalisations of much lower pitch than most birds. This means we can more easily recognise individual crows than individual robins, blue tits or blackbirds.

Scientific studies show that adult corvids have huge variation in their voices. Using artificial intelligence, we found that rooks not only have individually distinct voices, but that each male has its

**“Corvids may be able to develop individual voices because they have a rare ability for animals: they can imitate sounds”**

own repertoire of calls that are distinct from those of other males.

By analogy, imagine everyone you knew spoke your language, but used a completely different vocabulary. Unlike most species, rook song isn’t tied to territoriality or courtship: rook songs seem to allow them to play, to improvise with their own voices, sometimes for minutes at a time. And they use any sound they can produce, with no discernible pattern other than to portray their acoustic distinctiveness.



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## This week’s new questions

**Far off** Large planets have more distant horizons than small ones, but lower mountains due to higher gravity. On which would you see further? *Hillary Shaw, Newport, Shropshire, UK*

**Healthy appetite** Other than humans, animals just eat what they find, as they find it – no cooking, no washing, Why aren’t they vomiting all the time? *Robert Watson, Jesmond, Australia*

Individually distinctive voices are especially important for social species where multiple individuals can live together for extended periods and may need to tell each other apart. In corvids, rooks and jackdaws form huge colonies during the breeding season and for nightly roosts, while crows, ravens and Eurasian jays are more territorial, often living alone or in breeding pairs. Distinctive voices might be more essential for the more social species than the less social ones, but work is in progress to investigate the impact of sociality on vocal individuality.

Most birds learn one or more songs early in life from their parents and other members of their species, then produce them throughout their adulthood with little modification. We have no

data on how corvids acquire their vocalisations, but they may have an easier time developing individual voices because they have a rare ability for animals: they can imitate environmental sounds, including human speech.

Even in adulthood, corvids can still incorporate new sounds into their vocalisations, which could help them form their own individual signature. Ultimately, however, we know very little about corvids’ vocal agility.

**David Kroop**

*West Friendship, Maryland, US*

About a year ago, I decided to make friends with the local crows. After some coaxing, I got them to come to a feeder I built on my deck. Whenever I put out food and used a distinctive

call I devised, they would come. Their typical caw-caw sounds are more for alerting others about an event, such as when one sees me putting out food. But they also have a rather distinctive “speech”, as I discovered one time. A single crow landed on a nearby branch, looking at me on the deck, and proceeded to “talk” to me for 5 minutes. The sounds were more subtle and varied in intonation and length. The “sentences” were a series of these sounds, but each was slightly different. It looked at me the whole time it talked. That particular crow was slightly smaller (I believe her to be female), and I see her all the time. She has a mate and they tend to feed together, taking turns eating.

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## Going grey

**Why is it that our hair – and for men, our beard – goes white while the other hair on our head (eyebrows and eyelashes) stays its original colour?**

**Ron Dippold**

*San Diego, California, US*

Eyebrows and eyelashes can go white if you live long enough. About 15 per cent of people over the age of 70 have white lashes, and lots have white eyebrow hairs. My dad had both. But they generally stay darker longer than head hair – why? Greying isn’t fully understood, but the vague consensus seems to be that follicles – complex machines that grow hair – in the scalp and beard work much harder.

You are born with all your hair follicles for life. Cells called melanocytes in your follicles colour the growing hairs. Crucially, hair isn’t growing all the time. In the “on” (anagen) stage, a follicle grows and colours a new hair at about 0.15 to 0.5 millimetres a day. In the “off” (telogen) stage, a follicle rests and rebuilds itself while the dead hair sits there until



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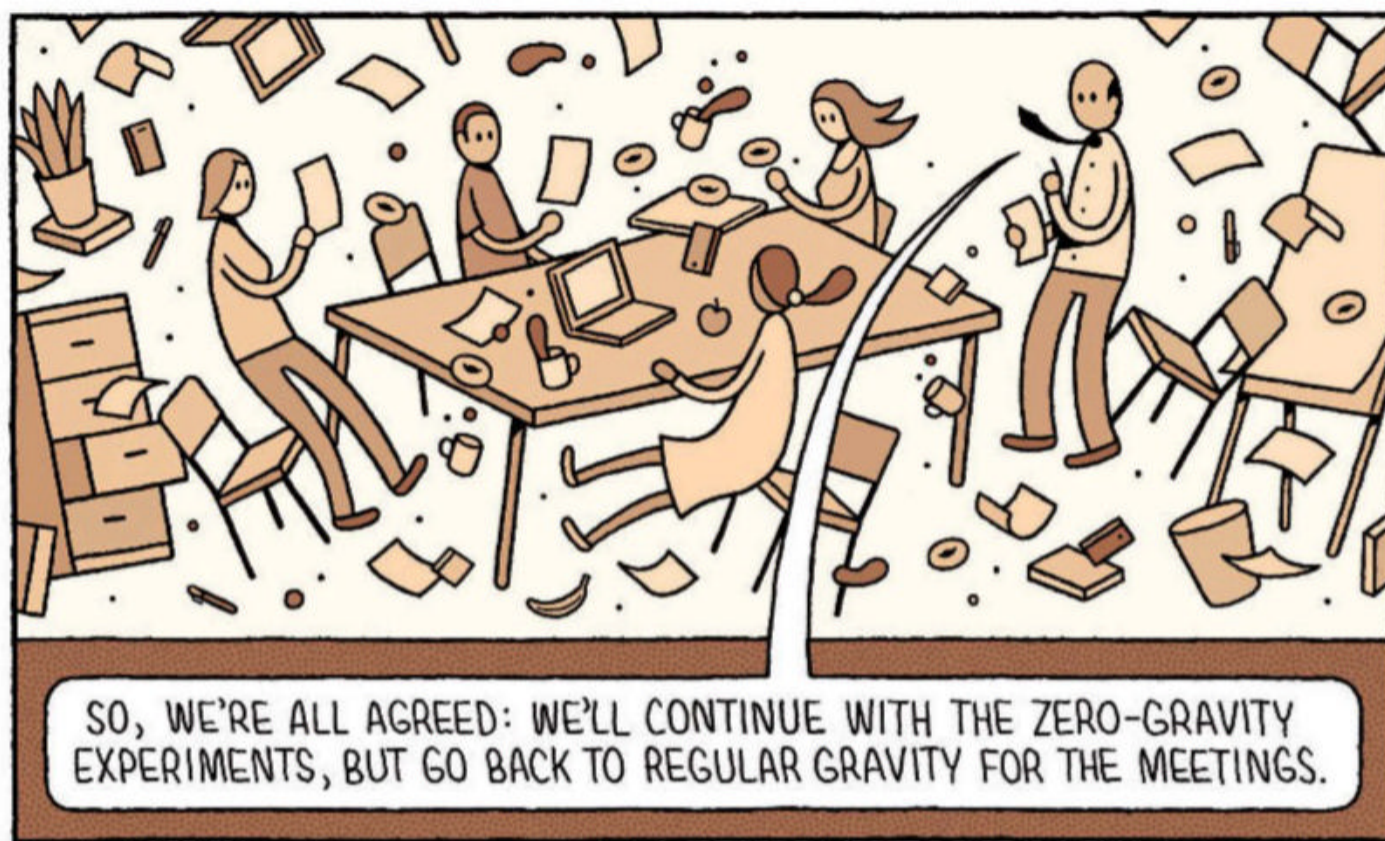
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**Tom Gauld**  
for *New Scientist*



it falls out. Thankfully, every follicle is on a separate schedule or we would occasionally lose all our hair at once.

Genetics introduces variability, but for scalp hair, the cycle is about two to eight years on, three to four months off. They are busy! For eyebrows, it is around four to seven months on, nine to 10 months off; for eyelashes, one to two months on, three to four months off. The growth stage sets the maximum length of hair – you don't want your eyebrows or lashes to be too long or you would have trouble seeing. From these schedules, scalp hair follicles are working 10 times harder to crank out luxurious hair.

Eventually, the melanocytes just give up and your hair goes grey, then completely white. And the hardest working seem to wear out first. For most men, the growth stage for their facial hair is a bit shorter than that for their scalp hair, so the beard stays coloured a little longer.

Eyebrows and lashes are also some of the darkest pigmented

**“If you are a Tibetan, you could travel back to around 600 million years ago, otherwise wait until about 400 million years ago”**

hairs of the body, so they may start with more melanocytes, which may help them last longer.

### Safe time travel

**When I invent a time machine, what is the earliest period in Earth's history in which I could comfortably survive? (continued)**

*Richard Swifte*

*Darmstadt, Germany*

The most important survival factor is whether the atmosphere is breathable by humans.

Today, air is 21 per cent oxygen. We don't know the exact historical composition of the atmosphere, but we have a rough idea. Significant oxygen was only produced with the advent of photosynthesising plant life,

but, since oxygen is reactive, for a long period, this was taken up by minerals instead of accumulating in the atmosphere. From around 600 million years ago, oxygen reached about half today's level, then fluctuated, possibly peaking at 35 per cent about 280 million years ago. Subsequently, during the dinosaur era, levels were also higher than now.

Humans have evolved to cope with current conditions. Most of us would suffer no ill effects with levels a few percentage points above or below 21 per cent. But only those such as Tibetans, who live at altitude, have adapted to the thinner air that delivers oxygen levels effectively around 55 per cent those of sea level amounts.

Too much oxygen is harmful in the long term and eventually fatal due to tissue damage by free radicals. So, if you are a Tibetan, you could travel back to around 600 million years ago, otherwise wait until about 400 million years ago. But avoid around 200 million years ago – if the dinosaurs don't get you, too much oxygen might. ■

## Answers

### Quick quiz #246 Answers

- 1 Two: white and brown
- 2 Polytopes
- 3 Anticlockwise
- 4 Anura
- 5 Edward Drinker Cope

### Cryptic crossword #132 Answers

**ACROSS** 1 Gas laws, 5 Human, 8 Opine, 9 Erratum, 10 Ice storm, 11 Psis, 13 Glossy, 15 Doused, 18 Time, 19 Crystals, 22 Basenji, 23 Franc, 24 Endow, 25 Gallium

**DOWN** 1 Glowing, 2 Spike, 3 Ames test, 4 Sheers, 5 Harm, 6 Mitosis, 7 Numbs, 12 Boastful, 14 Osmosed, 16 Dash cam, 17 Irking, 18 Table, 20 Atari, 21 Snow

### #13 Number Venns Solution

Here is one set of rules for each diagram – you may find others!

1. A contains multiples of 3 and B contains multiples of 4. The number 24 could also be added to the centre section.
2. A contains prime numbers and B contains even numbers. Nothing else can be added to the intersection, as 2 is the only even prime.
3. A contains triangular numbers (those that can be represented by that many dots arranged in an equilateral triangle, like 3, 6 or 10) and B contains square numbers. The next number that is both square and triangular is 36, which is out of our range of 1–30, so nothing else can be added here.

## Paved with good tea

What to do with all the waste from preparing zillions of cups of tea? Researchers in Malaysia propose converting some of it into infrastructure.

Mohammad Al Biajawi at University Malaysia Pahang Al-Sultan Abdullah and his team outline both the problem and their plan to attack it: "The annual consumption of a country's population of hundreds of tons of black tea results in considerable numbers of discarded teabags. These huge quantities are disposed in landfills... The aim of this study is to experimentally investigate the effect of [carbon nanotubes] from tea waste on the mechanical and fresh properties of cement mortars."

They suggest how to best go about this, in a paper called "Investigation the effect of nanocarbon tube prepared from tea waste on microstructure and properties of cement mortar", which was published in the journal *Environmental Science and Pollution Research*.

They ran tests that appear to predict good results: "incorporation of nanocarbon tube from tea waste into mortar resulted in a reduction in cement use, thus indirectly reducing CO<sub>2</sub> emissions and the greenhouse impact".

They propose, as one of the main uses, incorporating the converted tea waste into "sub-bases for highway pavements and highway medians". Doing that would, Feedback fears, tempt millions of tea drinkers to jolly themselves by declaring: "The road to [specify any location] is paved with used teabags."

## Solar blades

Electricity-producing solar cells could go the way – well, a way – of razor blades.

Layers of razor blades, rather than solitary blades, gave hairy-legged and hairy-faced people a more efficient way to get sunlight to interact with those legs and faces (benefitting those people

## Twisteddoodles for New Scientist



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Consideration of items sent in the post will be delayed

by making their skin more clearly visible to admiring spectators). A great transformation happened several decades ago when double-blade, then triple-blade razors went on sale and quickly captured market share as well as hairs. Single-blade razors came to seem a bit passé.

Now, plans are a-print to create solar cells that have multiple layers. Under some schemes, each layer would be made of a different semiconducting material that would absorb its own, distinctive range of sunlight frequencies. Most solar cells, these days, are essentially just one layer, made of silicon.

Already, some solar cell designers use one or another variety of perovskite (a family of minerals), rather than silicon.

Perovskite-layering research has led to one of the most mildly-

fun-to-try-to-say-out-loud titles ever to appear in a recent chemical journal.

The *Journal of the American Chemical Society* brings us the not-quite-mellifluous "La<sub>2</sub>SrSc<sub>2</sub>O<sub>7</sub>: A-site cation disorder induces ferroelectricity in Ruddlesden–Popper layered perovskite oxide", written by the slightly-more-mellifluously named, Japan-based septet of Wei Yi, Tatsushi Kawasaki, Yang Zhang, Hirofumi Akamatsu, Ryo Ota, Shuki Torii and Koji Fujita.

## Individual alligators

Grown-up children, as well as young children, who like to impress their friends by making loud imitations of animal sounds can easily up their game – after they realise that alligators are individuals, not cookie-cutter soundalikes.

Every alligator, like every chimpanzee, cat, dog, crow or most kinds of large animal (every human, too!), makes its own, personally distinctive sounds. A study by Thomas Rejsenhus Jensen and colleagues at Lund University, Sweden, chats up the ubiquity and the power of this noisy individuality.

The study, in the journal *Animal Behaviour*, is called "Knowing a fellow by their bellow: Acoustic individuality in the bellows of the American alligator". Co-author Stephan Reber made noise, so to speak, in 2020 when he and four other colleagues were awarded an Ig Nobel prize for inducing a female Chinese alligator to bellow in an airtight chamber filled with helium-enriched air.

## Ants for arteries

The scourge of atherosclerosis, like many other medical scourges, might sometimes succumb to attack by dining. Dietary discipline could carry the cardiovascular system to victory, so to speak.

A study by Abdul Ademola Olaleye at Federal University Dutse in Nigeria and his colleagues highlights a health benefit of eating small bits of one kind of all-natural, but little-publicised foodstuff.

Details are in their study, "Analytical evaluation of fatty acid, phospholipid and sterol profiles of five species of edible insects: Lipid composition in five species of edible insects", in the *Pakistan Journal of Scientific and Industrial Research Series B: Biological Sciences*.

Olaleye and his team focus especially on the ratio, in a food, of polyunsaturated fatty acids (PUFA) to saturated fatty acids (SFA). They analysed samples of ants gathered from several farms and markets. Their conclusion: "The PUFA/SFA ratios in the present study are good enough to discourage atherosclerosis tendency."

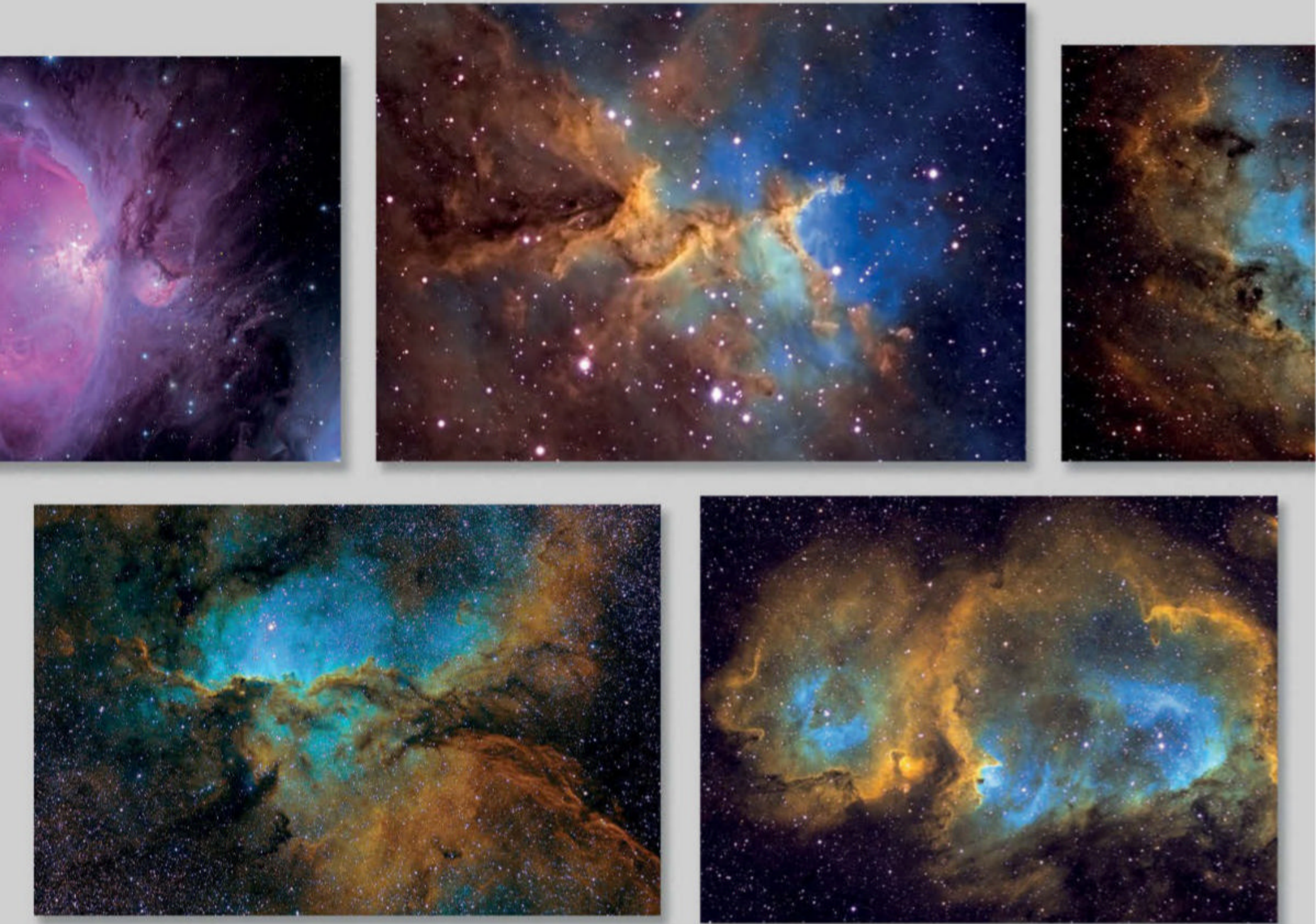
Of all the discouraging news in the world, Feedback suggests this is the best kind. ■

Marc Abrahams

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AIRPLANES FLW?**

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- B. NEWTON'S SECOND LAW
- C. MURPHY'S LAW
- D. BERNOULLI'S PRINCIPLE

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SCIENCE  
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TAKE  
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QUIZ

