

# New Scientist

WEEKLY May 6 - 12, 2023

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YOU CAN'T TRUST AI  
SEARCH ENGINES

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THINK THE UNIVERSE  
IS A HOLOGRAM

THE EERIE BLUE LIGHTS  
THAT ACCOMPANY  
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*The explosion in diagnosis, and why it matters*

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ANNOUNCEMENT

# AN EVENING WITH DR. ZAHİ HAWASS

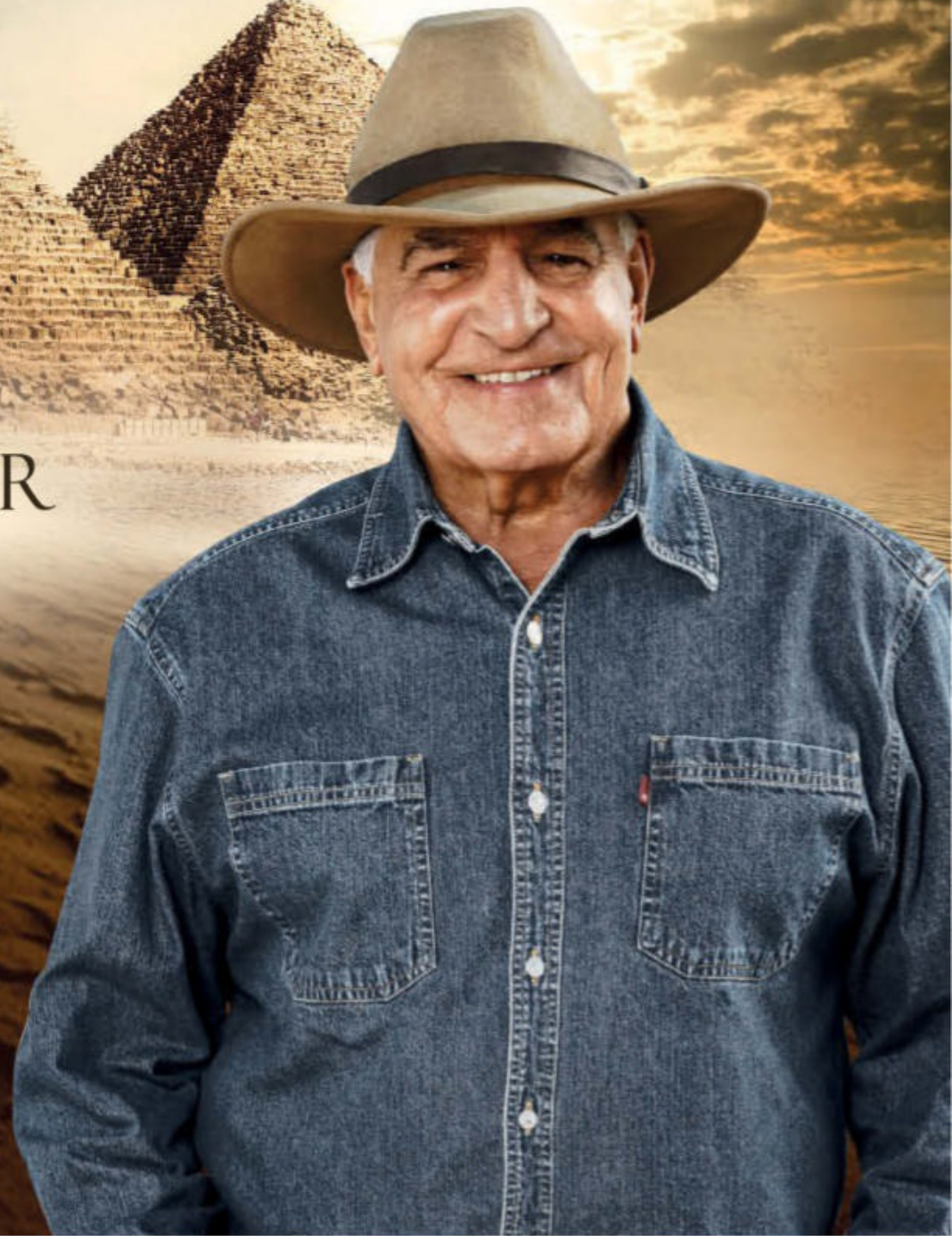
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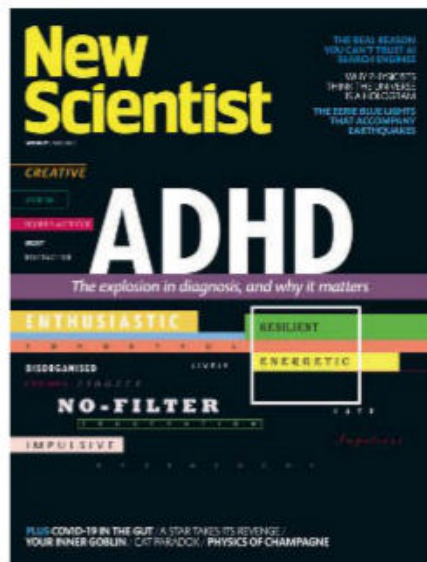
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MATTHEW SMITH/WILDCARD PHOTOGRAPHY/LAMY

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## Virtual event

### Opening the Infrared Treasure Chest with the James Webb Space Telescope

Join Nobel prizewinning astrophysicist John Mather as he discusses how NASA and its partners built the James Webb Space Telescope – and learn about the discoveries made since it began its science operations last year. Watch online at 6pm BST/1pm EDT on 17 May. Early bird tickets are £14.

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## Podcast

### Weekly

Was Rosalind Franklin really the “wronged heroine” of DNA research? Podcast editor Rowan Hooper speaks to zoologist Matthew Cobb about a new interpretation. The team also listens to pond soundscapes. Plus, in the CultureLab podcast, there is an interview with musician Cosmo Sheldrake.

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

## Newsletter



NICK HIGHAM/LAMY

**Carbon sink** Switchgrass might help us fight climate change

## Tour



BETTYMAYAFOOT/NRAO

**Galaxy spotter** One of the telescopes in the Very Large Array

## Video

### Inflatable drones

On our YouTube channel this week, there is footage of an inflatable drone that can perch on a range of objects by colliding with them. The approach loosely mimics the physics that birds use to land on branches. Perching could help drones conserve energy and battery life, which is important when they are used in observation missions.

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

## Newsletter

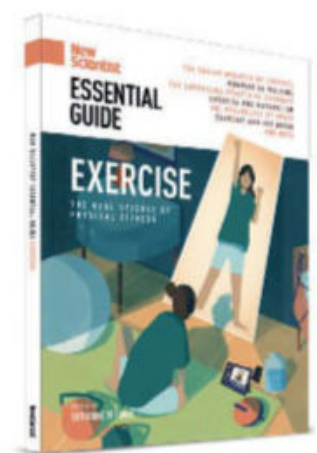
### Fix the Planet

Carbon capture and storage might be easier than we thought, writes environment reporter Madeleine Cuff. A new idea is to plant fast-growing crops, then harvest, dry and bury them to store the carbon they captured. Archaeological sites where dried plants survive for millennia hint that the plan might work.

[newscientist.com/fix-the-planet](https://www.newscientist.com/fix-the-planet)

## Podcast

**“At night, the insects in the pond make scratching noises with their genitals”**



## Essential guide

Exercise is the best medicine. It keeps body and mind in prime condition and adds years to our lives. But why do so few of us get enough? This *New Scientist Essential Guide* offers some clues. Available to download in the *New Scientist* app or to purchase in print from our shop.

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# Raising awareness

As awareness of “hidden” conditions rises, we must make sure research keeps up

INVISIBLE conditions used to be just that: hidden away, misunderstood and more often than not ignored. Not anymore. Thanks in large part to social media, awareness of everything from mental health conditions to chronic pain, fatigue to neurodiversity has never been higher.

In almost every aspect, this is all for the good. Greater awareness chips away at the stigma that has, for so long, left people suffering in silence. The support, solidarity and practical tips in online communities can also provide a lifeline for those with limited access to in-person support who might otherwise feel isolated.

But we shouldn't ignore those who sound the warning that, in some cases, awareness may cause harm. Studies of school mental health schemes for

teenagers, for instance, have found that some interventions actually increase symptoms of depression and anxiety. The effect was especially seen in those who were already vulnerable to mental health problems, perhaps because they were being encouraged to focus on negative

**“With good research, and an open mind, we can make sure people get the right help”**

thoughts and feelings without sufficient support to help them deal with them.

Others have also warned that greater awareness of mental health issues is leading to “concept creep”, where the everyday meaning of terms such as “abuse”, “trauma” and “bullying” are

becoming so broad that they risk losing their power to help people get heard.

And, as we explore in our feature on ADHD (see page 38), where there is profit to be made in diagnosis, combined with a large grey area between what is deemed typical and what is deemed clinically problematic, it can lead to overdiagnosis and over-medication and feed into greater stigma.

The way forward is through research. Clearly, we need to keep talking about these conditions and provide support to those who need it. But where the evidence suggests that the prevailing approach may cause harm, we shouldn't shy away from thinking again. With good research, and an open mind, we can make sure people get the right help. No stigma attached. ■

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## Automated chemistry

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## Price of success

Male elephant seals with large harems die younger **p11**

## Look into my eyes

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## Fuel for thought

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## Fold under pressure

Brain mechanism makes us choke when stakes are high **p19**



JOE MARINO/UP/SHUTTERSTOCK

## Space

### Launch, launch and launch again

SpaceX's Falcon Heavy rocket blasted off from NASA's Kennedy Space Center in Florida on 30 April. Its blackened side boosters show SpaceX's reusable approach at work – one had launched six times before, the other two. But this was the final mission for these boosters, letting them be pushed to the limit to place a large communications satellite in geostationary orbit.



## Evolution

# Strange alga has seven genomes

DNA analysis has revealed that a single-celled alga has an unusual collection of different organisms living inside it, finds **Michael Le Page**

A SINGLE-CELLED alga collected more than 50 years ago and grown in labs ever since has turned out to be a bizarre conglomeration of once-independent organisms, with no fewer than seven different genomes inside it.

“As far as I know, seven is a record number of distinct genomes in a single cell,” says Emma George, who carried out the work while at the University of British Columbia in Canada.

The alga, of a kind called a cryptomonad, was collected by naturalist Ernst Georg Pringsheim sometime before 1970 and became part of a collection at the University of Göttingen in Germany. In 1988, a microscopic study revealed bacteria within the algal cells, and also viruses within some of the bacteria.

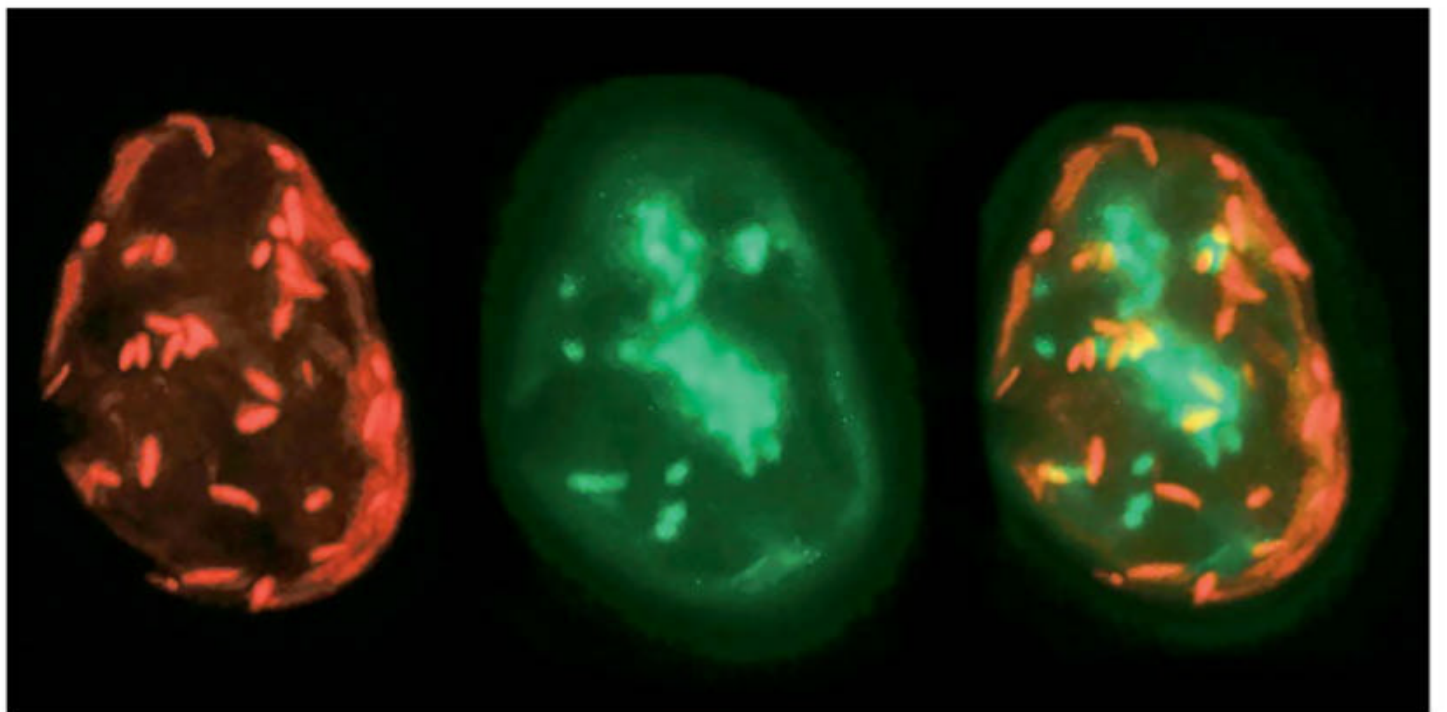
After reading this study, George asked for samples of the alga so her team could sequence all the DNA inside the cells and identify the virus and bacterium.

It isn't that unusual for cells to host symbiotic bacteria. Complex cells are thought to have arisen about 3 billion years ago when a bacterium started living inside another simple cell and formed a partnership, a phenomenon known as endosymbiosis. That bacterium evolved into the energy-producing mitochondria found in almost all complex cells.

The main genome of complex cells is in the cell nucleus, but mitochondria retain their own small genome. This means most animal cells have two distinct genomes, with up to several thousand copies of the mitochondrial genome per cell.

About a billion years ago, plant cells gained the ability to photosynthesise by acquiring a cyanobacterium. This evolved into the chloroplast, which has also retained part of its

EMMA GEORGE ET AL.



genome, so plant cells have three different genomes.

Cryptomonad algae, however, aren't plant cells. They started out as free-swimming predatory cells and gained the ability to photosynthesise by engulfing a complex plant cell – a red alga – rather than a cyanobacterium.

The nucleus of this red alga has been retained in a shrunken form because it contains some genes essential for photosynthesis. So all cryptomonads have four distinct

## 4400

The number of generations of this alga that have lived in labs

genomes: the main genome in the cell nucleus, the remnant nucleus of the red alga, the mitochondrion and the red algal chloroplast.

The Göttingen strain has an extra three distinct genomes. It has acquired two more bacterial endosymbionts, George's team found, one of which is infected with a bacteriophage virus. “For there to be two different ones and then one of them infected with a phage, all within a single

cell, it's amazing,” says George.

Her team identified the host cell as *Cryptomonas gyrogyrenoidosa*, the two bacteria as *Grellia numerosa* and *Megaira polyxenophila*, and the virus infecting *M. polyxenophila* as one called MAnkyphage (*Current Biology*, doi.org/j7wx).

George thinks this conglomeration existed in the alga collected by Pringsheim and has been passed down to all its descendants ever since, over some 4400 generations.

Surprisingly, the phage-infected bacterium is more abundant in the host cryptomonads than the non-infected bacterium. How the phage has persisted without wiping out its host bacterium isn't clear, but the phage does have genes that might help the bacterium get along with the cryptomonads, says George. “There must be a balance in that system,” she says.

The study is thoroughly researched, says Dave Speijer at the University of Amsterdam in the Netherlands, and shows that the relationships between the host and the bacteria and virus within

The colours in these images of an algal cell show bacteria; the red ones host viruses

it are surprisingly complex. But he wonders if these relations would survive in real-world conditions or have persisted only because of the stable lab environment the cells have been kept in.

It was already known there are single-celled organisms called dinoflagellates that host single-celled algae called diatoms inside them, with at least six distinct genomes in one cell. One of these “dinotoms”, discovered by Norico Yamada at the University of Konstanz in Germany, acquired diatoms on four occasions and might have nine distinct genomes.

But Yamada says her unpublished results suggest the same diatom species was acquired on each occasion, meaning it might still have only six distinct genomes, depending on what you count as distinct.

“Either way, both systems are extremely complex, and these ‘records’ will likely be beaten by another system yet to be discovered,” says George. ■



## Neurology

# Signs of near-death experiences seen in brain activity of dying people

Clare Wilson

A SURGE of brainwaves in two people who lay dying after their life support was turned off may help to explain the phenomenon of near-death experiences.

The sensation of moving down a tunnel towards a bright light, reliving memories and hearing or seeing deceased relatives have all been reported by people from many cultures who have had a brush with death. Some scientists, however, say these experiences could be caused by hallucinations as people recover in hospital. Now, we have identified brain activity that could be behind these experiences.

Ten years ago, Jimo Borjigin at the University of Michigan Medical School and her colleagues showed that rats have a surge of electrical activity in their brains as they die. To look for the same thing in humans, the team combed through anonymised medical records for people who had an electroencephalogram, or EEG, recorded as their life support was switched off because

they had no hope of recovery, finding four such people.

These people were critically ill in intensive care units, and had electrodes placed on their head to monitor their brainwaves for signs of epileptic seizures.

Studying this data allowed the team to investigate what was happening in dying brains. Brainwaves can be seen on an EEG when large numbers of brain cells fire together in synchronised cycles. These waves can happen at different frequencies.

Previous work suggests that faster frequencies, known as gamma brainwaves, are a hallmark of consciousness, higher thought processes and memory retrieval. This is particularly true if they occur in two areas on each side of the head, known as the temporoparieto-occipital (TPO) junctions.

Of the four people in the study, two showed surges of gamma brainwaves in their TPO junctions when their life support was withdrawn. This surge lasted a few minutes and was very intense at

times, says Borjigin, but it is impossible to know if these people had any visions as they were dying. "Had they survived, those two patients might have had some story to tell," says Borjigin.

The other two people didn't show any gamma brainwaves. The brains of the two who did exhibit a wave of activity were

**Even at the very end of life, there might be a spike of brain activity**



LUIS ALVAREZ/GETTY IMAGES

working enough to raise their heart rate as their blood oxygen levels fell. This suggests that a functioning autonomic nervous system may be necessary for the gamma brainwave surge to occur (*PNAS*, doi.org/gr6x8d).

These two people also had a suspected history of epilepsy, which could have permanently affected their brains. But it hasn't previously been noted that epilepsy is linked to having a near-death experience, says Borjigin.

Sam Parnia at NYU Langone Health says a gamma wave surge could happen as people die because falling oxygen levels disable some natural "braking systems" on brain activity. "This allows for the activation of normally dormant pathways, which are seen as transient electrical spikes," he says. "The braking systems that require energy are lost."

The findings provide additional evidence for awareness in some people who are otherwise thought to be unconscious at the end of their life, says Parnia. ■

## Astrophysics

### Star being eaten will take revenge as a black hole

A FARAWAY star is being consumed by its next-door neighbour, but it is preparing to get even. The two stars are so close together they are touching, and together form the most massive contact binary star system ever found.

The pair of stars is called SSN 7 and is located in a star-forming region called NGC 346 in the Small Magellanic Cloud, a galaxy about 200,000 light years away from us. To learn more about SSN 7, Matthew Rickard at University

College London and Daniel Pauli at the University of Potsdam in Germany compiled observations from six observatories taken over more than a decade.

They found that the two stars – one about 32 times the mass of the sun and the other about 55 solar masses – are orbiting each other much more closely than previous analyses implied. We thought that it took more than 20 days for them to circle one another, but it turns out it takes only about three days.

The observations also suggest that the larger of the two stars is sucking matter away from the smaller one at a rate of about 13 Earth masses per year. But

in about 800,000 years, we expect the situation to change. The researchers' models suggest that, at that point, the smaller star will collapse in on itself and a black hole will form there (*Astronomy & Astrophysics*, doi.org/gr6pc4).

"They will be uneasy companions for a few million years, but, at some point, the remaining star will start to expand," says Pauli. Then, the tables will turn. "The black hole will get its 'revenge' by eating off the companion star which

**"There's no emotion going on, it's just what happens when you put two massive bodies next to each other"**

previously it was feeding," he says.

"Of course, there's no emotion going on, it's just what happens when you put two massive bodies next to each other," adds Rickard. Eventually, the other star will also collapse into a black hole and the two will spiral closer together over billions of years, and merge.

"With the advent of black hole mergers being observed through gravitational waves, there is now a need to explain how black holes in this mass range come to be so close together and merge," says Rickard. Studying binaries like SSN 7 could help us understand those gravitational wave observations. ■ Leah Crane



## Artificial intelligence

# Chemists are teaching GPT-4 to experiment and control robots

Alex Wilkins

LANGUAGE models that power chatbots like ChatGPT can be used for automated chemistry, from synthesising molecules and discovering drugs to designing and carrying out scientific experiments.

Large language models like GPT-4 have been trained on data from across the internet and seem competent at answering questions about a wide range of disciplines, but they can struggle with tasks requiring expert learning.

“They lack this chemical knowledge and they are not really good at representing molecules,” says Philippe Schwaller at the Swiss Federal Institute of Technology in Lausanne.

To make GPT-4 a better chemist, Schwaller and his team enabled it to search through libraries of molecules, chemical reactions and scientific research. “This basically makes it possible for the language models to automatically query those tools while solving a task and get much more specific information, and then be a lot more accurate on the chemistry tasks,” says Schwaller.

The researchers tested this augmented AI, dubbed ChemCrow, on 12 chemistry tasks, such as synthesising the drug atorvastatin – a medication for high blood pressure – and calculating how much the ingredients would cost. They also gave the same tasks to the regular version of GPT-4, then asked chemists to evaluate the feasibility of both AIs’ plans.

For the atorvastatin task, GPT-4 failed to synthesise the

compound, while ChemCrow came up with a workable seven-step plan, including quantities, timings and lab conditions.

On average, ChemCrow scored more than 9 out of 10 for completing the 12 requests, but sometimes failed on tasks like judging whether a synthesis method was novel or toxic. GPT-4 got less than 7 out of 10.

**“Basic AIs lack chemical knowledge and they aren’t really good at representing molecules”**

The evaluators were also asked to judge whether the AIs provided factually accurate information, and again ChemCrow scored more than 9 out of 10 versus less than 5 for GPT-4 (arXiv, doi.org/j7wn).

In a separate study, Gabriel Gomes at Carnegie Mellon University in Pennsylvania and his colleagues augmented GPT-4 with chemistry tools, similar to ChemCrow, but also supplied it with the documentation and software interface of a remotely controlled chemistry lab with

liquid compounds that could be manipulated by robotic arms.

They then asked it to perform specific reactions using the liquids and found that it could draft a workable plan and carry out actions to produce the desired compounds (arXiv, doi.org/j7wp).

Gomes and his team also asked the language model to come up with plans for making illegal or dangerous substances, such as heroin or sarin gas, but the model refused. For tools like ChemCrow, which Schwaller says could help people without much scientific experience do chemistry, there is also the risk that AI suggestions lead to accidents or the creation of harmful compounds.

However, many recipes for synthesising dangerous compounds are already available via web searches, says Ross King at the University of Cambridge. “You can get public domain tools to help you do that sort of thing if you were really determined to try to synthesise something illegal or dangerous.” ■



WLADIMIR BULGAR/SCIENCE PHOTO LIBRARY/ALAMY

## Physics

# We finally know why champagne bubbles rise in a straight line

Karmela Padavic-Callaghan

**BUBBLES** in champagne and other carbonated drinks can rise in straight columns thanks to chemicals that also give these drinks their flavour.

Each bubble in a liquid creates a wake behind it as it rises, which can knock other bubbles around. Yet, in champagne, bubbles manage to rise from the bottom of a glass in steady vertical columns without being pushed off course.

To investigate, Roberto Zenit at Brown University in Rhode Island and his colleagues removed the gas from fizzy drinks including carbonated water, beer and champagne.

They then poured the liquids into a tank with a needle at its bottom, pumped in bursts of air through the needle and recorded how the bubbles rose.

The researchers combined these observations with a mathematical model that describes how certain properties of liquids determine the amount of swirling that happens near a bubble.

This revealed two characteristics driving swirling: the size of the bubbles and the concentration of molecules called surfactants. These include the fatty acids that give champagne its fruity notes, and proteins that contribute to the flavour of beer.

By sticking to the bubbles, these molecules can change how much the bubbles’ surface can move.

Big, elliptical bubbles and bubbles coated with surfactants encourage more swirling, which interrupts the wakes of nearby bubbles enough to prevent any sideways knocking. This lets the bubbles rise in stable, vertical chains, one above another.

Bubbles in champagne are typically so small that they wouldn’t form steady columns, but thanks to the fatty acids in the sparkling wine, they do. The work will be published in *Physical Review Fluids*. ■

**A modified version of GPT-4 can control robot arms**



## Space

# Theoretical objects called topological solitons may look like leaky black holes

Karmela Padavic-Callaghan

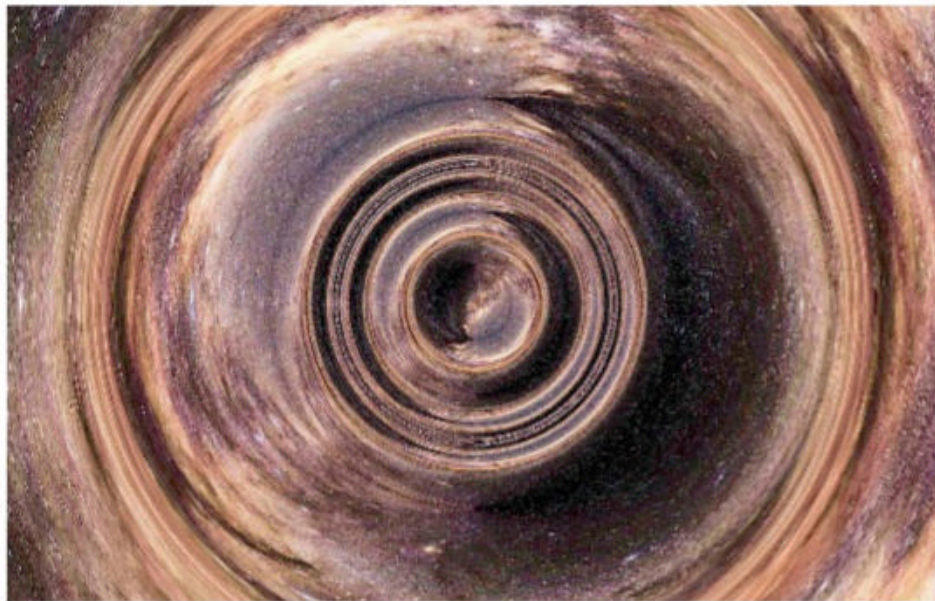
STRANGE cosmic objects described by string theory could be mistaken for ordinary black holes from far away. If these objects, called topological solitons, do exist, they could solve a long-standing paradox about black holes.

A topological soliton is a region where space-time itself warps and forms a hole that light can fall into. This would be a bit like the light sliding down a space-time hill.

In two-dimensional space-time, the object would resemble a flat ring doughnut that traps light in its hole. However, string theory posits that there are many dimensions, so the topological soliton's true shape can't be fully perceived in the three spatial dimensions we experience.

Although light would fall into one of these structures much as it falls into a black hole, topological solitons wouldn't be fully dark in the middle. If they are real, looking at them up close would show light swirling about their centre.

Black holes are hard to directly image because they trap all the light that enters them, but in 2019



PIERRE HEIDMANN/JOHNS HOPKINS UNIVERSITY

**A topological soliton may look like a black hole but have a lighter centre**

the Event Horizon Telescope (EHT) produced a striking image of one black hole by detecting light and matter circling around it.

Ibrahima Bah at Johns Hopkins University in Maryland and his colleagues wondered whether other space objects could produce similar images, and they focused on the topological soliton. "We are

not making predictions about whether these objects are in the sky, [we are] just getting at the question of if there was something that mimics a black hole, could we even see the difference," says Bah.

He and his colleagues modelled the trajectories of light around a topological soliton and used visualisation techniques to give them images of topological solitons as they would look if they were taken with an instrument like the EHT.

Emanuele Berti, also at Johns Hopkins University, says these images revealed that light that fell into the topological soliton's hole kept bouncing inside its edges, so the centre wasn't as black as that of a conventional black hole. Some light could even escape, which is impossible for black holes. The work will be published in *Physical Review D*.

Nicholas Warner at the University of Southern California says that understanding objects like topological solitons could help solve the so-called black hole information paradox, in which these cosmic behemoths seem to violate the laws of quantum physics by destroying information about objects that fall into them.

If signals from space that were previously interpreted as black holes are actually coming from a topological soliton that can let light or information escape, the paradox would become irrelevant. This would give insight into which type of theory of quantum gravity may be most accurate, says Warner. ■

## Zoology

# Male elephant seals with large harems die younger

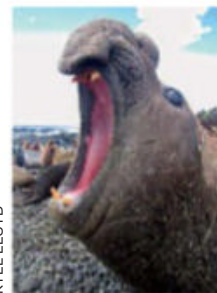
THE duties that come with a big harem seem to make male elephant seals die younger, but it is worth it for them genetically.

Elephant seal harems consist of anywhere from five to 50 females associated with one dominant male. These males have to defend the females and their pups, as well as the beach they live on, from rivals. They can also incur injuries during fights with other males. And because they stay on land

during the breeding season, the 5-tonne marine mammals don't eat for three months while expending energy patrolling and mating with all the females in their group.

"These breeding seasons are quite chaotic," says Kyle Lloyd at the University of Pretoria in South Africa. "There's lots happening; the beaches are so busy, and the males are working hard."

Lloyd spotted that male southern elephant seals (*Mirounga leonina*) – especially those with the most females – were losing weight and body condition over the breeding season in Marion Island in the



KYLE LLOYD

Male southern elephant seals defend harems in the breeding season while forgoing food

sub-Antarctic Indian Ocean.

To investigate, he and his colleagues examined 34 years' worth of records for the population, based on annual tagging and counting campaigns, including the life histories of 324 breeding males.

They found that dominant males usually survive to an age of 8 to

10 years and that they died younger when their harems were bigger. This was particularly true for males that had their first harem at a younger age, starting at about 5 years old. By contrast, females generally live at least 20 years.

If the males had large harems year after year, they might father up to 200 pups, but their chance of survival got lower each year (*Animal Behaviour*, doi.org/j8cgv). "That cost just got worse and worse," says Lloyd. But in evolutionary terms, that cost is worth it, because the males have already passed on their genetic material, he says. ■  
Christa Lesté-Lasserre



# Can we trust AI search engines?

Als that generate convincing answers are more likely to cite information incorrectly

Chris Stokel-Walker

IF YOU think search engines powered by artificial intelligence, such as Microsoft's Bing Chat, are providing you with useful-sounding answers, it is more likely that they are wrong, researchers have found.

"In these current systems, accuracy is inversely correlated with perceived utility," says Nelson Liu at Stanford University in California. "The things that look better end up being worse."

Microsoft is just one of many companies offering AI-powered search tools, which generate results in digestible paragraphs that cite other websites rather than simply returning a list of links. To investigate these tools, Liu and his colleagues fed 1450 popular search queries, taken from existing data sets, into Bing Chat and other such tools, including You.com, NeevaAI and

Perplexity.ai. These queries included examples such as "What are the latest discoveries from the James Webb Space Telescope?"

The team then asked people to rate whether the content of the websites used as citations in the results actually supported the statements made by the AIs.

**"It's a little concerning to me just how quickly these systems are being rolled into search"**

According to this assessment, only 75 per cent of citations supported the sentence they were appended to, and only 52 per cent of statements were supported by citations at all. "That means the rest either have no citations, or they are just wrong," says Liu.

The researchers also asked people to rate fluency of responses

and how useful they seemed on a five-point scale, and discovered a negative correlation with precision – a measure of how well the AIs were actually reflecting the sources they cited. For every 0.1 increase in fluency ratings, the precision decreased by 10.6 per cent (arXiv, doi.org/j7v6).

Microsoft declined to comment on the work, while You.com hadn't responded at the time of publication. Aravind Srinivas, a co-founder of Perplexity.ai, says he welcomes the study and is committed to improving that product. "Never judge an upcoming technology by what it is today, but rather by the potential for what it can be in the future," he says.

Sridhar Ramaswamy, CEO of NeevaAI, says the results are similar to work the company has conducted internally, and that

improvements are possible. "We haven't seen this kind of transformational technology applied to search in nearly two decades," he says. "While it's certainly early days, the paper and real-world use demonstrate the extraordinary opportunity to turn traditional search engines into answer engines grounded in sources."

But Liu isn't sure whether AI-powered search is the right approach. "I'm a little bit mixed on whether or not they should be rolled into systems," he says. "A lot of these sites have disclaimers about how these generated statements might not be accurate, but broadly speaking, a lot of us don't pay attention to those disclaimers. It's a little concerning to me just how quickly these systems are being rolled into search." ■

Space

## Alien eavesdroppers might respond to us by 2029

IF ALIENS are nearby and listening in on the signals going to and from our spacecraft, we could hear from them in the next few years.

Since 1972, NASA has used a system of radio antennae called the Deep Space Network (DSN) to track spacecraft and send powerful radio signals towards them.

Howard Isaacson at the University of California, Berkeley, and Reilly Derrick at the University of California, Los Angeles, have worked out which stars these radio signals may have reached and when responses could be received here.

"In the search for extraterrestrial intelligence, we're always thinking about the best places to look



NASA/CANBERRA DEEP SPACE COMMUNICATION COMPLEX

A radio antenna at the Deep Space Network's Canberra facility in Australia

because we can't look at every single place at once," says Isaacson.

To do this, Isaacson and Derrick mapped out the paths of five spacecraft – Voyager 1 and Voyager 2, which have left our solar system, and Pioneer 10, Pioneer 11 and New Horizons, which are heading

that way – and the radio signals sent to those spacecraft during their travels. They then used the Gaia catalogue of stars to see when those signals would have reached systems in our local neighbourhood.

They found that the DSN signals have already reached four stars.

Aliens living near one of them, which lay in the path of Pioneer 10's received signals, could theoretically have sent a response that would reach Earth by 2029. Replies from aliens near two more star systems, reached by Voyager 2's signals, could reach us in 2031 and 2033 (*Publications of the Astronomical Society of the Pacific*, doi.org/j7vb).

We know little about whether these stars host planets or could be hospitable for life because they are much fainter than our own sun, says Isaacson, so any exoplanets would be hard to detect. But, statistically, planets seem relatively common and there should still be many undiscovered ones, he says. ■

Alex Wilkins



## Technology

# Smart glasses dim only the brightest objects in your view

Matthew Sparkes

A PAIR of smart glasses fitted with a camera and LCD screens can “balance” a scene by dimming the brightest objects and leaving dim ones unchanged. The device could help people with photophobia, who can experience pain or discomfort from intense light.

Standard sunglasses help with photophobia, but they alter the whole field of view and can make darker areas difficult to see.

The smart glasses developed by Xiaodan Hu at Nara Institute of Science and Technology, Japan, and her colleagues work by feeding the input from a camera through a small computer. This balances the image by running an algorithm that dims the brightest areas.

The wearer sees the scene through transparent LCD screens, which look like spectacle lenses but can adjust how much light passes through each pixel they display based on the computer’s output.

The system takes just 20 microseconds to adjust to changing light conditions, meaning that even rapid transitions appear seamless (arXiv, doi.org/j7th).

Previous devices have attempted to block specific areas of a view while allowing the rest of the scene to be visible through a transparent screen, but this results in a blurred image. Hu’s approach avoids that by rendering the entire image, with areas of pixels serving only to dim the natural light, not replace it.

Hu says that the glasses could be miniaturised to look like normal glasses and that the current system costs around \$900 per pair, but this would fall if produced at scale.

“For photophobic individuals, the system allows them to wear sunglasses at all times without fear of being bothered by either sunlight or fluorescent lights,” she says. “In addition, the general public can use them while driving or cycling for added comfort and safety.” ■

## Health

# Doctors are hypnotising people before surgery

Clare Wilson



HYPNOTISING people before an operation may sound like a stunt, but it is becoming standard medical practice in several countries.

Last month, the UK’s Royal College of Anaesthetists (RCoA) called for more staff to give people self-hypnosis recordings to listen to before a procedure. Hypnosis is also being used in some hospitals in the US, Australia, Canada and the Netherlands.

The cases of surgical hypnosis that get the most attention involve someone having a major operation without any anaesthetic, but the number of people who could be hypnotised so deeply is thought to be small.

What is more widely feasible is for doctors to use hypnosis alongside drugs to help people feel less anxious when having procedures that they remain awake through, such as biopsies. This can cut the amount of medication needed.

A randomised trial in US women who had a tissue sample taken from a breast lump found that hearing a hypnosis script

reduced their pain and anxiety.

This approach could also be used before surgeries in which people are put to sleep with a general anaesthetic. One trial looked at children having a catheter pushed into their hearts, which requires a

**“Patients can wait hours for operations. It’s very hard to relax in that kind of environment”**

general anaesthetic. Those who listened to a nurse reading from a hypnosis script in the preoperative period required a lower dose of sedatives.

“It’s not an alternative to anaesthesia, it’s an adjunct,” says Samantha Black, an anaesthetist who helped develop hypnosis recordings for the RCoA.

As well as supplying recordings or reading from a script, staff can use “hypnotic suggestions” by using key phrases to help people relax, for example by saying they can feel themselves becoming sleepy.

At a conference on “adjunctive medical hypnosis”

**Hypnotism can cut the amount of drugs needed in surgery**

at the Royal Society of Medicine in London in April, Black said people should be advised to listen to the recordings at home before a procedure. “Sometimes, patients can wait a couple of hours for their operations,” she says. “It’s very hard to relax in that kind of environment.”

There are no records of how often staff are using the hypnosis techniques, says Black. It isn’t part of standard training for doctors learning to be anaesthetists, but hospitals and doctors’ professional bodies in many countries are increasingly providing training sessions in hypnotic techniques. “It needs to become integrated into the medical school curriculum,” says Black.

Elvira Lang, a former radiologist who was involved in both trials, has set up a firm called Comfort Talk in Boston that provides hypnosis training to medical staff. In February, she advised the Dutch national breast cancer screening service how to use hypnosis to make mammograms less painful. “If it is less painful, women are more likely to come,” she says.

Allan Cyna, an anaesthetist at Women’s and Children’s Hospital in Adelaide, Australia, says even avoiding language that gives negative suggestions can reduce people’s pain and anxiety. For instance, instead of warning someone that an injection is going to sting, staff could say it will provide a numbing sensation. “By giving negative suggestions, we are harming patients inadvertently,” he says. ■



Coronavirus

# Covid-19's impact on the gut

The coronavirus is increasingly being linked to gastrointestinal symptoms, but how the infection affects the gut – or how to treat it – is unclear, reports **Michael Marshall**

AS THE first wave of cases of the coronavirus swept the world in early 2020, gastroenterologist Siew Ng at the Chinese University of Hong Kong was expecting the impact of the virus to extend beyond the body's airways. She and her colleagues vividly remembered the SARS coronavirus outbreak of 2003, giving them some notion of what to expect from SARS-CoV-2. In particular, they anticipated that many people would develop gut problems.

**“Does the coronavirus cause inflammation in the gut? Or affect its microbiome or the gut wall's permeability?”**

As these early cases emerged, Ng and her team started collecting stool samples. At the start of the outbreak, everyone in Hong Kong who tested positive for the coronavirus had to go to hospital, regardless of the severity of their symptoms, says Ng. As a result, the team's collection soon ran to hundreds of samples, providing some of the first evidence that the infection can disrupt gut function.

In some cases, this disruption was linked to an increased risk of death or chronic complications. However, despite an ever-growing mountain of evidence, it is unclear what the virus does to the gut, which makes developing effective treatments all the more difficult.

The primary challenge with understanding the impact that SARS-CoV-2 can have on the gut is that multiple systems interact in our gastrointestinal tract. For instance, the walls of the gut produce enzymes to digest our food. Our gut is also home to trillions of microorganisms, known as our microbiome. What's more, the gut has a big influence on our immune system and even has strong connections to our



MARCOS DEL MAZO/LIGHTROCKET VIA GETTY IMAGES

brain. All this interconnectivity makes it hard to figure out what is causing what.

## A common problem

Nevertheless, it is clear that gastrointestinal problems can be a big part of the coronavirus's symptoms. Up to 1 in 5 people present with gut-related symptoms, the most common being diarrhoea, abdominal pain, loss of appetite and nausea, sometimes with vomiting. For some, these symptoms last months. A 2021 study found that 16 per cent of people reported at least one gastrointestinal symptom more than 100 days after being hospitalised for covid-19, the condition caused by SARS-CoV-2.

What this means for a person's prognosis isn't entirely clear. A 2022 review pulled together 53 studies covering more than

55,000 people with the coronavirus and found that gastrointestinal symptoms weren't associated with a higher risk of death.

However, a different picture emerges from studies that focused specifically on disruption to the gut microbiome, suggesting that this may be linked to an increased risk of death from covid-19. The stool samples that Ng and her team examined revealed that many helpful "commensal" bacteria can become depleted when people are infected with the coronavirus, while harmful ones become more populous. The fungi in the gut – the mycobiome – have shown similar disruptions. Crucially, those with more severe illness tended to have more disrupted microbiomes, mimicking the results of other studies.

The most obvious smoking gun for all this is a molecule called angiotensin-converting

## Coronavirus measures in downtown Madrid in March 2021

enzyme 2 (ACE2). It sits in the outer membranes of many human cells and is involved in keeping our blood pressure steady. SARS-CoV-2 binds to ACE2 when infecting cells. ACE2 is extremely common in the gut, even more so than in the lungs.

This helps explain why SARS-CoV-2 is so good at disrupting the gut, where its impact is "bigger than what we see in influenza and malaria", says Ng.

But picking out what is happening in the guts of people with the coronavirus remains tricky. "When you look at the evidence, there are a lot of knowledge gaps," says Laure-Alix Clerbaux at the European Commission's Joint Research Centre in Ispra, Italy. She is one of the coordinators of the CIAO





project, which is attempting to trace the sequences of mechanisms that take place in people with covid-19 and has revealed some peculiarities.

“There’s a lot of receptors for the virus in the gut and there’s disorder in the gut,” says Clerbaux. At first glance, this implies that the virus is infecting gut cells and replicating, but that may not be the case. “We could not find a body of evidence, or the body of evidence was weak, that there is this active replication of the virus,” she says. Nor is there much evidence that SARS-CoV-2 can infect the bacteria in the gut.

“We propose a different pathway,” says Clerbaux. If the virus is binding to the ACE2 receptor, that could disrupt nutrient uptake by the gut because ACE2 has a role in the uptake of tryptophan, an essential amino acid. “Clearly this could be a really interesting mechanism, because we could have also a therapeutic target there,” says Clerbaux.

Other lines of evidence suggest that gut microbiota are crucial to SARS-CoV-2’s potential gastrointestinal impact, even if the microbes aren’t being infected themselves. In a small study published in 2022, Ng and her colleagues gave 25 people with a non-critical SARS-CoV-2 infection a mix of helpful gut bacteria and carbohydrates, which they took

sooner and any disruption to their gut microbiome resolved faster. This suggests that treating the harms caused to the gut microbiota can help to resolve the infection, says Ng.

Unfortunately, gastrointestinal disturbances can persist for many weeks or longer. Gastric distress of some form can be a symptom that affects people with long covid, a post-infection condition that sometimes lasts years.

### Treatment confusion

This was somewhat predictable, because many infections disrupt the gut-brain axis with lasting consequences, says Max Schmulson at the National Autonomous University of Mexico in Mexico City. In 2021, he and his colleagues published a study pushing for gastroenterologists to manage the “inevitable surge of post-covid-19 functional gastrointestinal disorders”.

Again, direct viral infection may not be to blame. A 2022 study found viral genetic material in the

# 1 in 5

people have a symptom like diarrhoea while infected with SARS-CoV-2

# 16%

of people have gastrointestinal-related issues 100 days after leaving hospital for covid-19

guts of people with long covid, but the researchers couldn’t grow viruses from the samples. “There are these viral particles that are non-viable but are still in there,” says Schmulson. “What are they doing there? Are they producing some kind of inflammation? Are they stimulating the nervous endings? Are they impacting in the flora in the microbiota? Are they having some impact on the permeability [of the gut wall]? We don’t know.”

This difficulty in elucidating the mechanisms of lasting gastrointestinal symptoms makes it harder to design treatments. Some researchers have proposed giving people probiotics to restore their gut flora. “There are many studies coming out with probiotics, but they don’t have great evidence,” says Schmulson.

Another suggestion that has been mooted is faecal transplantation – transferring bacteria via a processed stool from a healthy donor to another person’s intestine, with the aim of restoring their potentially disrupted microbiome. There is evidence that it treats certain gastrointestinal symptoms and it is already approved in many countries for recurrent *Clostridium difficile* infection. However, Schmulson says there isn’t evidence yet that this helps people with long covid.

Ng and her colleagues are experimenting with probiotics and faecal transplants in clinical trials, but the going is slow – partly because treatments that work for some people don’t work for others and it isn’t clear why.

All this means that when it comes to the impact SARS-CoV-2 can have on the gut, and how best to treat it, “the evidence is still in [its] infancy”, says Ng. “There just aren’t enough clinical trials.” ■



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

### “The evidence on how best to treat the coronavirus’s potential effect on the gut is still in its infancy”

every day for 28 days alongside other treatments. Compared with 30 infected people who didn’t get the mixture, those who did were quicker to develop antibodies against the virus. Inflammatory markers in their blood also fell



### Sales of electric vehicles are soaring – but is that all good? One in five cars sold worldwide in 2023 will be electric, but the shift to batteries brings its own problems, finds **Madeleine Cuff**

A REVOLUTION has gathered pace in the transport sector. Electric cars, once the preserve of those with deep pockets, have hit the mainstream.

Figures released on 26 April by the International Energy Agency (IEA) suggest that almost one in five new cars sold worldwide this year will be either full battery electric or plug-in hybrid models. In total, 14 million of these kinds of vehicles are expected to be sold this year, up from about a million in 2017.

This explosive growth is testament to innovation and government interventions. Falling battery costs have delivered longer-range cars, boosting their appeal to consumers. Meanwhile, government policies, including looming bans on the sale of new petrol and diesel cars in some countries, have nudged people to embrace lower-emission driving.

This transformation in the car industry will reshape world energy use. Global oil demand for road transport will peak in 2025, the IEA predicts. "The internal combustion engine has gone unrivalled for over a century, but electric vehicles are changing the status quo," said Fatih Birol at the IEA in a statement.

Although electrification of the global vehicle fleet brings climate benefits, there is also cause for concern. SUVs have been growing in popularity, accounting for 42 per cent of all car sales in 2020. Electric SUVs have also gained ground, representing roughly 35 per cent of electric passenger car sales in 2022.

Christian Brand at the University of Oxford dubs this trend towards larger cars a "mobesity" epidemic. Electric

**More charging points have helped electric cars appeal to consumers**



VUKVALIC/ALAMY

SUVs are greener than their petrol and diesel counterparts, but their size erases some of the climate gains from moving to electric vehicles (EVs). Their larger batteries also require more raw minerals, like cobalt and lithium, putting extra pressure on stretched supplies. "The trend towards larger cars is definitely not desirable," says Brand.

He suggests policies may be needed to encourage people to opt for smaller EVs, such as hiking taxes for electric SUVs. "Of course, that's unpopular with policy-makers because they would fear losing

votes. But we could save hundreds of millions of tonnes of carbon over time, cumulatively to 2050, if we did something like this in the UK," he says.

Air pollution is another worry. In lower-income countries like India, electric scooters and tuk-tuks are replacing diesel-powered vehicles in their droves, the IEA reports, which will lead to improvements in urban air quality. But in higher-income countries, where petrol and diesel cars tend to be cleaner, the situation isn't so clear, says Frank Kelly at Imperial College London.

"The benefit of moving to an electric vehicle, from an exhaust emission point of view, is actually pretty small," says Kelly. And since electric vehicles still produce pollution from tyres, brakes and road wear, air pollution won't go away. "We're still going to have a pretty big problem in our cities," says Kelly.

Governments must do more to reduce car dependency, says Kelly. "Clean public transport is the solution to our air pollution problem in urban areas," he says. "And really, we should be minimising all private vehicles as much as possible, not celebrating the increased numbers." ■

## Space

### Japanese Hakuto-R spacecraft crashes into the moon

LUNAR lander Hakuto-R, launched by Japanese firm ispace in December 2022, was supposed to touch down on the moon on 25 April. If it had been successful, it would have been the first privately funded moon landing. But like a previous attempt, it crashed.

For the landing, the spacecraft needed to slow down from more than 750 kilometres per hour to zero in less than 3 minutes. At

a media briefing before the landing, Ryo Ujiie, ispace's chief technology officer, likened slowing Hakuto-R down for a soft landing to "stepping on the brakes on a running bicycle at the edge of a ski-jumping hill".

The Hakuto-R Mission Control Center in Nihonbashi, Tokyo, confirmed that the lander was in a vertical position as it carried out the final approach to the lunar surface, but then its descent speed accelerated rather than slowed.

"Our engineers will continue to investigate the situation," said ispace founder and CEO Takeshi Hakamada minutes

after the landing attempt.

While the trip to the moon can be as short as a few days, Hakuto-R didn't take a direct path. To save fuel, it took a circuitous route, using the gravity of Earth and the sun to give it an extra push over the course of its three-month voyage. It arrived in lunar orbit in March and had been circling towards the moon since then, examining the surface to make sure its landing spot was safe.

**"Slowing the spacecraft is like stepping on the brakes on a running bicycle at the edge of a ski-jumping hill"**

The lander didn't crash alone: it carried payloads for assorted countries and customers. Among them were a small rover called Rashid for the United Arab Emirates's Mohammed bin Rashid Space Centre and an even smaller two-wheeled robot for the Japan Aerospace Exploration Agency.

ispace plans further launches, but two US firms intend to send up lunar landers in 2023: Intuitive Machines has the Nova-C lander and Astrobotics has the Peregrine lander. They are all still vying to achieve the first successful private moon landing. ■ Leah Crane



**New  
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# Science of the Arctic expedition cruise: Norway

**18 June 2024 | 13 days**

Join our marine expedition exploring the northernmost region of Earth, the realm of the polar bear and the midnight sun. Gain extensive knowledge of marine and polar nature while deepening your connection to this remote and rugged archipelago.

Witness polar bears on ice flows (June is one of the best months to spot them), beluga whales and a plethora of species on land, sea and in the air. Plus, you will explore the Arctic town of Longyearbyen.

Aboard a new state-of-the-art polar expedition vessel, the Greg Mortimer, you will experience the majesty of Norway's Svalbard with its ancient glaciers, glass-still fjords, imposing pack ice and distinct landscape where wildlife thrives at nearly 80° north.

## Highlights

- Accompanied by *New Scientist* podcast editor, author and biologist Rowan Hooper who will give exclusive talks throughout the voyage.
- Carefully curated mixture of daytime activity designed to immerse you in your polar surroundings and evening talks.

- The onboard expedition team (at least one for every eight passengers) will help you experience a range of activities centered around daytime exploration via Zodiac boat safaris (investigating coves, glaciers and wildlife), guided hikes (exploring pristine beaches and stunning wilderness), citizen science and photography (helping you to improve your skills with a camera).
- You will have the opportunity to participate in AE's unique Citizen Science Program. It's designed to be a hands-on, immersive and transformative experience that helps you to protect the beauty of our planet. Various sampling and data collection projects will be conducted on your voyage and a Citizen Science Coordinator will be on hand to introduce and assist you.
- Travel aboard the recently-built Greg Mortimer, a purpose-built low-impact expedition ship for just 132 guests with great facilities and a relaxed and intimate atmosphere.
- On the final evening aboard, the captain will host a Farewell Reception with a four-course dinner and cocktails.



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Neuroscience

# Brain disruption makes us mess up when under pressure

Moheb Costandi

REWARDS usually motivate us to perform better, but a particularly big one can have the opposite effect – like making sportspeople crumble under the pressure at key moments. Now, researchers have identified a potential brain mechanism that may cause us to choke when the stakes are high.

In 2021, Adam Smoulder at Carnegie Mellon University, Pennsylvania, and his colleagues showed that non-human primates can also succumb to pressure.

The researchers trained three rhesus monkeys to perform a difficult reaching task in return for a reward – sugary water – and found that the monkeys performed worst when the reward was most plentiful.

To better understand why this happens, the same researchers trained other rhesus monkeys to reach for a small moving target, which required fast and accurate movements, in exchange for different quantities of sugary water. They used microelectrodes to record the activity of neurons in the animals' motor cortex, the brain region that plans and executes movements.

Smoulder and his colleagues found that individual cells in this region were sensitive to the size of the expected reward and “tuned” their responses accordingly, increasing their activity in anticipation of larger rewards and decreasing it when they expected smaller ones.

When looking at the coordinated activity of the region's cells, the researchers also found neural “signatures”

for planned movements, with each of the monkeys' upcoming efforts to reach out being associated with a distinct pattern of neural activity that corresponded to planning the execution of the movement.

But when the monkeys expected a jackpot reward, the difference between the signatures for each planned movement decreased dramatically. The movement-planning information that was

**“Monkeys choke under pressure in similar ways to us, and our cerebral cortices are similar”**

encoded in the cell population broke down, making the patterns associated with each possible movement harder to distinguish from one another (bioRxiv, doi.org/j7pp).

This suggests that reward-related information interacts with the formation of motor command signals in the motor cortex, say the researchers.

The anticipation of a reward therefore appears to boost our motor planning so that we execute the best possible

movement to achieve this prize, but the expectation of a huge reward seems to interfere with this process, making it harder to select the best motor command. Consequently, the movement may not be prepared, or executed, as well as it could be.

Why this occurs, however, is unclear. “We'd really love to find out if it's the dopamine [a neurotransmitter involved in pleasurable rewards and motivation] system going haywire that throws the motor cortex off balance at the key moment,” says team member Aaron Batista at the University of Pittsburgh, Pennsylvania.

The researchers expect that a similar neurological mechanism occurs in people. “Monkeys choke under pressure in ways similar to how humans do, and the cerebral cortices of monkeys and humans are similar,” says Batista.

It is tantalising to think that if we could eventually find a brain signature displayed when people are about to crumble under the pressure, we could let people know whether they are likely to succumb to it, says Batista. ■



SIPA/SHUTTERSTOCK

A French relay team drop the baton at the 2008 Beijing Olympics

Animal behaviour

# Hyenas seen sharing dens with warthogs and porcupines

Ryan Truscott

**PORCUPINES and warthogs are often eaten by spotted hyenas, but the three species have been seen living in the same dens in Kenya.**

Marc Dupuis-Désormeaux at York University in Toronto and his colleagues were monitoring camera traps in the Lewa wildlife conservancy when they saw strange footage. For periods lasting several weeks between 2016 and 2019, two spotted hyena dens harboured crested porcupines and common warthogs at the same time as hyenas (*African Journal of Ecology*, doi.org/j7tz).

The animals were all using the same entrance, sometimes just 2 minutes apart. “It was like a party,” says Dupuis-Désormeaux.

The same den probably doesn't mean the same bed, though. The dens are likely to have branches and chambers, so each species would probably have had its own quarters, say the researchers.

Hyena droppings near the dens contained no traces of porcupine or warthog. The hyenas may not have eaten their roommates because warthogs and porcupines are well-armed with tusks and spines and, within the confines of a den, hyenas are unable to launch a surprise attack as a group. Plus, despite moments of peak traffic, warthogs tended to vacate the den during the day, while the porcupines and hyenas, which are mostly nocturnal, would have left at night.

Communal living may also benefit porcupines, which crunch on bones, a food that hyenas are likely to bring back to the dens.

But it doesn't appear the den-shares were a long-term arrangement. They haven't been seen since 2019. “Maybe it was just a freak thing,” says Dupuis-Désormeaux. “It may happen every now and then, when the conditions are such that they provide a small window of opportunity.” ■



Ecology

# Wildfires have drastically reduced lynx habitat in Washington state

Corryn Wetzel

CANADA lynxes in Washington state have had about a third of their habitat destroyed by fires in the past two decades, slashing the region's ability to support the cats.

The stocky, short-tailed cats, which can be identified by their black ear tufts and tail tip, once ranged across snowy forests in North America. Canada lynx (*Lynx canadensis*) were hunted for their pelts in the 1900s, but habitat and hunting protections in recent decades have aided their recovery. Tens of thousands are now found in Canada's forests. But many populations in the continental US have been slower to recover or are declining. There, the species is classified as threatened under the Endangered Species Act.

Based on limited observations, experts suspect that Washington state is home to fewer than 50 lynx, all of which live in the North Cascades mountains. Lynx rely on snowshoe hares as prey, but fires have been charring the vegetation the hares feed on in recent years, so the cats' primary food source has become scarce.



JANET HORTON/ALAMY

## Canada lynx are a threatened species in the continental US

To find out more, Andrea Lyons at the Washington Conservation Science Institute and her colleagues used population simulation software to estimate how many lynx the region can sustain given its resources. They assessed the cats' range in Washington state during three time periods: during 2000, before fires were common in the region; in 2013, when about 17 per cent of

the region's area burned; and in 2020, when 15 per cent more was scorched – almost a third in total.

The team found that wildfires dramatically altered the region's ability to support lynx, reducing the maximum number of cats the area can host by up to 73 per cent.

"It provided this really apparent trend that things are not going in the right direction for lynx," says Lyons. The trend mirrors the region's falling lynx numbers reported since the turn of the century (*Journal of Wildlife Management*, doi.org/j7kf).

Contrasting three time periods is a strength of the paper, says Karen Hodges at the University of British Columbia in Canada. She says she was impressed by the collaboration between experts on forest, fire and wildlife. "It really offers a unique opportunity for some of these insights."

The surge in big fires is in part fuelled by rising temperatures and drier summers linked to climate change. But their severity is also increased by a tradition of stopping blazes. Limiting the spread of fires has loaded forests with combustible material, so when they do ignite, they can be bigger and more destructive, says Lyons.

"These fires are burning so hot that it's taking the food source for the snowshoe hares longer to recover," says Lyons. Some areas may benefit from prescribed burns or removing flammable vegetation, which could limit the power of future fires. "Lynx habitat is generally managed with a hands-off approach, but we might need to do something a little differently for lynx here." ■

Astrophysics

# Supermassive black hole reveals its powerful jet

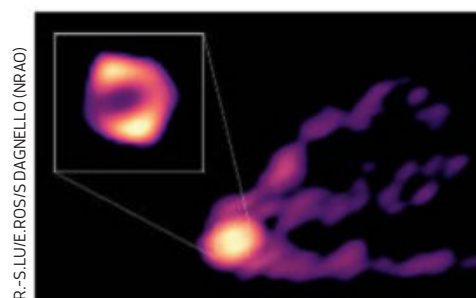
THE disc of matter falling into a black hole and the powerful winds created by that process have been unveiled by a new image. The black hole in question, M87\*, was the first one to be directly imaged, and this new information will help us understand how it works.

M87\* is about 55 million light years away, and it lies at the centre of an enormous galaxy called M87. In 2017, the eight telescopes of the Event Horizon Telescope (EHT) took

the first image of M87\*, a fuzzy-looking doughnut shape showing the silhouette of the black hole against a background of glowing matter falling into it, in what is called an accretion flow.

Now, another team has used a network of 10 radio telescopes to take an image (pictured, right) using a longer wavelength of radio emissions. They spotted a similar shape, but it was about 50 per cent thicker than the one seen by the EHT (*Nature*, doi.org/j7k3).

"Frankly speaking, I did not expect to see the ring with these observations, while we expected we might see the outer part of the



R.-S. LU/E. ROS/S. D'AGNELLO (INRAO)

accretion flow," says Keiichi Asada at Academia Sinica in Taiwan. Because the observing frequency of this set of telescopes is about one-third of that of the EHT, the image should be about three times blurrier, which the researchers expected to smear out the black hole's shadow in the centre.

Instead, the image showed the black hole's silhouette, the accretion flow and the jet emerging from the system. Simulations of the system revealed that the jet's base is wider than anticipated, and the accretion flow seems to be powering an unexpectedly strong wind.

There are already plans to observe M87\* at an even broader range of frequencies.

"By combining information obtained at different frequencies, we will be able to understand the accretion flow and innermost region of the jet together with the black hole itself," says Asada. ■ Leah Crane



# Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

**With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.**

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

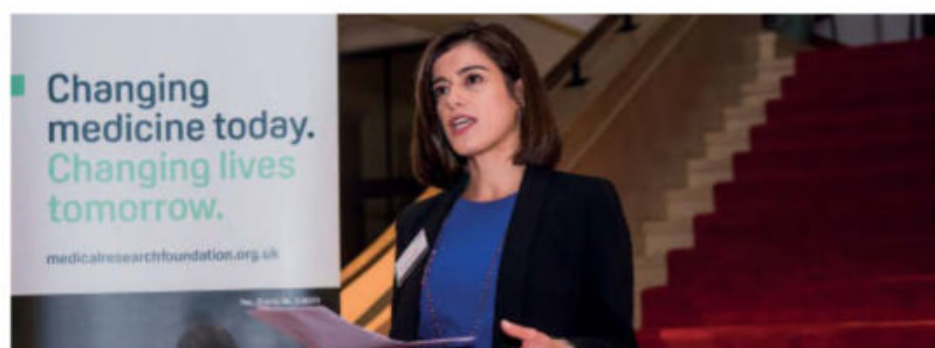
Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

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**“As scientists, our duty is to secure the future of research for the generations that follow.”**

Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that



“The funding I received through the Medical Research Foundation will be transformative for my research.” Dr Myrsini Kaforou

research forward, are the key to meeting those challenges for years to come.

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

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## Technology

### A way to write words inside liquid

WRITING on solid materials, like paper, is possible because ink binds to the surface and remains undisturbed. But in a liquid, ink quickly disperses – until now.

Thomas Palberg at Johannes Gutenberg University Mainz in Germany and his colleagues have used a resin bead to draw lines in water containing ink particles.

The technique works because as the bead moves through the water, it produces paths of low acidity that attract the ink particles. The researchers managed to form words, shapes, including the initials of Johannes Gutenberg University, and a simple drawing of a house ([arXiv, doi.org/j7p2](https://arxiv.org/doi.org/j7p2)).

The lines began to widen after 10 minutes, but Palberg says it should be possible to fix them in place permanently using ultraviolet light. **Alex Wilkins**



FERNANDO SOLEY

## Food science

### Yeast-filled robots speed up brewing

TINY robots packed with yeast speed up the fermentation of beer and eliminate the need to filter it.

Martin Pumera at the Brno University of Technology in the Czech Republic and his colleagues made the robots, called BioBots, by encasing yeast cells and iron oxide in porous shells of alginate, a gelatine-like material. Then they added the robots to the sugary liquid used to make beer.

Yeast cells usually float, turning sugars into alcohol and carbon monoxide gas. But with the yeast inside the BioBots, released gas moved the robots up and down, accelerating fermentation: it took 6 to 12 hours instead of several days ([ACS Nano, doi.org/gr59zz](https://doi.org/10.1021/acs.nanolett.2c05922)).

The BioBots were then pulled up with magnets and skimmed off, so the yeast was removed without the usual need for filtering. **Karmela Padavic-Callaghan**

## Zoology

### Assassin bugs lather up with sticky resin to help trap prey

BUGS in Australia utilise gooey plant resin to help them capture prey, in a rare example of tool use by insects.

Australian assassin bugs, from the genus *Gorareduvius*, are often seen resting on the blades of spinifex grass. This grass produces sticky resin that was used by the first human inhabitants of Australia for tool-making.

Biologists thought several species of assassin bugs might be using the spinifex resin for capturing prey, but this had never been shown in experiments, says Fernando Soley at Macquarie University in Sydney.

So he and his colleague Marie Herberstein, also at Macquarie University, collected 26 assassin bugs in the Kimberley region of

Western Australia. They noticed that males, females and immature nymphs scraped the resin off the leaves of spinifex and meticulously applied it over the body, especially their forelegs.

Each bug was placed in a glass jar and offered two prey, a housefly and an ant, one at a time. Then the researchers removed the resin from the bugs with makeup remover pads and repeated the experiment.

The bugs were 26 per cent more successful at capturing prey when equipped with resin than without it. Without resin, the flies were 64 per cent more likely to escape ([Biology Letters, doi.org/j7pv](https://doi.org/10.1093/biollett/blz100)).

The resin didn't guarantee success, but it seemed to slow down the prey enough for the assassin bugs to grasp and stab it.

Soley and Herberstein say this is an example of tool use by insects, which is quite rare. The behaviour may be hardwired, they say, because they saw even freshly hatched nymphs smearing the resin over themselves. **Soumya Sagar**

## Really brief



ANGELALEXIS LUNA LARIOS/SHUTTERS TOCK

### Excess melatonin in supplements

Most chewy melatonin supplements sold in the US contain far more of this hormone – which helps regulate our circadian rhythms – than is listed on labels. This increases the risk of overdosing, especially in children who may mistake these gummies for sweets ([JAMA, doi.org/gr6dp9](https://doi.org/10.1093/jama/gr6dp9)).

### Famous husky Balto was a mix of breeds

An analysis of the genome of sled dog Balto, thought to be a Siberian husky, reveals he was also descended from Greenland sled dogs, Vietnamese village dogs and Tibetan mastiffs. Balto led a team on a journey in Alaska in 1925 to deliver diphtheria medicine ([Science, DOI: 10.1126/science.abn5887](https://doi.org/10.1126/science.abn5887)).

### Pop a pill to make yourself hungry

A pill has been used to electrically stimulate stomach cells in pigs to increase levels of ghrelin, a hormone that regulates hunger and alleviates nausea. If it works in humans, it could treat nausea, vomiting and lack of appetite in those having cancer treatment ([Science Robotics, doi.org/gr6jrq](https://doi.org/10.1093/robotics/gr6jrq)).



# Signal Boost

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **The Royal Society of Medicine**



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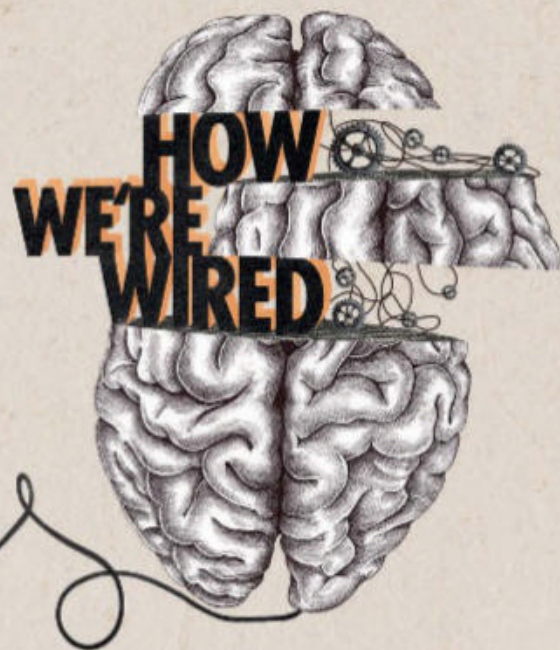
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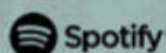
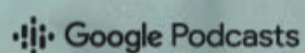
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## Culture columnist

Jacob Aron plays a nature-based city building game **p36**

## Comment

# Overcoming your inner goblin

A rise in antisocial behaviour indicates covid-19 lockdowns disrupted our cultural evolution, says **Jonathan R. Goodman**

**R**ECENTLY, some colleagues of mine put on a public health conference. More than 80 people registered for the in-person-only event, and we ordered coffees and snacks for a little under that number – assuming, as is the norm, that 20 to 30 per cent of people would drop out.

Surprisingly, it was closer to 90 per cent. Only a handful of people showed up. We were shocked and distressed, and started speculating about why the turnout was so bad. Then someone mentioned that this kind of thing is more common after the covid-19 lockdowns: people just don't like leaving their homes anymore.

A quick search online will show you that our experience wasn't a fluke. Some journalists and science centres have also noted that people were behaving antisocially – harassing others or causing distress – during the lockdowns. All this suggests that the process underlying cultural change – what is known as cultural evolution – requires a lot of regular social interaction to maintain itself. Society is probably more fragile than many of us would like to think.

Cultural evolution is how information that can't be encoded in your genes is shared or changes. We learn a lot from our elders and contemporaries, things like language and social norms that we just can't spring from the womb understanding. Over the past 30 years or so, cultural evolution



SIMONE ROTELLA

has exploded as an academic field, with computer models and lab experiments showing that the cultural sharing of social norms is central to the stability of society.

Yet it may be that those norms need a lot more maintenance than we might have thought. A 2022 paper in *Crime Science* showed a 50 per cent uptick in antisocial behaviours during periods in 2020 and 2021. These findings contrasted strongly with data suggesting that rates of crimes such as theft and burglary dropped.

Other strange trends – or new cultural traits, to use the language of cultural evolution researchers –

popped up over the 2020 to 2022 period. People started referring to “goblin mode”, or hiding in your house, closing the blinds, playing games, watching TV and eating junk food for hours. (I confess that when I first heard the term, I thought: “That sounds nice!”)

In a way, the covid-19 lockdowns were a large-scale experiment in what happens to our culturally transmitted norms when we enforce physical separation from others. The results are, to say the least, discouraging. The behaviours we have seen over the past few years suggest that not only do we need cultural

transmission to learn how to behave sociably, we need repeated and regular interaction to maintain norms. In other words, if I explain to a child that it is mean to yell at other people, it seems it isn't enough to only do this once.

The behaviours we have seen – and continue to see, if our recent conference failure reflects wider trends – indicate that covid-19 lockdowns forced a kind of reverse cultural evolutionary process. We are social animals who need regular interaction, and depriving us of socialising releases a culturally primitive, largely antisocial goblin.

The good news, however, is that the world's accidental experiment in the shortcomings of our ability to hold on to cultural norms implicitly suggests some fixes. It is clear that digital communication – sitting in depressing Zoom meetings and playing the odd online game with friends – isn't enough to maintain norms across society. And so we, individually and as cultural groups, should promote in-person socialisation (this does not mean required appearances at the office) where possible – and encourage others to overcome their inner goblins.

Otherwise, at the very least, many more free biscuits might go to waste. ■



Jonathan R. Goodman is author of *Invisible Rivals: How we evolved to compete in a cooperative world*, out in 2024



## No planet B

**Keeping fossil fuels underground** A radical new proposal wants the world to sign up to a deal to halt development of new oil, gas and coal fields. It is gaining a lot of traction, says **Graham Lawton**



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

### Graham's week

#### What I'm reading

*An old favourite, the Jeeves and Wooster stories by P.G. Wodehouse*

#### What I'm watching

*Beef on Netflix*

#### What I'm working on

*I have a new cat, he needs some work...*

This column appears monthly. Up next week: Annalee Newitz

**J**UST over a year ago, climate activists were breathing a sigh of relief at news that a planned new oilfield in the North Sea, Cambo, was to be shelved after investor Shell pulled out. At the time, *New Scientist* speculated this might “mark the end of new oil and gas extraction in the region”.

If only. Last month, the UK government confirmed that it will press ahead with new rounds of licensing for oil and gas. A decision is also pending on an oilfield called Rosebank, the largest undeveloped resource in the North Sea.

On the surface this looks absurd. How does the continued extraction of fossil fuels fit with the UK's net-zero commitment, let alone the UN's Paris Agreement on climate change? What sense does it make to invest in a source of energy that is already outcompeted by renewables?

Drill deeper, however, and the real reason comes to light. It is still absurd, but perhaps slightly less so. With Rosebank, the UK is simply living up to its legal obligations. Yes, you read that right. The UK is legally bound to let Rosebank be sucked dry of oil, assuming the investors decide they want to do that.

That is because the UK is a signatory to a little-known entity called the Energy Charter Treaty, which came into force in 1998 to help the countries of the former Soviet Union and Eastern Europe integrate into global energy markets. One of its provisions is that corporations can sue national governments for loss of profit if the government doesn't make good on its promises.

The UK government issued a licence for Rosebank in 2001. If the project jumps through the final regulatory hoops only to be denied by a ministerial veto, its current licensees could sue for

compensation. Some existing claims in other countries run into the billions.

This seems like yet more proof that the fossil fuel industry has the planet over a barrel. But there is an alternative waiting in the wings. It is called the Fossil Fuel Non-Proliferation Treaty and the campaign behind it aims to get the world to sign up to a deal to halt the development of all new oil, gas and coal fields. The proposed treaty is the brainchild of Peter Newell and Andrew Simms, who both work on energy transition at the University of Sussex in Brighton, UK. They came up with

### “Peter Newell and Andrew Simms first came up with the idea for the treaty over a few drinks”

it in 2018 over a few drinks. But it wasn't one of those beer-fuelled ideas that crumbles under the light of day.

In fact, it has gained remarkable traction for such a radical proposal. It is backed by thousands of scientists and NGOs, the European Parliament, the World Health Organization and more than 70 city governments. In 2022, Vanuatu was the first nation state to endorse the treaty. It was soon joined by Tuvalu, and last month Tonga, Fiji, Niue and the Solomon Islands climbed on board.

As the new treaty's star rises, the old one's fades. Russia and Norway signed the Energy Charter Treaty, but didn't ratify it. Italy pulled out in 2016 over environmental concerns. France, Germany and Poland have notified the treaty of their intent to withdraw, while Denmark, Luxembourg, the Netherlands, Poland and Slovenia

have said they plan to do so.

The proposed treaty has history on its side, says Julia Steinberger at the University of Lausanne, Switzerland, a lead author on the latest Intergovernmental Panel on Climate Change (IPCC) report.

“The fossil fuel industry itself can't be trusted,” she says. “We know that in a very simple way: because they still exist. Exxon knew already since 50 years that the emissions from their product caused climate change.” Instead of investing in alternatives, she says, the industry spread disinformation and doubled down.

“The only way that we can sensibly prevent climate cataclysm from worsening is to move our politicians and governments to openly confront this industry by endorsing and passing the Fossil Fuel Non-Proliferation Treaty,” she says.

Good luck with that. According to Simms, the standard politician's response is “we've got the Paris Agreement, why do we need that?” The answer, he says, is that the Paris Agreement doesn't mention fossil fuels. They are also a taboo subject at climate talks. Yet they are the single most important contributor to global warming. Hence the need for an explicit mechanism to bury them.

The exact wording of the treaty, the path forward and how it would be policed are all still unclear. Time is also not on our side. But as Newell and Simms point out, their inspiration, the 1968 Treaty on the Non-Proliferation of Nuclear Weapons, took only three years to negotiate. It didn't entirely stop nuclear proliferation, but it arguably reduced the risk of nuclear annihilation, at least until now. Fossil fuels will also surely fry us unless we find a way to keep them where they belong: underground. ■



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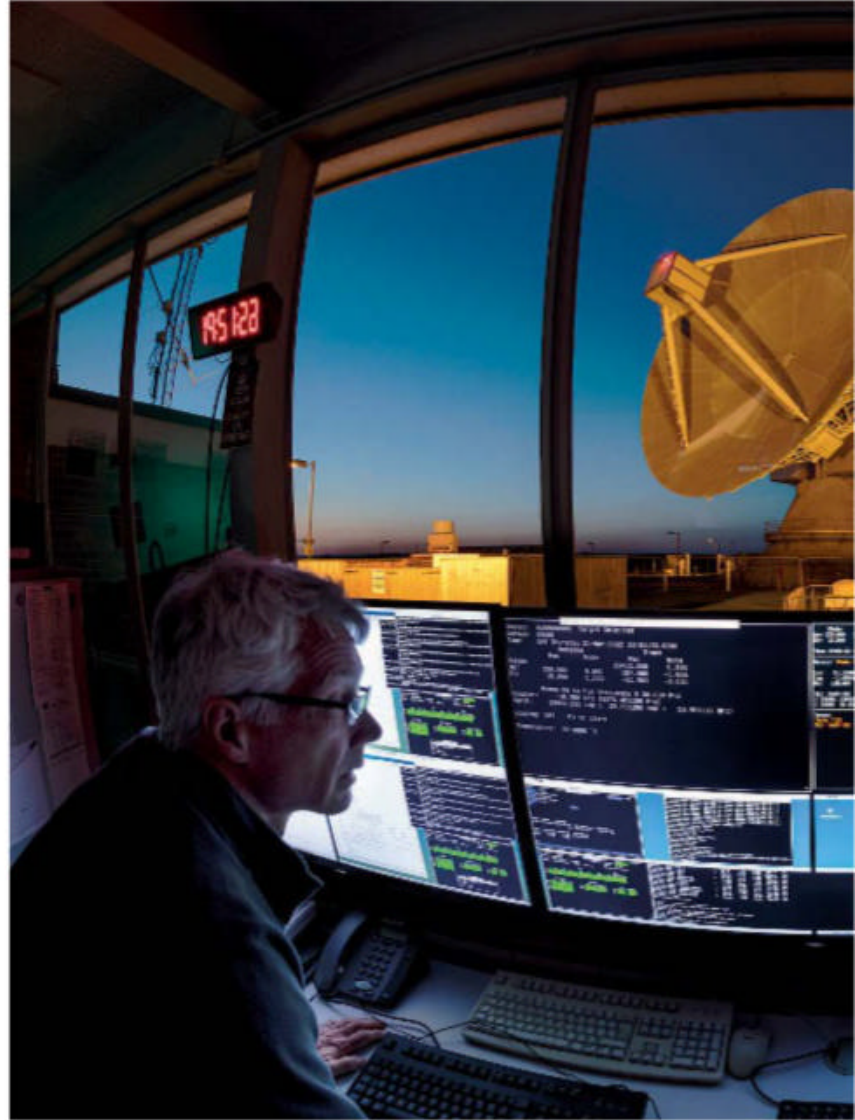
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## Space junk



Photographer **Max Alexander**

THESE images aren't just a whimsical collection of space memorabilia. Part of *Our Fragile Space: Protecting the near-space environment*, an exhibition by photographer Max Alexander, they highlight a growing problem: increasing amounts of debris are orbiting Earth in the same region of space as thousands of satellites, heightening the risk of collisions.

Alexander collaborated with astronomy writer Stuart Clark, the University of Warwick, UK, and its Centre for Space Domain Awareness, among others, to draw attention to the impact of the some 160 million pieces of cosmic waste circling Earth – all of which have human-made origins.

Clockwise from top left, the images show: a fuel tank from the second stage of a Delta rocket that returned to Earth in 1997, with craters from impacts with space debris and micrometeorites; the control room of Chilbolton Observatory, the main UK facility for tracking civilian satellites and space debris; a piece of an Ariane 4 rocket, which launched a satellite in 1995 that was later involved in the first verified satellite-debris collision; a puncture made in an aluminium plate by a plastic projectile travelling at high velocity, as part of a study into the effects of impacts at orbital speed; a view of Greenwich in London with a montage of examples of space debris superimposed on the sky; and an astronaut's glove dropped during a spacewalk from the Gemini IV mission in 1965.

*Our Fragile Space* will run at Coventry Cathedral, UK, from 6 to 21 May; at the Vienna International Centre in Austria from 31 May to 9 June; then at Jodrell Bank, UK, from 12 June to mid-September. ■

**Gege Li**



## Editor's pick

### How to get to grips with conspiracy theories

15 April, p 12

From Philip Welsby, Edinburgh, UK

**It seems that conspiracy theories are very hard to counter, the problem being that it is difficult to change people's minds. A possible solution to this seemingly insoluble problem is to encourage them to change their own minds.**

**Asking "Is there any evidence that would cause you to change your mind?" would force people to think for themselves. If their answer is no, then you should stop wasting your time. If it is yes, with an outline of the evidence they would require, you can assess whether it is worth investing time in the discussion.**

From Tim McCormick,

Evesham, Worcestershire, UK

I am often, and depressingly, amazed by a general lack of basic scientific or even factual knowledge among some people.

Sometimes, I will ask others about the stars, for instance. All those tiny points of light in the night sky: what do you think they are? It is staggering how many people have no clue at all how far away they might be or what their relationship with our own sun could be. Nor can they give a ballpark idea of how far away our sun, the moon or the other planets could be from Earth.

We need to devise a school syllabus for learning such things. If people know how far the stars are, they are less likely to believe in flying saucers. If they have a basic grasp of gravity, they will know that a double-decker bus 25 metres away exerts more pull on them than all the planets – aside from Earth – combined, and will be less likely to believe in astrology.

From Steph Györy,

Sydney, Australia

You note that the most effective method so far reported to counter conspiracy theories is a three-

month course where people are taught how to think, not what to think. You have just described critical thinking, and the solution would seem to be teaching this to everyone from a very young age.

### Too much indulgence may not be a good thing

15 April, p 51

From Gautam Menon,

Walsall, West Midlands, UK

It was interesting to read David Robson's take on procrastination.

Virtually everyone will have experienced trouble getting going with a project, task, report or piece of homework.

To explain this as a conditional and subliminal response to fear of failure is illustrative. While methods to mitigate this may include deconstructing the task or asking for help, I am not certain if "strategic indulgence" is a good method. There is probably a fine line between recharging oneself by being indulgent and feeling even more despondent should the indulgence be perceived as having wasted more time.

### No need to worry about the quantum observer

8 April, p 36

From Roger Hull,

Craigellachie, Moray, UK

The idea that a conscious being is needed to collapse the quantum wave function, which describes the probability that a particle will behave a certain way, has been abandoned by most physicists.

The main difficulty in building quantum computers is how to maintain the quantum state (another name for wave function) through multiple quantum gates – which do the processing – for long enough to do something useful.

Stray interactions of any type cause an immediate collapse, which is why IBM and others are building giant fridges for their quantum computers to avoid thermal disturbances. To get the results of a computation, one or more qubits must be measured, putting them into a definite state. None of this is mediated by a conscious being.

### Is big food changing the natural microbial milieu?

15 April, p 46

From Anne Sweeney,

Maidenhead, Berkshire, UK

With reference to your feature on the extinction of microbes, one thing has increasingly concerned me. The fruit and vegetables I grow on my allotment decay very differently from the same varieties purchased at a supermarket.

Perhaps the time has come for serious research into whether the globalisation of food products, along with whatever is being done to prevent them decaying naturally, is having a potentially catastrophic affect on microbes worldwide. I seriously worry about what happens when foods that don't rot quickly and naturally, especially imported products, are turned into compost and added to the soil.

### Why heat pumps are a good option now

Letters, 22 April

From Diana Wilkins,

Lewes, East Sussex, UK

David Le Maistre suggests that his gas boiler has a lower carbon footprint than a heat pump. This isn't the case. As leading energy efficiency expert Jan Rosenow states: "A heat pump delivers about three units of heat for one unit of

energy... A gas boiler delivers only about 0.9 units of heat for one unit of energy." As a result, "the numbers support the early retirement of gas boilers".

Given the seriousness of the climate crisis, it is important to get this point over.

### Brightest of all time? Maybe not, after all

8 April, p 19

From Adam Osen,

Harlow, Essex, UK

You report on an extremely powerful space explosion that may have broken our understanding of how similar explosions work. This event, called GRB221009A, was a gamma ray burst (GRB) and has been dubbed "the BOAT" – the brightest of all time.

Eric Burns at Louisiana State University and his colleagues found that GRBs this bright probably only occur about once every 10,000 years, so the title of BOAT is said to fit. Well, it doesn't.

We can't say for sure when time began. It may have started when our universe did, at the big bang, 14 billion years ago. But it may go back further than that if the big bang was, in fact, a big bounce.

Even taking the shorter time span of 14 billion years, there will have been 1.4 million of these explosions in all time, making this a common event. Since the 10,000 years is an estimate, and an average, this may not even be the brightest of human time, itself not even a blip in all time. Calling GRB221009A the brightest of all time is a tad hubristic.

### Birds of prey are well aware of glowing mice

1 April, p 11

From Alex Bowman, Glasgow, UK

Researchers aren't the first living beings to notice that an ultraviolet glow can betray the presence of small animals such as dormice – eagles can see in UV and are said to use this ability to hunt small mammals. ■



### Want to get in touch?

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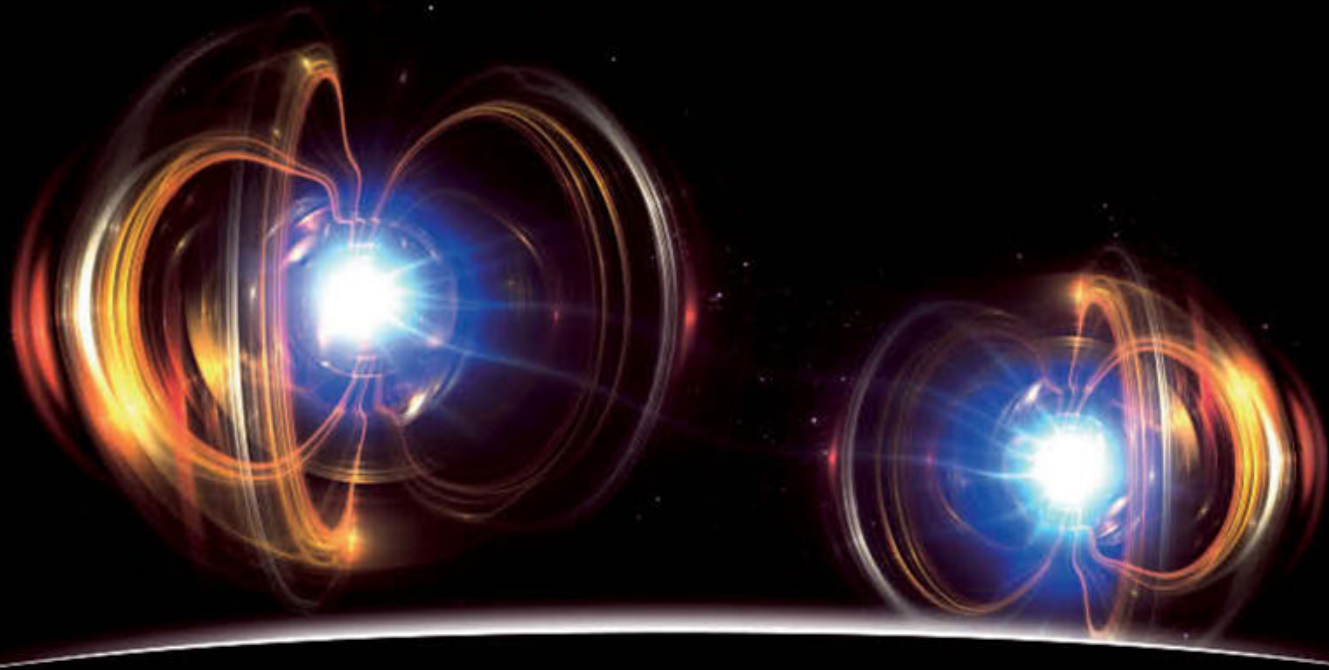


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# Wild at heart

Domestic cats are a paradox, argues a new book that delves into their origins and the emerging science of feline behaviour. **Michael Marshall** explores



Book

## The Age of Cats

Jonathan B. Losos

HarperCollins (UK, out 11 May)

ON THE face of it, as Jonathan B. Losos admits early in his new book, it isn't obvious why he would write about cats.

Losos, a biologist at Washington University in St Louis, Missouri, has spent most of his career studying the evolution of lizards. His research has explored the mechanisms driving this and, by extension, how evolution works in general.

This culminated in his 2017 book *Improbable Destinies*, which tackled a long-standing biological mystery: is evolution wildly unpredictable, or is it liable to produce the same solutions to the same recurring problems? Losos concluded that it is a bit of both.

All of which is fine, but why follow that up with a book on the biology and evolution of cats? As Losos explains in chapter one, he has loved cats since he was 5, when he and his mother adopted a Siamese called Tammy as a surprise for his father's birthday. Despite being a budding biologist, it never occurred to him to study cats – they are too secretive, he says. Lizards seemed altogether more manageable.

Nevertheless, in later life, Losos discovered the burgeoning field of cat biology and used it as a hook for an introductory biology course he was teaching. In the process, he ended up going down the cat science rabbit hole, and *The Age of Cats: From the savannah to your sofa* (published in the US as *The Cat's Meow: How cats evolved from the savanna to your sofa*) is the result.

The book is a wide-ranging



Domestic cats may have a less intense fear response than wildcats

fear response, enabling them to spend more time with us.

He also tackles the science of feline behaviour, including experiments showing that domestic cats meow differently to wildcats – perhaps to make their calls more appealing to humans. I particularly appreciated Losos's effort, in a footnote, to devise a name for cat biology. Rejecting "felinology", which combines Greek and Latin, he proposes the all-Greek "ailurology".

In the final chapters, Losos asks where cat evolution is heading. Clearly, part of the answer is towards an increasing diversity of breeds, as people experiment to see what they can come up with. He suggests, tongue slightly in cheek, that we might breed a domestic variety with massive canine teeth like those of the extinct sabre-toothed cats.

But Losos's big idea is that we should breed cats that don't want to hunt. He highlights evidence domestic felines hunt significantly less than feral ones, so their impact on small animal populations has already been reduced.

He argues we could take this further, selectively breeding only the cats that hunt the least. This would reduce the environmental toll of these pets considerably, without the need to keep them indoors (which makes many owners uncomfortable).

Such cats would be totally dependent on their humans for food. This would be a big step towards true domestication, and perhaps the biggest change in cat biology in 10,000 years. ■

Michael Marshall is a writer based in Devon, UK

guide to the biology of cats, from their evolutionary origins and partial domestication to their behaviour and genetics. This diversity of material makes

**“Losos's big idea is to breed cats that don't want to hunt. This would reduce their environmental toll”**

for slightly disjointed reading: the book would have benefited from restructuring to give it a better flow. But the individual chapters are all excellent. Losos is an engaging and often funny guide who explains the science clearly and with nuance.

The central premise of *The Age of Cats* is that domestic cats are something of a paradox. In many ways, they have barely changed

from their wild ancestors: Losos describes an encounter on safari with an African wildcat, which he initially mistook for a domestic one. Yet modern cat breeds like Siamese are drastically different from anything found in nature. “How can cat evolution be simultaneously in slow and fast gear?” asks Losos. The answer, he concludes, is that “multiple realms of cats exist”. Pedigree cats, whose breeding is strictly controlled, aren't the same as ordinary ones that breed with any other cat they please (unless they are neutered).

Along the way, Losos explores the archaeological evidence for when and where cats first started hanging out with humans. He digs into the genetics, which suggests that most domestic cats are only subtly different from wildcats – but these changes may include crucial ones such as a reduced



# Musical magic

Transmuting the sounds of the deep ocean and the marvels of geometry into music is a class act, finds **Bethan Ackerley**



**Music**  
**Wild Wet World**  
Cosmo Sheldrake

**Torus**  
Emily Howard  
NMC Recordings

THERE are worlds out there, both beyond and within our own, that aren't easily reached or captured in the mind's eye. Two new albums tackling disparate subjects – the soundscape of the deep ocean and the many wonders of geometry – have managed to bring two such realms to life, making the intangible tangible through their carefully crafted songs.

*Wild Wet World*, the latest album from musician and composer Cosmo Sheldrake, is a seven-track homage to the ocean as told by the creatures in it. It is a sonic collage of marine life, comprised almost entirely of underwater recordings. These range from whale song and grunting toadfish to the drumming of male haddock, a mating call each

Composer Cosmo Sheldrake celebrates the ocean using recordings of the creatures in it



FLORA WALLACE

creates by vibrating specialised muscles next to its swim bladder.

While sounds recur across tracks – the snapping of shrimp, a crackling noise that can be heard throughout the ocean, forms the backdrop to most of them – they are recontextualised so judiciously you hardly notice it. *Benthos*, for instance, named for the organisms at the bottom of a body of water, is pulsating and grimy in a way quite unlike any other song on the album, despite sharing sounds with tracks like *Plankton* and *Blow Hole*.

The recordings were captured by marine biologists, the US Navy or Sheldrake himself. The only time a human presence is felt is in the album's opening track, *Bathed in Sound*, where Sheldrake's haunting vocals bring the listener down into the depths of the ocean and conjure images of whales "all wrapped in plankton and glinting green, drifting onwards through shifting seas".

Those shifting seas, beset by overfishing, pollution and ambient human-made noise, are highlighted in the album's final song, *Nekton*, featuring the mournful calls of the UK's last resident colony of orcas in the Hebrides. While our oceans can feel remote and alien at times, the album's call to conserve them is a

concrete message to hold onto.

A more abstract realm is conjured by composer Emily Howard in *Torus*, a collection of four geometry-inspired pieces. Each of these "orchestral geometries" attempts to capture the "shape energy" of its subject – language that might alienate some listeners, but Howard's lyricism has led to marvellously uncanny results that take vast leaps in pitch and volume in their stride.

The album's title track is a 20-minute epic depicting that topological marvel the torus, a three-dimensional shape with one hole that is often likened to a ring doughnut. This is perhaps the easiest composition to connect to its corresponding shape. You feel a sense of oscillation and the void at its centre. At points, you could easily imagine yourself beside an actual torus: a thrumming tokamak at the heart of a nuclear fusion reactor.

To compose *Sphere*, the album's outlier in that it is just 5 minutes long, Howard imagined travelling over the shape's convex surface and encountering new landscapes. It is a spiralling work of fits and starts, with long pauses punctuated by bursts of brass and restless strings.

But it is in rendering *Sphere's* dark double, *Antisphere*, that *Torus* is most interesting. Picturing this shape – a surface with constant negative curvature that falls outside Euclidean geometry – would be difficult enough, let alone capturing it in sound. The result is triumphant and strange, a shimmering klaxon that sounds like the workings of some near-future mechanism.

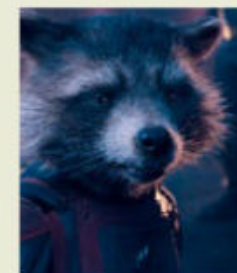
*Antisphere* shares some DNA with another track, *Compass*, a marriage of percussion and strings that is the most opaque of the four pieces. It is also the only one that left me feeling adrift – but there are far worse places to get lost than in these vivid geometries. ■

## Don't miss



### Visit

**Animals: Art, science and sound** exhibits artefacts from centuries of exploring the animal world. See beetles' iridescent colours and illustrations (pictured) by naturalist John Abbot, at the British Library, London, until 28 August.



### Watch

**Guardians of the Galaxy Vol. 3** is director James Gunn's emotional farewell to the Marvel Cinematic Universe's most colourful heroes, like Rocket (pictured). Peter Quill (Chris Pratt) rallies his team to protect one of their own. In cinemas now.



### Visit

**A Microbial Future** beckons as Robin May celebrates the potential of organisms that have existed for a thousand times longer than us. The talk is at Gresham College in London or online, at 6pm BST/ 1pm EDT on 10 May.



## The games column

**Build it and they will come** Simulation-style city builders like *SimCity* have tended to mirror US urban living. *Terra Nil*, the latest of a new and very different wave of builder games, puts nature first, says **Jacob Aron**



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



**Terra Nil always lets you leave the world better than you found it**

as a reverse city builder and a great example of how you can create something new by challenging the assumptions of a storied series like *SimCity*. The game tasks you with restoring lifeless wastelands, from dried-up river valleys to flooded cities, with the goal of building a thriving ecosystem.

While a traditional city builder might have you laying roads or placing residential zones, *Terra Nil* is all about creating the right conditions to promote plant species, such as trees or grasses. You do this by placing energy sources – renewable, of course – to power toxin scrubbers, irrigators, dehumidifiers and other facilities that manipulate the local environment. Each building costs you a number of “leaves” (the game’s currency), while hitting restoration goals grants you more of them, so it is a constant balance between encouraging nature and allowing it to take its own course. You can’t simply plaster the landscape in technology.

Once you achieve a certain spread of plant life, animals will start returning to the world. This happens through a nice mini game that has you hunting down certain habitats – a forest by the coast, for example – in your new ecosystem. Then, in a masterstroke, you can only complete a level by disassembling and recycling all the machines you have built. This creates its own puzzle, as you try to reduce your infrastructure footprint to a single airship that flies away, leaving a pristine landscape that the game invites you to contemplate. Unlike *SimCity*, there are no disasters – you will always leave the world a better place than you found it. ■



### Game

#### Terra Nil

Free Lives

PC, Android, iOS

### Jacob also recommends...

### Game

#### SimCity (2013)

Maxis

PC

#### Townscaper

Oskar Stålberg

PC, Xbox One and Series X/S, Nintendo Switch, Android, iOS

#### Frostpunk

11 bit studios

PC, PlayStation 4, Xbox One and Series X/S

WHEN I was a child, my neighbour and I would often while away the weekend playing *SimCity 2000* on his computer. We would work together to build a sprawling metropolis before destroying it by selecting from a tempting menu of disasters, which you could use to wreak havoc on your creation.

I have been a fan of the city-building genre ever since, but a 2013 interview forever changed the way I view the games. Speaking to *The Atlantic* about the release of a new *SimCity*, lead designer Stone Librande explained why his team had decided not to include car parks. “We were originally just going to model real cities, but we quickly realised there were way too many parking lots in the real world and that our game was going to be really boring,” he said.

I find this fascinating because it shines a light on a somewhat dirty secret of simulation-style games – far from being neutral reflections of reality, they involve trade-offs that encode specific world views. In the case of the *SimCity* series, that is a US, car-centric model of urban living. The games have

in-built beliefs about city layouts that make it hard to recreate the lived-in, weaving roads of London or Paris, yet easy to produce the stark grid of New York or the sprawl of Houston.

Now, a new generation of city builders are looking at different ways of modelling the built environment. Take *Townscaper*,

**“The game is a constant balance between encouraging nature and allowing it to take its own course”**

which lets you create charming and colourful island towns with a swish of a cursor. With no way to fail and no specific goal, it is more of a meditative toy than a game. Then there is *Frostpunk*, a game which, despite being set on a frozen version of Earth, calls to mind some of the challenges we face on a warming world today. I reviewed the original in 2019 and am eagerly awaiting a sequel.

The latest game to widen the genre is *Terra Nil*, which is billed





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*Impatient*

# Paying attention to ADHD

More and more people suspect they have attention deficit hyperactivity disorder, including **Caroline Williams**. But how can we best diagnose this misunderstood condition and help those who have it?

**I**BET I can make you roll your eyes: I think I have ADHD. I imagine you are thinking: “Of course you have. How kooky. How creative. Now, go away and post about it on social media.” If so, I totally understand. Since I first saw a list of ADHD symptoms in the mid-2000s and had an “aha” moment, I have lost count of the number of times I have talked myself in and out of seeking a diagnosis.

At first, it was because the idea felt ridiculous. Back then, attention deficit hyperactivity disorder – to give it its full name – was for fidgety schoolboys. Fully grown women with a career and family need not apply.

Nearly 20 years later, I still feel ridiculous, but now it is because ADHD is so apparently fashionable. From celebrity interviews to



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variation. And as new research questions the core nature of ADHD, we may even need to rethink this condition.

The first mention of a condition that seems similar to ADHD in medical texts was in 1798, when physician Alexander Crichton described the “incapacity of attending with a necessary degree of constancy to any one object”. According to Crichton, these people had their own name for what they experienced. “They say they have the fidgets,” he wrote.

Since then, the condition has been renamed many times. Between the 1930s and 1980s, it was known as hyperkinetic disorder. The modern name was coined by the American Psychiatric Association in the 1994 edition of the Diagnostic and Statistical Manual of Mental Disorders. Known as the DSM, this document provides official guidance on how to diagnose ADHD in the US. The World Health Organization’s International Classification of Diseases provides a similar list of diagnostic symptoms. In both systems, being a bit fidgety doesn’t cut it. To qualify for a diagnosis, you must have experienced problems with hyperactivity or inattention since childhood, and these symptoms must have a significant negative impact (see “Do you have ADHD?”, page 41).

There were certainly signs in my own childhood. According to my mum, I was “always on the go”, an exhausting chatterbox who followed her everywhere, singing, dancing and repeatedly falling down the stairs. As an adult, I am much the same, though you would have to live with me to notice. Aside from the fidgeting and fast-talking, these days

it mostly manifests as messiness and domestic disorganisation. I don’t just forget appointments. I can forget them in the 10 minutes between the reminder pinging on my phone and the moment I should be leaving the house – more often than not, I get sidetracked on the way to the front door.

In my working life, some days I write at an alarming speed, knocking out thousands of words without blinking. On others, I spend hours staring into space, trying to concentrate and getting increasingly frustrated because it shouldn’t be this hard. There is little middle ground and nothing I do can turn a staring day into a writing day. It makes it impossible to plan my workload and incredibly stressful trying to juggle more than one deadline.

It isn’t all bad. Creativity and curiosity are two notable upsides, and if I believe my loved ones, they wouldn’t have me any other way. In some ways, my symptoms aren’t all that unusual; lots of people would describe themselves as disorganised. But when it affects everything you do, the lack of control over your own mind can be exhausting and cause more negative self-talk than is probably healthy.

Getting a diagnosis isn’t easy, at least in the UK, where waiting times range from six months to several years depending on where you live. I am currently three months into what I am told will be a six month wait on the National Health Service. But there are reasons to persevere. Research suggests that getting a diagnosis of ADHD in adulthood leads to not only better functioning in life and work, but improved quality of life and self-esteem. What’s more, when diagnosed, ADHD is

conversations at the pub and between parents at the school gate, everyone is talking about it. These days, I am hesitating because I don’t want to jump on an increasingly crowded bandwagon.

Now, though, I have decided to finally find out what is going on – not only in my own brain, but in wider science and society. Is ADHD getting the recognition and understanding it deserves, or is the rise in interest a fad being pushed by drugs companies, online prescribers and attention-seeking influencers?

Getting answers matters. If ADHD is underdiagnosed we are letting huge numbers of people struggle. If the opposite, then we are pathologising, and drugging, normal human





## “On TikTok, posts with the hashtag ADHD have 23 billion views”

highly treatable, including with drugs like methylphenidate or a mix of amphetamine and dextroamphetamine, better known as Ritalin and Adderall respectively (see “What is the best way to treat ADHD?”, page 42).

It is the use of these stimulant drugs that makes ADHD diagnosis more controversial than other common neurodevelopmental conditions, such as dyslexia or autism, which aren't usually medicated. The use of stimulants, which can be addictive if misused, stirs in the perception that we, and our children, could be hijacked by the vested interests of big pharma, which profits from telling us there is something to fix.

This is a particular concern at the moment because many services have sprung up in the US offering speedy online diagnoses of ADHD and treatment plans. Because these services are for-profit, some worry that they may rush-through consultations and over-diagnose. Plus, ADHD is hugely popular on social media. On TikTok, posts labelled with the hashtag ADHD have 23 billion views.

### Untapped markets

Medical sociologist Peter Conrad at Brandeis University in Massachusetts has sounded warnings about this. In a 2014 paper, he and his colleague Meredith Bergey argued that the rise of ADHD has more to do with marketing than medical need. The expansion of criteria in successive versions of the DSM, particularly to include adults, they wrote, is a direct result of drug companies expanding into new, untapped markets.

It is also possible that diagnosis in children could be driven by parents' desire to secure extra support for them. Getting a diagnosis of ADHD can unlock extra funds from local government that can be invaluable to children struggling at school. One 2018 study looked at children in the US and found that those living in states where these kinds of incentives exist were 15 per cent more likely to be diagnosed with ADHD and 22 per cent more likely to be medicated than those elsewhere.

Even with all this attention on ADHD, it isn't easy to tell whether there is a rise in diagnoses, not least because authorities don't tend to release figures on diagnoses per se. Instead,

the best figures we have estimate rates of ADHD based on the number of people using stimulant drugs. These provide a good but not perfect picture because not everyone with ADHD uses stimulants and a small number use them to help with other conditions. Still, these estimates suggest that ADHD is indeed on the rise in Australia, England and the US, with the latter well ahead of the pack (see graph, below).

When you break down the data and look at individual age brackets it is clear that in the US, children make up the bulk of the cases. For example, one study that looked at parent-reported ADHD diagnosis and treatment estimated that 8.4 per cent of young people in the US aged between 2 and 17 had ADHD in 2016. The equivalent figures for the UK and Australia were below 2 per cent.

What kind of prevalence should we expect? We can get an idea from studies that look at randomly selected groups of people (rather than those that actively seek a diagnosis) and see how many exhibit symptoms of ADHD. A systematic review of such studies estimated the global prevalence of ADHD in children at 5.3 per cent. This suggests a nuanced picture. In the UK and Australia it seems that ADHD is being underdiagnosed while in the US we may be overdoing it.

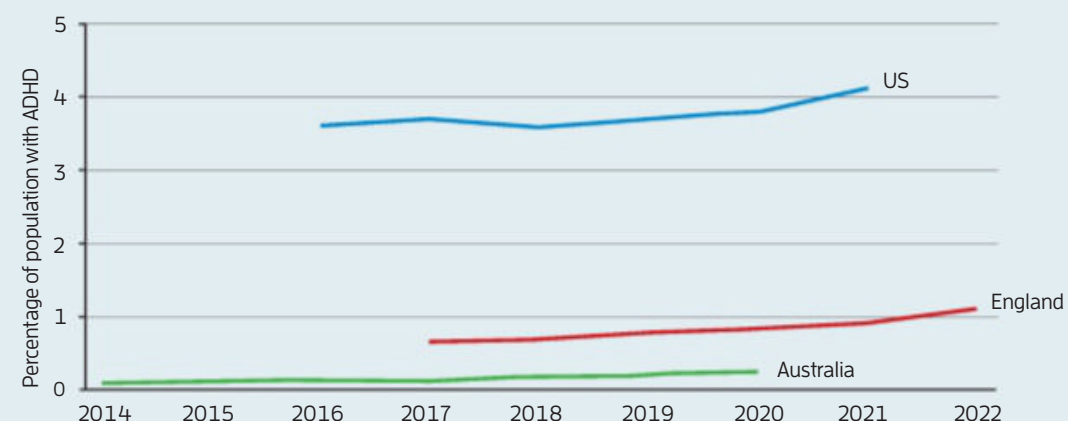
When it comes to adults, studies of randomly selected people suggest the global prevalence of ADHD should be about



**ADHD was once thought to affect mostly children, but we now know many adults experience it too**

### The prevalence of ADHD

Our best estimates suggest that ADHD diagnoses have been rising in England, Australia and the US. However, the proportion of people with a diagnosis is by far the highest in the US



SOURCE: US DATA IS FROM THE CENTERS FOR DISEASE CONTROL DOI.ORG/J6JW. ENGLAND DATA FROM NHS BUSINESS SERVICES UNIT TINYURL.COM/443DSZJT AUSTRALIA DATA FROM DOI.ORG/J6JT





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ADHD that rules out general distractibility once and for all.

There are several candidates that could fit the bill. In children, electroencephalogram (EEG) studies, which monitor patterns in electrical activity across the brain, have suggested that ADHD may be associated with a higher ratio of theta brainwaves, linked with a “zoned-out” state, relative to more “on-task” beta brainwaves. In 2013, the US Food and Drug Administration (FDA) approved one commercial EEG device called NEBA as a diagnostic aid in children, which has started appearing in clinics across the US. Not everyone agrees that this application of EEG is ready for the clinic, though, and the evidence for using EEG as a biomarker in adults is unclear, says consultant psychiatrist Marios Adamou at the University of Huddersfield, UK.

Despite clear indications that ADHD runs in families, genetic analysis can’t tell us definitively who has it. A genome-wide study in 2018 analysed the DNA of more than 55,000 people, 20,000 of whom had ADHD. Twelve

3 per cent, not dissimilar from that in children. In the US, the actual proportion of adults thought to have the condition (based on who takes stimulant medication) varies significantly depending on age group. Rates tend to be low in older people, but, for example, figures published by the US Centers for Disease Control show that 5 per cent of men aged 20 to 25 had ADHD in 2021. Rates of ADHD in adults are much lower in the UK and Australia. Last year, only 0.5 per cent of UK adults had a prescription for ADHD medication.

This means that, despite all the hype, in some age groups and in some places we are still underdiagnosing the condition in adults. “ADHD has been unrecognised and undiagnosed for many years, so we are starting from a very low point,” says Philip Asherson at King’s College London.

Another argument against ADHD being a fad, says Asherson, is that many of the people now seeking a diagnosis have previously sought help and been diagnosed with a different condition, such as anxiety or depression. We shouldn’t see the people now wondering if they have ADHD as having dreamed up the idea out of nowhere, says Asherson.

One way to tread the narrow path between overdiagnosis and leaving people struggling would be to have a quick, accurate way to sort people with a clinical condition from those who are in the typical range of human behaviour. So, the hunt is on for a tell-tale diagnostic marker that points directly to

common gene variants increased the risk of a diagnosis, each adding a tiny amount of risk. As yet, though, there isn’t enough data to provide a threshold for diagnosis.

The most objective and user-friendly option available comes in the form of standardised cognitive tests. One variation, which is becoming widely used in the US and UK, is the so-called Qb (quantitative behavioural) test. This was adapted from psychological tests created in the 1950s to measure sustained attention. These alone couldn’t distinguish ADHD from other conditions that affect attention, so Swedish company QbTech added a motion-capture element to the test that records the movements of the head as a proxy for hyperactivity.

In late March, I visited the company’s London office to try the test myself. Charlotte Cooper, the firm’s clinical operations manager, took me into a featureless room and explained that the test is supposed to be boring. It involves watching a computer screen for 20 minutes while one of four simple shapes briefly appears on the screen. My task was to press the button if the symbol on the screen matched the one that came just 2 seconds before. It is simple enough, but the idea is that people with ADHD are more likely to zone out and then miss the short window to press the button when the symbols match – or impulsively press the button when they don’t.

Afterwards, Cooper ran me through my results. Surprisingly, to me at least, my fidgeting levels were in the normal range for my age and gender, as was my reaction time. My error rate, though, was significantly higher than controls: 93 per cent of people made fewer mistakes than me. Most of my errors involved hitting the button when I shouldn’t have. That sounds about right. Several times, I caught myself zoning out, snapped back and hit the button – as it turned out, in error. This might point to both inattention and impulsiveness, Cooper says. Indeed, the test showed that 97 per cent of people were less impulsive than me.

The test was approved to be used alongside standard medical interviews in the US by the FDA in 2016 and is currently being assessed by the equivalent body in the UK. In a recent randomised controlled trial, led by Chris Hollis at the University of Nottingham, UK, ➤

## DO YOU HAVE ADHD?

**ADHD is officially diagnosed following the guidance in the Diagnostic and Statistical Manual of Mental Disorders or the World Health Organization’s International Classification of Diseases. Both set out more or less the same criteria for diagnosis. There are symptoms of inattention, such as being easily distracted or making careless mistakes, and of hyperactivity, such as having trouble sitting still and interrupting people. Adults must have at least five of these symptoms (for children it is six) and these must have been around since before they were 12 years old. They must manifest in more than one setting, such as their work, home and social life. On top of that, all this must negatively affect their ability to function in those settings.**

**If you tick all those boxes then a doctor could diagnose you with ADHD. The diagnosis will come in one of three types. You could be predominantly inattentive, predominantly hyperactive or a “combined” type.**





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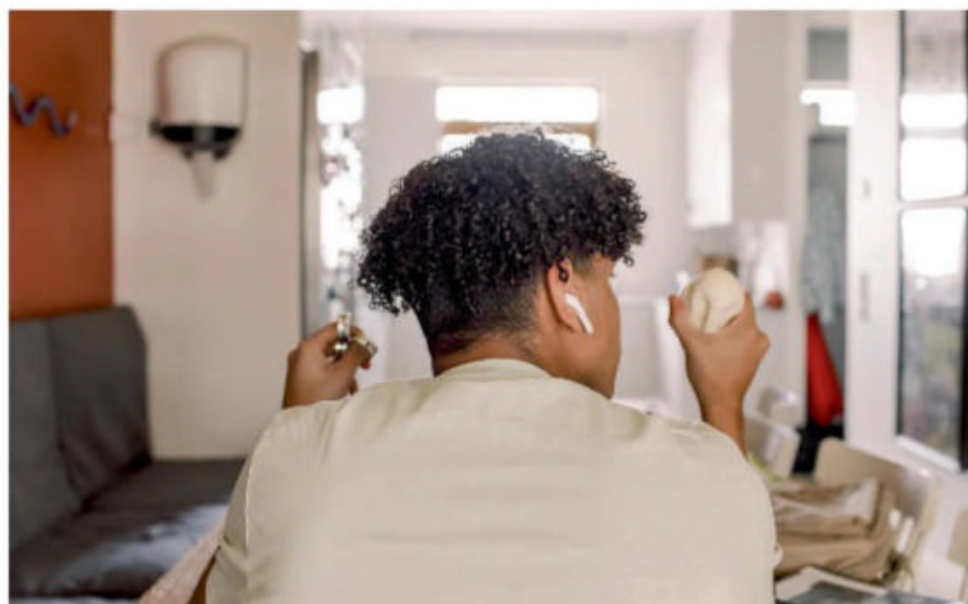
psychiatrists who used the Qb test alongside standard questionnaires and a consultation ruled people in and out of an ADHD diagnosis 15 per cent faster than those using questionnaires and interviews alone, and with no change in accuracy. With these kinds of objective tests, we are getting closer to making sure the right people get treatment.

### Now and not now

Meanwhile, scientists are digging deeper into the core nature of the condition. In the past few years, several studies have begun exploring the links between ADHD and perception of time. Radek Ptacek at Charles University in the Czech Republic reviewed this work in 2019 and showed that people with ADHD have problems estimating how quickly time passes and this can be addressed with stimulant medication.

He believes that a problem with the perception of time could be the true underlying cause of many ADHD symptoms. Restlessness may stem from a sense that time is dragging. An inability to keep track of time may cause problems with planning and memory. “People [with ADHD] talk about the sense that things are either now or not now, and they can’t make sense of what ‘not now’ is,” says Hollis. Poor time perception should be added to the next edition of the DSM as a core symptom, says Ptacek.

Other potential additions include problems with emotional control, which Asherson says



People with ADHD can find they fidget with things

MASKOTGETTY IMAGES

## “A problem with the perception of time could be the underlying cause of many ADHD symptoms”

“is now quite well established as a symptom that often accompanies ADHD”, and is often taken into account in diagnosis, even though it isn’t on the official list.

Then there are the little-known upsides: creativity, which seems to be above average in people with ADHD and may be a direct result of a brain that hops from subject to subject, making connections where others wouldn’t. There is also hyperfocus, the counterintuitive symptom that sees people with ADHD drawn deep into tasks that interest them for hours at a time – also known as the only reason I am ever able to finish an article.

In fact, some researchers argue that we need to rename the condition altogether, to reflect that there is no deficit of attention in ADHD, more a problem with the control over where it goes. My suggestion is attention regulation disorder, or ARD – which feels apt because, in my experience, it makes life way ARD-er than it needs to be.

At the time of writing, I am still waiting to reach the front of the queue for diagnosis. In the meantime, I can hang onto the knowing nods of Hollis and Asherson as I explained my struggles to them and the highly suggestive results of the Qb test. Interestingly, Asherson says that in his experience, people who self-diagnose based on what they have read about ADHD often turn out to be right. “So far, almost everyone who thinks they have it, does,” he says. I guess we will see. ■



Caroline Williams is a science journalist and author of *Move! The new science of body over mind*

### WHAT IS THE BEST WAY TO TREAT ADHD?

ADHD is considered highly treatable. For those who opt to try drugs, the first option is often a stimulant, such as methylphenidate (Ritalin), a mixture of amphetamine and dextroamphetamine (Adderall) or the lesser-known lisdexamfetamine (Vyvanse). According to a 2021 consensus statement from the World Federation of ADHD, methylphenidate has the best risk-benefit ratio for children and

adolescents, while amphetamines work best for adults. Other drug-based options include non-stimulants such as atomoxetine, which boosts the neurotransmitter norepinephrine and therefore alertness. The blood pressure medications guanfacine and clonidine have also been found to reduce some symptoms and can be used with or instead of stimulants. Alternatives include

talking therapies such as cognitive behavioural therapy, which aims not to reduce symptoms, but to help people work around the challenges ADHD can bring in everyday life. There is some evidence in favour of brain training exercises, but large-scale trials have yet to be done and these methods are still considered experimental. You should consult your doctor before starting medical treatment.



MR. KURIBAYASHI/COURTESY OF THE BULLETIN OF THE SEISMOLOGICAL SOCIETY OF AMERICA

# Warning lights

A flickering glow in the sky seems to accompany some earthquakes. Could this point to a way of predicting these disasters? **Nathaniel Scharping** investigates

**T**HE resort of Acapulco in Mexico has long been known for its attractions: gorgeous mountains, upmarket hotels, crystal clear waters. But on 7 September 2021, something happened that was on nobody's wish list – a magnitude-7.0 earthquake rocked the city's sandy beaches and seafront high-rises.

Along with trembling buildings and shaking trees, those caught in the quake also witnessed something substantially more eerie. A barrage of blue lights, like flashes of cerulean lightning, lit up the night sky, apparently right above the fault line. This strange display was an example of what are known as “earthquake lights”, a semi-mythical phenomenon that has cropped up in reports of tremors for centuries.

The idea that these blue flashes are caused by an earthquake is often dismissed by scientists. Indeed, after Acapulco, some suggested the flickering lights may have come from damaged power lines. But a small group of researchers now claim to have evidence for an alternative hypothesis. It says that when tectonic faults rupture, electrical currents are created. And whether these currents produce lights or not, there should be telltale electromagnetic signals produced by them that would be detectable in advance.

If they are right, we could potentially use these signals as a warning of disaster. It is a long shot: the search for ways to predict earthquakes has frustrated us for decades. But new evidence linked to these uncanny,

## Earthquake lights captured over Mount Kimyo, Japan, in 1968

dancing lights in the sky is shaking up the field.

Predicting major tremors is currently just about impossible. Scientists, including those at the United States Geological Survey (USGS), a national agency, compile long-term seismological data that can tell us the chance of an earthquake hitting a given area, but only across a window of time that spans years or decades, rather than anything more precise. Then, there are warning systems like ShakeAlert in the US, which uses seismometers to give people alerts of incoming quakes – but only seconds in advance. ➤



## “EXISTING WARNING SYSTEMS CAN GIVE ALERTS OF INCOMING EARTHQUAKES – BUT ONLY SECONDS IN ADVANCE”

To do better, we would have to find what is known as an earthquake precursor, a signal that reliably precedes an earthquake much further ahead of time. The trouble is, it isn't clear what that could look like. “There are some schools of thought that hold that it's never going to be possible,” says seismologist Susan Hough at the USGS. Even the more optimistic reckon that this would, at best, be akin to weather forecasts, giving the probability of an earthquake in the coming days and weeks.

But it is worth pursuing, no matter how slim the chances of success. After all, we had a reminder of just how deadly strong quakes can be in early February, when several struck Syria and Turkey, killing more than 54,000 people.

### Charged atmosphere

The idea that electromagnetic signals could be produced in the run-up to a quake was put forward decades ago by Friedemann Freund, a physicist then based at NASA's Ames Research Center in California. He suggested that imperfections in the molecular structure of rocks in Earth's crust can be disrupted during earthquakes, unleashing electrical currents that can propagate up through the ground and create a charge in the atmosphere. These charges could build up and cause flashes of electricity – earthquake lights – and even explain other phenomena associated with seismic activity, like temperature changes and abnormal animal behaviour.

Freund's hypothesis has never gained mainstream acceptance, and some question the basic precepts of his model. Still, the broader idea that there could be an electrical connection between the rocks in Earth's crust and the atmosphere isn't so wild, even if the details aren't well understood.

The story of the recent excitement around earthquake electricity starts back in 1985 when an engineer named Tom Bleier read about earthquake lights and had an idea. If earthquakes were creating bursts of electricity at the surface, he reasoned, they were probably also generating electromagnetic fields deep underground at the epicentre. Earth's crust will screen out everything but the lowest electromagnetic frequencies. However, an induction magnetometer tuned to those low frequencies might pick up a signal. These devices – tens of thousands of metres of fine copper wire wrapped round a metal core – aren't

hard to build. Surely it was worth a try?

Bleier tried to persuade the USGS to fund research into this idea. But the agency wasn't interested and for years it went nowhere. Then, in the late 1990s, Bleier began working as a satellite engineer for a California-based company called Stellar Solutions whose founder, Celeste Ford, was an old friend. He persuaded her to put up philanthropic funding for an earthquake monitoring system and, in 2000, a company called QuakeFinder was born. With it, Bleier began building a network of magnetometers optimised for ultra-low frequencies around California. To get as close to faults as possible, the devices were installed in backyards, farms, hay fields – anywhere property owners would allow. “We'd knock on their door and say: ‘Can we have your permission to do it?’” says Bleier. “And in the next day or so, we had it in there and working.”

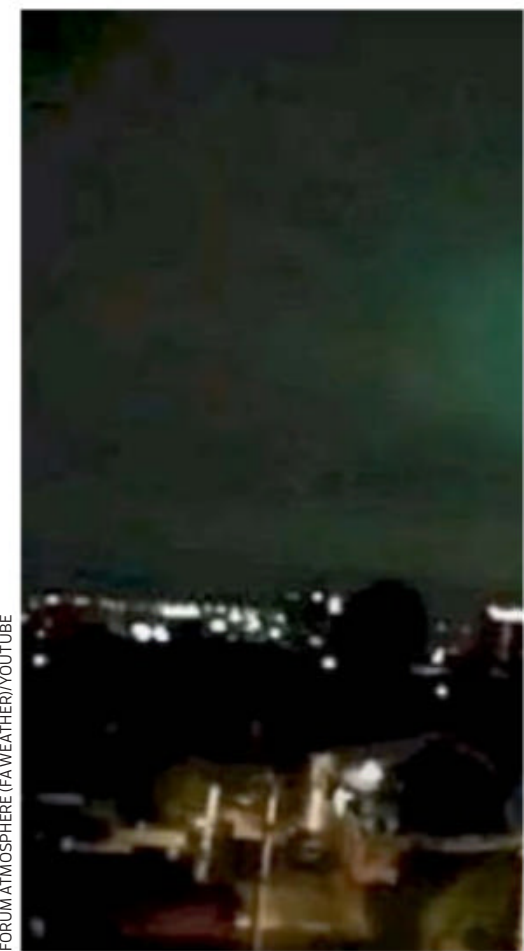
By 2017, QuakeFinder had 125 of the instruments strung along California's major faults. It has been gathering data dozens of times per second for over a decade, picking up on even extraordinarily slight electromagnetic fluctuations. “It's really hard work to collect good data, clean data, to maintain instruments out in the field,” says Simon Klemperer, a geophysicist at Stanford University in California who has independently analysed QuakeFinder's data. “QuakeFinder did this very successfully.”

People can't naturally sense Earth's electromagnetic field. But if we could, it might

### QuakeFinder set up its magnetometers throughout California



FORUM ATMOSPHERE (FA WEATHER)/YOUTUBE



sound like an ocean of fluctuating static, never the same from one moment to the next. Everything from solar storms to passing cars alters the frequencies magnetometers pick up. Subtracting that background noise to find the signals of interest underneath is a challenge, says Karl Kappler, QuakeFinder's chief scientist.

The company's researchers have been wrestling with this for years, but began to make progress around 2019. In a study published that year, they looked at whether the range of electromagnetic frequencies they saw changed in the days before an earthquake. Using a subset of their data that was comprised of nearly 900 quakes of magnitude 4 or greater, the researchers reported a slight change in electromagnetic field signals between four and 12 days before these tremors. Their analysis showed that the signals had a statistical significance of 3 sigma, meaning there is a 99.7 per cent chance that they aren't just a fluke. “What that suggested was that there really was an effect,” says Kappler.

Emboldened, QuakeFinder turned over its data to researchers from Google, who trained a machine-learning algorithm to sort through it and identify relevant signals. Turning the number-crunching over to this computer let them comb the data with far greater sensitivity and optimise the algorithm specifically for the problem at hand. Crucially, they only chose signals picked up by two or more magnetometers and they split the data set in two, using one half to train the algorithm and then testing it on the second half, which





**A still from one of many online videos that claim to show the strange earthquake lights phenomenon**

the algorithm hadn't seen before.

In this study, the researchers again saw intriguing evidence that electromagnetic activity changed before large earthquakes. The results, published in 2022, also achieved around a 3-sigma confidence level. Kappler says the second paper felt like a breakthrough for the company. It put the firm in the position of being "well past the threshold of evidence", he says.

## Suspicious signals

Klemperer sounds a note of caution about QuakeFinder's results. His own independent analysis of some of the company's early data didn't turn up the same precursor signals. That could just be down to differences in data processing methods. But he also points out that the company is looking retrospectively at earthquake data for any signal that looks suspicious, rather than coming up with a hypothesis and testing it. This is a common criticism of earthquake precursor research. "If you're starting with the time of an earthquake, and looking back, that's just not the right way to do science," says Hough.

That is because it leaves scientists vulnerable to bias, she says, picking out signals that fit a hypothesis and ignoring those that don't. The gold standard of proof, of course, would be to use these signals to successfully predict an earthquake in advance – something QuakeFinder hasn't yet managed.

Dan Schneider, QuakeFinder's director of research and development, takes this point.

The company's work thus far is more about proving that earthquake precursors exist and that prediction is theoretically possible, than about forecasting any individual tremors, he says. "This doesn't find any particular needles in any particular haystacks," says Schneider. "But it does point in the direction that there are needles in these haystacks to be found."

The QuakeFinder team also argues that similar results from Japanese researchers are further evidence for precursors. Using data recorded between 2001 and 2010 by six magnetometers arrayed near Tokyo, this study found a significant increase in the number of electromagnetic anomalies before large earthquakes compared with afterwards. "You can't discount three independent studies," says Bleier. "There's something there."

Where does all this leave us? Some scientists argue that, despite years of dismissing the

"THE RESEARCHERS SAW INTRIGUING EVIDENCE THAT ELECTROMAGNETIC ACTIVITY CHANGED BEFORE A QUAKE"

possibility, intriguing evidence that earthquakes can be predicted keeps popping up. Geophysicist Angelo De Santis at the National Institute of Geophysics and Volcanology in Rome, who studies pre-earthquake signals, says that there are probably many different kinds of precursors. "It is not only a [single] precursory anomaly that we are looking for, but it is a pattern," he says. "We are able to see a sort of chain, a sequence of different kinds of anomalies."

De Santis and others have published research identifying what they say is a reliable series of events that happens before earthquakes, beginning with changes to atmospheric temperature and humidity, followed by increases in infrared radiation from Earth's surface and elevated levels of methane and carbon monoxide, then, finally, anomalies in our planet's ionosphere, the highest slice of the atmosphere. Together, these kinds of changes might represent a more trustworthy indicator than any one signal alone.

Still, the science of earthquake precursors remains on wobbly ground. Stellar Solutions, QuakeFinder's primary source of funding, paused its financial support in 2021. QuakeFinder's employees are now doing research in their spare time as they work other jobs, while the magnetometers in their network are beginning to go silent one by one as their batteries die.

In general, scientists seem torn over the value of this kind of research. Even Hough, who is sceptical that we will ever find reliable precursors, can't help but sometimes ponder the possibility of success.

Three decades ago, she went to Joshua Tree in California to investigate the aftermath of a large earthquake. She heard from local ranchers that their horses had spent the night before the quake "screaming". Is it possible the animals somehow knew what was coming? Hough's scientific brain urges her to throw out this kind of fanciful idea. "The screaming horses... it's not a meaningful scientific observation," she says. "But at the same time, you wonder." ■



Nathaniel Scharping is a freelance science journalist based in Tacoma, Washington. You can find him on Twitter @nathanielscharp



# Features



SPOOKYPOOKA



# Our holographic universe

Why are physicists so enthralled by the idea that space-time somehow emerges from a surface at an unseen cosmic boundary, asks **Katie McCormick**

**I**N NOVEMBER 1997, a young physicist named Juan Maldacena proposed an almost ludicrously bold idea: that space-time, the fabric of the universe and apparently the backdrop against which reality plays out, is a hologram.

For many working in the fields of particle physics and gravity at the time, Maldacena's proposal was as surprising as it was ingenious. Before it was published, the notion of a holographic universe was "way out there", says Ed Witten, a mathematical physicist at the Institute for Advanced Studies in Princeton (IAS), New Jersey. "I would have described it as wild speculation."

And yet today, just over 25 years on, the holographic universe is widely revered as one of the most important breakthroughs of the past few decades. The reason is that it strikes at the mystery of quantum gravity – the long-sought unification of quantum physics, which governs particles and their interactions, and general relativity, which casts gravity as the product of warped space-time.

Then again, you might wonder why the idea is held in such high regard given that it remains a mathematical conjecture, which means it is unproven, and that the model universe it applies to has a bizarre geometry that doesn't resemble our universe.

The answer, it turns out, is twofold. First, the holographic conjecture has helped to make sense of otherwise intractable problems in particle physics and black holes. Second, and more intriguing perhaps, physicists have finally begun to make headway in their attempts to demonstrate that the holographic principle applies to the cosmos we actually reside in.

Maldacena, now also at the IAS, was originally inspired by two separate branches of physics. The first was string theory, a way to describe reality in which particles are made up of vibrating loops of string. Early in the idea's development, physicist Alexander Polyakov realised these strings had to live in more dimensions than our familiar universe of three spatial dimensions plus one of time. Most modern versions of string theory require 10 dimensions to describe our four-dimensional universe.

## Black hole clue

Around the same time, Stephen Hawking, Jacob Bekenstein and others were trying to understand the role that quantum mechanics plays in black holes, where space-time is so warped and gravity so strong that nothing can escape its pull. Every particle in the universe contains some amount of information – its energy, momentum and position, for example. Hawking and Bekenstein wanted to know the maximum amount of information you could put into a given region of space, in this case a black hole. Since packing in more and more particles will eventually produce a black hole, their question was equivalent to asking: what is the information content of a black hole?

The pair had imagined that the maximum amount of information a black hole could contain would be proportional to the volume within its event horizon, the boundary inside which nothing can escape. This seems to make sense: the number of sweets you can fit in a jar depends on its volume, after all, and not the surface area of its opening.

But, to their surprise, Bekenstein and Hawking discovered this wasn't the case for black holes. The information contained in these objects depends on the event horizon's area, not the volume it encloses. Somehow, all the information from a three-dimensional region of space could fit on the two-dimensional boundary around it.

These two insights – that our familiar universe could be equivalent in some sense to a 10-dimensional stringy cosmos, and that all the information contained in a three-dimensional black hole lived on its two-dimensional horizon – got Maldacena thinking. Perhaps our universe might also emerge from a kind of reality with fewer dimensions, just like a hologram?

To realise a holographic universe, Maldacena exploited the concept of a duality: a correspondence between two seemingly disparate ideas. On one side of the duality was a space-time that had some of the familiar properties of our cosmos, where objects feel the pull of gravity, called an Anti-de-Sitter (AdS) universe. On the other side was the so-called conformal field theory (CFT), a quantum theory that only existed on the two-dimensional boundary of this universe and had no connection to gravity at all. Mysteriously, this duality implied that gravity somehow emerged as a hologram in the three-dimensional world from this two-dimensional CFT. "It's like a universe in a box," says Maldacena. Inscribed on the surface of the box is the entirety of its contents.

This theoretical universe, known as AdS space, is different to the one we observe. For starters, the intrinsic energy contained



# Quantum corrections

**Believe it or not, the strange correspondence between a model universe and the boundary around it that is central to the holographic universe idea (see main story) might have practical implications.**

**By exploiting the laws of quantum physics, quantum computers promise to solve certain types of problems exponentially more efficiently than classical computers can. And yet their immense potential may be undermined by a crucial drawback: quantum bits of information, or qubits, are extremely delicate. Any disturbance from the environment can interfere with the computation at any time, causing it to fail.**

**In 1995, a group led by mathematician Peter Shor, now at the Massachusetts Institute of Technology, came up with the first example of how one might protect qubits: encode a single qubit into many individual “physical” qubits. Even if an error occurred on one “physical” qubit, the redundancy meant researchers could correct it, making the computer more resilient.**

**Since this first proposal, countless other implementations of these “error-correcting codes” have been invented. Then, in 2014, Ahmed Almheiri at Stanford University in California and two of his colleagues discovered that the qubits on the boundary of a type of model universe called an Anti-de-Sitter (AdS) space encoded the stuff in the interior in exactly the same way that error-correcting codes do in quantum computing.**

**The implications of that are jaw-dropping for fundamental physicists, because it suggests that space-time could itself be an error-correcting code. But the insight could also accelerate progress towards robust quantum computers by inspiring new error-correcting techniques.**

in empty space in this model version is negative, meaning space-time bends in bizarre ways so that it takes on a saddle shape. In our universe, on the other hand, the value of this so-called vacuum energy is positive. This warps the geometry in precisely the opposite way to the saddle-like AdS space, shaping our universe like an ever-expanding sphere. Hence, we live in a de-Sitter space.

Regardless of the differences, Maldacena’s idea captured the imagination of string theorists and people who work on general relativity alike. Working independently, Witten and another group that included Polyakov quickly followed up with papers that explicitly established the holographic implications of the AdS/CFT correspondence, as it became known. Maldacena’s work has since become one of the top-cited papers in all of physics.

## Universe in a box

That might seem puzzling when you consider that it isn’t a mathematically proven fact. “There are many parts of the correspondence which are on a firm footing,” says Jonathan Oppenheim, a physicist at University College London. “There are other parts of the correspondence which, I think, are on a much weaker footing.” With that in mind, Oppenheim is concerned we are overreaching when physicists argue that it has something profound to teach us about the universe. That is fine if you believe the conjecture, he says. “On the other hand, if it’s not true,

then we’re being led in the wrong direction.”

What might seem even more damning is the fact that the conjecture is still only valid in that strange, saddle-shaped theoretical universe. “It can’t be straightforwardly adapted to our universe,” says Witten. But that hasn’t led physicists to abandon the idea, and that is largely because it has helped us solve many real-world problems that were previously hard, if not impossible, to crack. “For many things, it is the best model we have,” says Witten.

Consider problems in quantum field theory, our best way of understanding subatomic particles and their interactions, that involve “strongly coupled” interactions – that is, particle interactions so strong that the techniques used to approximate the collective behaviour of a system of particles fail.

It turns out that putting the universe in a box helps. Since the “bulk” universe inside and the boundary of the box are considered one and the same, physicists can translate the problem to the boundary and solve it there. “The duality was one of the most significant insights about strongly coupled quantum theory in many decades,” says Witten. “Many questions that are hard to answer on the boundary can be answered much more easily in the bulk and vice versa.”

One of the most significant triumphs was in relation to a problem known as quark confinement. We know that quarks, the subatomic particles that compose protons and neutrons, must exist. But they are always detected in small groups, never in isolation. In the 1970s, it was suggested that this might be because the strong nuclear force that holds together quarks idiosyncratically becomes stronger the further two quarks are from one another. This increased pull with increasing distance tends to snap them back towards one another like a rubber band, causing them to always be clustered together. This was largely corroborated by computer simulations, but it was hard to make sense of on an intuitive level.

With the advent of Maldacena’s box universe, physicists had a new tool: a particular CFT that was similar in many ways to the theory that governs quarks in our universe, including displaying the familiar quark confinement. The calculations were messy even in this simplified theory, but, by using the correspondence, physicists were able to translate the problem into something more



BARTLOMIEJ K. WROBLEWSKI/ALAMY

**Could space-time share a core feature of quantum computers?**





MEHAU KULYK/SCIENCE PHOTO LIBRARY

tractable, something that could easily be solved with paper and pen.

The AdS/CFT correspondence has proven fruitful in many other respects, too. In just the past few years, it has helped push us closer than ever to understanding the enigmatic nature of black holes and the paradox of how they evaporate and, hence, how quantum physics and general relativity come together in these extreme regions of space-time. “One would certainly not want to go back to the old days without the duality,” says Witten. We have even found a possible way of using AdS/CFT to make quantum computers more reliable (see “Quantum corrections”, far left).

The fact is, however, that we still haven’t arrived at a holographic description of the universe we see around us.

It isn’t for lack of trying. Within just a few years of Maldacena’s discovery, many physicists, including Maldacena himself, had started trying to apply a similar holographic principle to a more realistic cosmos with the geometry of our universe. The problem is that the strange geometry of a saddle-like universe makes it easy to apply a boundary to it and put it in a box. But because our universe is infinitely expanding, putting a boundary around it isn’t so simple.

The answer, some physicists think, involves time. In AdS/CFT, time plays a similar role on both sides of the correspondence: in both the gravity theory in the bulk and the quantum theory on the boundary, time progresses and the system evolves. Space and gravity emerge like holograms from

## “Because our universe is infinitely expanding, putting it in a box isn’t easy”

the boundary CFT, whereas time doesn’t.

But an expanding universe can only be put in a box if the boundary extends infinitely far in the time dimension. If our universe were holographic, the boundary it emerges from would live in the infinite future and contain no notion of time. Somehow, time as we experience it in the bulk universe would emerge from the hologram.

Perhaps unsurprisingly, no such mind-bending duality exists. Not yet at least. But Eva Silverstein at Stanford University in California is among those working on it. Her pragmatic line of thinking is that, given we already have a description of a holographic universe, let’s see how much we can manipulate it so it resembles our own.

Silverstein starts with the familiar saddle-shaped space. But, in this particular space, she puts a black hole at the centre. Then, she slowly moves the boundary inwards until it just barely encompasses the black hole’s event horizon. “At this point, you can’t tell the difference between that and, say, a de-Sitter

### The idea that the universe is a hologram was inspired by string theory and black holes

black hole horizon,” says Silverstein. After bringing the boundary to this point where the two geometries are indistinguishable, she can then gradually move the boundary back outwards, all the while subtly deforming the geometry of the world to turn it into de-Sitter space. “It very much is an approach that builds on AdS/CFT,” says Silverstein.

Jordan Cotler at Harvard University, meanwhile, is starting in more familiar territory. He is interested in understanding how the rules of regular quantum theory change when embedded in an expanding universe, such as our de-Sitter one. In plain old quantum mechanics, we take certain things for granted, like the principle of unitarity – which says the universe is fully deterministic whether you run time forwards or backwards. But this is only strictly true in a static cosmos, says Cotler. As space expands in a de-Sitter universe, he thinks that the universe should correspondingly increase its maximum capacity of information. So, a quantum state now could evolve to any number of possible configurations in the future.

Cotler and his colleagues haven’t fully worked out the implications of these new rules of quantum mechanics in de-Sitter space, but he thinks they are an important waypoint in establishing what everyone is seeking: a dS/CFT correspondence. “A unique challenge of thinking about quantum gravity in de-Sitter space is that it’s almost never clear what you should be calculating,” says Cotler. “You have to learn what to compute and what the rules are supposed to be, and that’s a tricky business.”

Elsewhere, physicists are actively pursuing various other approaches to finding a duality in de-Sitter space. But, as Witten acknowledges, the work “hasn’t yet crystallised to enable anyone to find the right analogue of AdS/CFT”.

The reason so many continue to plug away at it is that finding such a correspondence that applies to our universe as well might help us answer the very deepest questions about the emergence of gravity and space-time. “The good news,” says Silverstein, “is we’re making progress.” ■



Katie McCormick is a science writer based in Sacramento, California. Follow her on Twitter @mccornut



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## Puzzles

Try our crossword, quick quiz and logic puzzle **p53**

## Almost the last word

Are racehorses aware that they are meant to finish first? **p54**

## Tom Gauld for *New Scientist*

A cartoonist's take on the world **p55**

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An earthquake excuse and a very fishy pun **p56**

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Picturing the lighter side of life **p56**

## Mathematics of life

# Time for a cuppa

Should you put milk in your cup of tea immediately or wait until you are ready to drink it? **Katie Steckles** does the maths



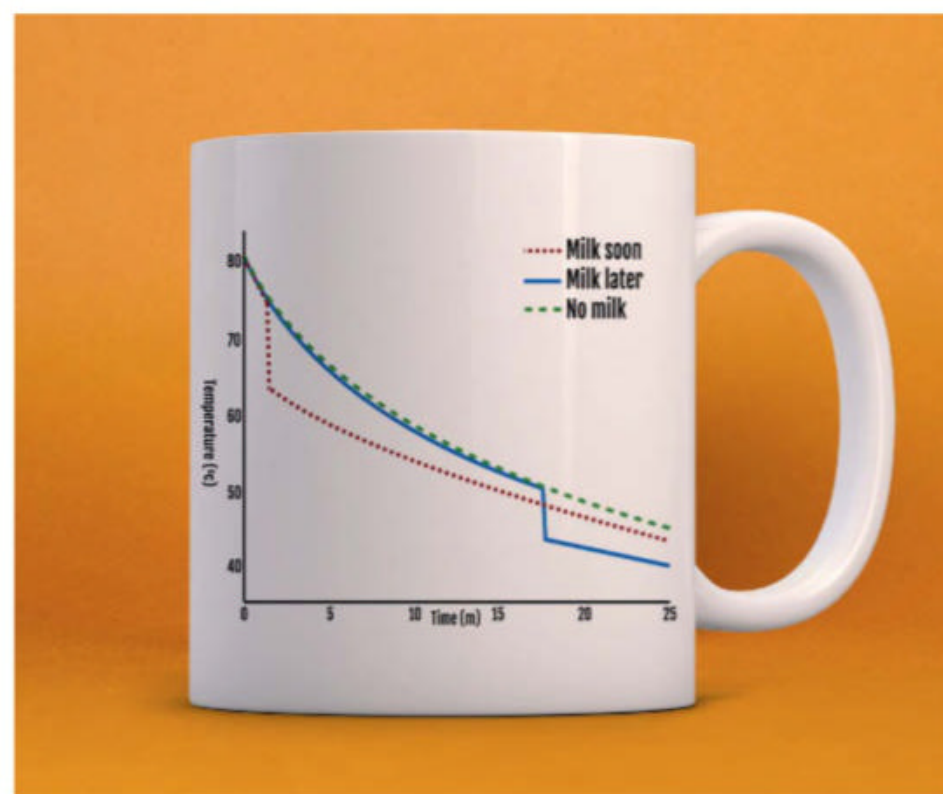
Katie Steckles is a mathematics presenter, lecturer, YouTuber and author based in Manchester, UK. Follow her @stecks

PICTURE the scene: you are making a cup of tea for a friend who is on their way and won't be arriving for a little while. But – disaster – you have already poured hot water onto a teabag! The question is, if you don't want their tea to be too cold when they come to drink it, do you add the cold milk straight away or wait until your friend arrives?

Luckily, maths has the answer. When a hot object like a cup of tea is exposed to cooler air, it will cool down by losing heat. This is the kind of situation we can describe using a mathematical model – in this case, one that represents cooling. The rate at which heat is lost depends on many factors, but since most have only a small effect, for simplicity we can base our model on the difference in temperature between the cup of tea and the cool air around it.

A bigger difference between these temperatures results in a much faster rate of cooling. So, as the tea and the surrounding air approach the same temperature, the heat transfer between them, and therefore cooling of the tea, slows down. This means that the crucial factor in this situation is the starting condition. In other words, the initial temperature of the tea relative to the temperature of the room will determine exactly how the cooling plays out.

When you put cold milk into the hot tea, it will also cause a drop in temperature. Your instinct might be to hold off putting milk into the tea, because that will cool it down and you want it to stay as



CLAIRE PLUMRIDGE/GETTY IMAGES

hot as possible until your friend comes to drink it. But does this fit with the model?

Let's say your tea starts off at around 80°C (176°F): if you put milk in straight away, the tea will drop to around 60°C (140°F), which is closer in temperature to the surrounding air. This means the rate of cooling will be much slower for the milky tea when compared with a cup of non-milky tea, which would have continued to lose heat at a faster rate. In either situation, the graph (pictured above) will show exponential decay, but adding milk at different times will lead to differences in the steepness of the curve.

Once your friend arrives, if you didn't put milk in initially, their tea may well have cooled to about 55°C (131°F) – and now adding milk

will cause another temperature drop, to around 45°C (113°F). By contrast, the tea that had milk put in straight away will have cooled much more slowly and will generally be hotter than if the milk had been added at a later stage.

Mathematicians use their knowledge of the rate at which objects cool to study the heat from stars, planets and even the human body, and there are further applications of this in chemistry, geology and architecture. But the same mathematical principles apply to them as to a cup of tea cooling on your table. Listening to the model will mean your friend's tea stays as hot as possible. ■

*Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations*

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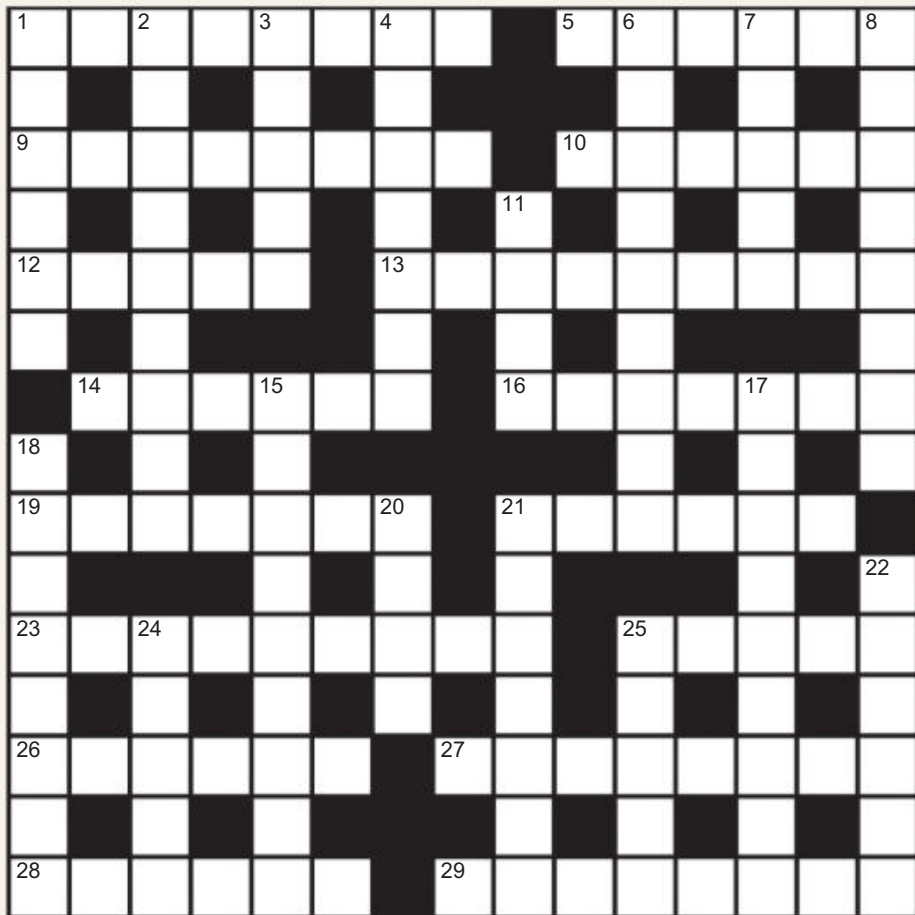
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## Quick crossword #132 Set by Richard Smyth



**Scribble zone**

Answers and the next cryptic crossword next week

### ACROSS

- 1 The Great Comet of 1997 (4-4)
- 5 Pigmented nipple area (6)
- 9 Narrow-bodied fish-like vertebrate relatives (8)
- 10 Wild sheep of eastern Asia (6)
- 12 Type of memory chip (5)
- 13 Cosmoses (9)
- 14 Change gradually and organically (6)
- 16 2016 sci-fi film directed by Denis Villeneuve (7)
- 19 Lingering; not acute (7)
- 21 Group of people with a common attribute (6)
- 23 Sheet of muscle beneath the thorax (9)
- 25 Will comply, in radio jargon (5)
- 26 Reduce in size (6)
- 27 Section of the small intestine (8)
- 28 Involuntary muscular contractions (6)
- 29 Large, long-bodied fish in the family Acipenseridae (8)

### DOWN

- 1 Bisection (6)
- 2 Brand of British off-road vehicles (4,5)
- 3 European freshwater fish, *Blicca bjoerkna* (5)
- 4 Foreskin (7)
- 6 Terbium or holmium, perhaps (4,5)
- 7 Elongated circles (5)
- 8 Monosodium phosphate or ammonium chloride, say (4,4)
- 11 Silicate mineral (4)
- 15 La (9)
- 17 Violence, fierceness (of an infection, perhaps) (9)
- 18 Low blood pH (8)
- 20 Carbon-rich sedimentary rock (4)
- 21 Burn (7)
- 22 Increase magnification (4,2)
- 24 Upper chambers of the heart (5)
- 25 More broad (5)

## Quick quiz #200

set by Bethan Ackerley

- 1 How many bones are there in the human foot?
- 2 What is the only prime number to immediately precede a cube?
- 3 How many years ago did the physicist and chemist Michael Faraday die?
- 4 What is the charge of a fluorine ion?
- 5 How many people have walked on the moon?

Answers – which add to 200 – on page 55

### Puzzle

set by Zoe Mensch

## #220 Artificial Intelli-Vision song contest

There was controversy at this year's Artificial Intelli-Vision song contest, in which each of the competing countries used AI to generate their entries.

Every nation had a judging panel that gave a score to each of the others. The "songwriters" all tried to engineer a higher score for their country by letting an AI generate their ditty as a danceable blend of one other country's all-time favourite tunes.

This led to a strange outcome. Each judging panel awarded 10 points to the song tailored to its national preferences and the same lower number of points to all of the others. For example, the Transylvania panel gave a perfect 10 to Ruritania's artificially intelligent effort *Everybody Let's Dance Last Night Tonight*, while giving only a 7 to all the rest.

The song contest's board decided to restore artistic integrity to this prestigious event by deducting the inflated 10 from each country's set of scores. After this, the grand total of all scores was 222, with no two nations tied for any position. Can you figure out how many countries took part and how many points the winning song scored?

Solution next week



Our crosswords are now solvable online

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## Racing ahead

**Are racehorses aware that they are expected to come first or are they just responding to the frantic urges of the jockey?**

**Laureen Roberts**

*Alderley Edge, Cheshire, UK*

In my experience, many ridden horses like to race each other, whatever the breed.

On good turf, my friends and I had to ride in single file, otherwise we could be out of control. Horses in that group included two ponies. If we allowed them to race, the “winner” was often one of the ponies.

Do they know they are supposed to “win”? The urge to race each other can be manipulated, of course, but “winning” is a human concept.

**David Marlin**

*Equine exercise physiologist, Cambridge, UK*

Horses are herd animals. Generally, in the wild, they want to keep together for safety.

**“Wild horses are herd animals whose main defence against attack by predators is to run. When one runs, the others follow”**

Some individuals are clearly more dominant, aggressive or gregarious than others, so you would assume these would be the ones that would want to be in front.

In training, it can be observed that some horses get level with the lead individual, but then are reluctant to pass it.

**Bryn Glover**

*Kirkby Malzeard, North Yorkshire, UK*

Wild horses are herd animals whose main defence against attack by predators is to run. When one horse runs, the others automatically follow.

The herd keeps together as



MAURELIUS/SHUTTERSTOCK

## This week's new questions

**Big spin** So much in the universe spins. Could the universe itself be spinning? *Murray Lang, Perth, Western Australia*

**Word memory** When I read a word that I don't know how to pronounce, I can't remember it. Why do I need to be able to pronounce a word for my brain to recall it? *Fay Davies, Bury, Greater Manchester, UK*

far as they are able, but, inevitably, it is the slowest animal that is most likely to be caught, for example, by packs of hunting dogs.

When a horse finds itself surrounded by other horses all intent on running in one direction, its simple instinct is to respond to the “danger” pursuing them and to strive not to be that final doomed straggler. This explains why riderless horses still make the effort to keep up with the pack, without any urging from a jockey.

The actual effect from the human is doubtful, but it may well be that the rider's efforts increase fear and anxiety levels in the horse and therefore induce faster running.

It is for this reason that some people, such as myself, oppose

horse racing on the grounds that it exploits the survival instinct and inevitably creates terror responses in the horses.

**James Cawse**

*Pittsfield, Massachusetts, US*

A recent essay, “Becoming a Centaur” by neuroscientist and horse trainer Janet Jones, gives an astonishing explanation of how horse and rider, through training, can almost mesh their nervous systems into something approaching a centaur.

She writes that, in races, dressage events and everyday trail rides, the mind of horse and rider is “in a very real sense... extended beyond its own skin into the mind of another, with physical interaction becoming a kind of neural dance”.

Planets, stars and galaxies like Andromeda all spin, so could the universe itself be spinning?

## Renewable loss

**Does harvesting renewables like solar and wind change the planet slightly? Is there a tipping point where this harvesting becomes as harmful as the effect of fossil fuels?**

**Alex McDowell**

*London, UK*

Covering a fifth of the Sahara desert with solar panels would have adverse effects on world climate.

A 2018 study found that covering the entire Sahara with wind farms and solar panels would double the local rainfall, improve vegetation and help power the world. However, another study in 2020 looked at the global impacts this would have. It found that effects on Earth's climate systems from covering just 20 per cent of the Sahara with solar panels could offset any local benefits.

Solar cells are darker than sand and only convert about 15 per cent of light into electricity, hence there would be a local temperature rise of around 1.5°C. The warmer air would rise and moist air would be drawn in from the coasts, resulting in rainfall and greening of the desert. Due to interactions of this region with others, there would be droughts in the Amazon and a rise in temperatures elsewhere, including in polar regions, leading to melting of the ice caps.

**Hillary Shaw**

*Newport, Shropshire, UK*

All renewables demand resources that could be used elsewhere, such as minerals and land. It is partly an economic argument: making a resource (energy) more plentiful through renewables will lower its price, and that encourages more use, not conservation. However, if we don't create more renewable energy, energy may remain costly and impoverish lower-income people and nations without energy resources. That may discourage



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**Tom Gauld**  
for *New Scientist*



installing energy conservation measures. For example, poorer homes might miss out on heat pumps and lower-income nations may retain wood or charcoal burning, damaging forests and creating a domestic health hazard.

Specific issues associated with the use of renewables include tidal energy disrupting marine ecosystems and solar energy taking up farmland. Wind harvesting reduces heat transfer (slightly) from the equator to the poles. That is good at the poles, in a warming world, but not for tropical regions.

The best energy conservation policy overall is to use less stuff.

### In bad taste

**How was rhubarb found to be edible? It certainly isn't palatable raw. (continued)**

**Guy Cox**  
*Sydney, Australia*

The idea that rhubarb "isn't palatable raw" is totally bonkers. During the second world war, food supplies were scarce in England,

**"Covering 20 per cent of the Sahara desert with solar panels would have adverse effects on the world's climate, despite local benefits"**

so councils divided up unused land into allotments, let out to households at a nominal rent, to encourage people to grow their own vegetables. My grandfather used his to grow tobacco.

By 1952, when I was seven, many of these had been abandoned, and my mates and I used to explore them looking for something tasty to eat. Rhubarb was a prized find, and I can assure you we loved eating the stems raw.

**Ron Dippold**  
*Bath, UK*

First, never underestimate thousands of years of hungry people desperate for things to eat. Cassava is deadly poison if it isn't cooked and slowly paralyses your legs if it isn't carefully processed. Eating this isn't something you

would just stumble upon, but people figured it out, presumably because they were hungry.

Rhubarb is slightly different, though. Its leaves are poisonous, like those of potatoes and tomatoes, so it was initially just a medicine, used thousands of years ago in Chinese Mongolia as a laxative and digestive. It reached Greece and Rome around the 1st century AD and was imported into Europe during the 14th century. At the time, it was more precious than saffron or opium. In the 1700s, it reached the UK and the climate was perfect for it, so it was widely grown there, especially in Scotland. By the 1800s, it was so common that people were eating it as a food. The timeline was similar in the US.

It isn't hard to imagine that people who were used to eating it as a digestive would get used to and then crave the bitter taste (like coffee) and then realise you could add sugar to it to make it more palatable (also like coffee).

Rhubarb is hardly the weirdest thing people have realised they could eat! ■

## Answers

### Quick quiz #200 Answers

- 1 26
- 2 7
- 3 156
- 4 -1
- 5 12

### Cryptic crossword #108 Answers

**ACROSS** 1 Herpes, 4 Cobalt, 9 Stamina, 10 Dryer, 11 Inter, 12 Trypsin, 13 Submersible, 18 Reagent, 20 Trace, 22 Boing, 23 Organic, 24 Summer, 25 Prison

**DOWN** 1 Hispid, 2 Roast, 3 Epigram, 5 Oddly, 6 Abyssal, 7 Turing, 8 Parturition, 14 Uranium, 15 Integer, 16 Grebes, 17 Beacon, 19 Eagle, 21 Aunts

### #219 The second red queen Solution

To maximise my chances of picking the second red queen, I should nominate the bottom card in the pack of 52. Working out the chance of the second queen's location is quite hard, so look instead at the chance of the first red queen being in particular positions. The chance that the first red queen is top of the pack is  $2/52$ , or about 3.85 per cent. The chance that it is second is slightly lower, the chance it is third lower still, and this continues to the bottom card, which has a zero chance of being the "first" red queen. Now, turn the pack upside down. What was the "first" red queen is now the "second" red queen. So, by symmetry, the most likely position for the second red queen is the bottom of the pack.



## Earthquake snack

The traditional excuse “the dog ate my homework” has a new counterpart: “the earthquake chewed my data.”

*Retraction Watch* reports the case of Atsunori Kamiya at Okayama University in Japan, who is accused of faking data in a paper published in *Nature Neuroscience*. Kamiya is the paper’s lead author.

According to *Retraction Watch*, which cites information from the university, Japanese newspapers and the journal: “When asked for the paper’s underlying data, Kamiya claimed that the hard disk storing them fell and broke during the June 2018 North Osaka earthquake. The paper versions were destroyed after chemical liquids from refrigerators and shelves fell on them during the earthquake, Kamiya told investigators.” At the time of writing, Kamiya’s study hasn’t been retracted, but its status may be on shaky ground while investigators doggedly pursue the truth.

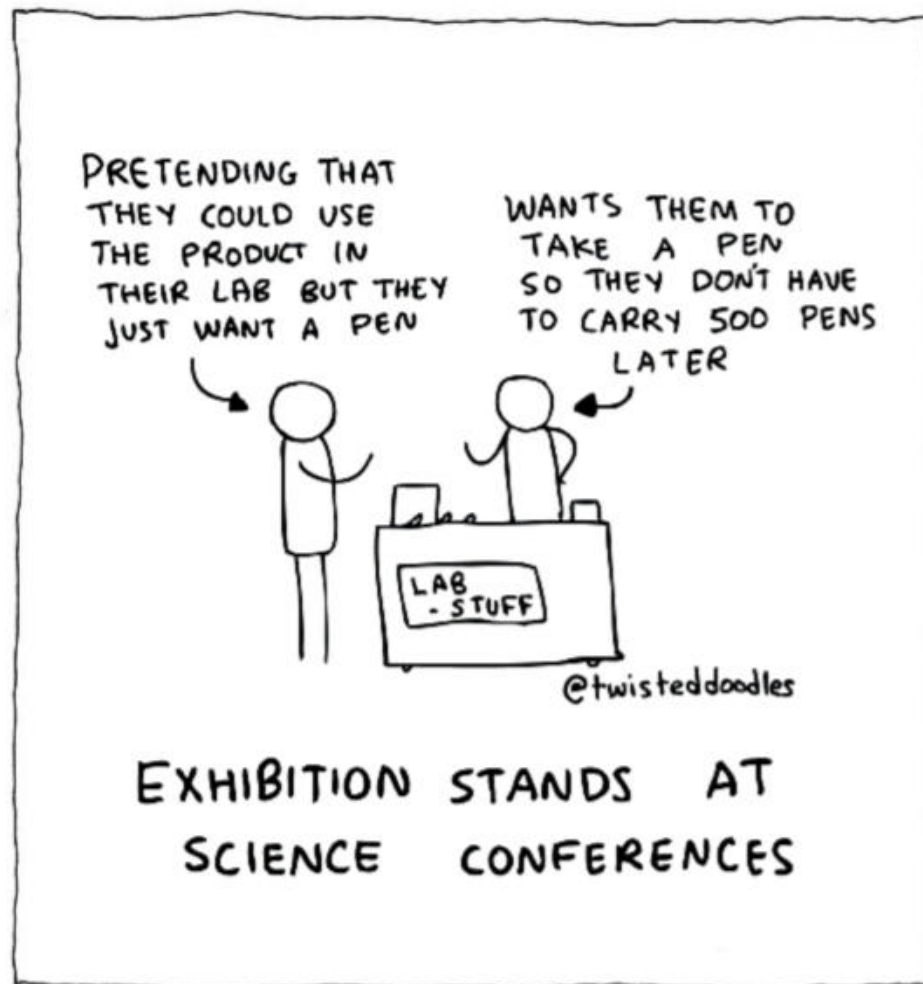
## Strained, fishy pun

Andrew Knapp and colleagues have added to the history of strained biological puns. Knapp is a postdoctoral researcher at the Natural History Museum, London. His co-punners are scattered across the UK and the US.

In concert, they wrote a paper called “How to Tuna Fish: Constraint, convergence, and integration in the neurocranium of pelagiarian fishes”. It occupies several pages in the journal *Evolution*. The neurocranium is the portion of the skull that surrounds and protects the brain. The paper tells how eons of evolution are likely to have fine-tuned the now-characteristic shapes of the neurocranium in different kinds of fish.

Blatantly fishy as it is, the paper’s title is a piece of evidence about people – evidence that the human neurocranium adequately, though unfortunately, protects the machinery that produces moan-inducing puns.

## Twisteddoodles for New Scientist



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## Parsnippet bonobos

Parsnips have become a go-to tool for testing and manipulating the emotions of bonobos.

Jonas Verspeek and Jeroen Stevens at the Royal Zoological Society of Antwerp in Belgium recorded video of 38 sessions in which they handed bonobos either a grape, which was delicious, or a parsnip, which was OK, but not as delicious. Verspeek and Stevens had earlier judged the relative deliciousness, to bonobos at least, of grapes and parsnips, documenting that adventure in the journal *Primates*.

Thus, armed with a fair amount of confidence in the relative desirability of the fruit and the vegetable, Verspeek and Stevens felt able to stage a series of psychological encounters between seven bonobos. They hoped to

see how the bonobos reacted to being treated fairly or unfairly.

Each fairness encounter was between two apes. Sometimes one was given a grape then the other a parsnip, sometimes the reverse, and sometimes both got identical treats. Enough encounters were staged to make sure, say Verspeek and Stevens, that they observed “all possible combinations of partners in each condition”.

The researchers judged the reactions by judging each bonobo’s arousal, partly from a chemical analysis of the ape’s saliva, partly from trying to measure how much “rough self-scratching” the animal did upon experiencing the unfair or fair giving of snacks. Further details, as well as their conclusion that bonobos aren’t keen on being treated unfairly, can be found in the *American Journal of Primatology*.

Bonobos are by no stretch the

first non-humans to make a meal of parsnips. Feedback will mention one other, little-publicised species: parsnip webworms, of which you can learn exciting details by reading Arthur Zangerl and May Berenbaum’s 2003 mini-opus “Phenotype Matching in Wild Parsnip and Parsnip Webworms: Causes and consequences”.

## Fashionable superpower

Feedback continues its search for trivial superpowers – abilities to perform tasks that may seem mundane to their wielders, but impossible to most other people. Some such powers may be innately colourful, and two examples pop out from the swirl of responses to Feedback’s invitation to help catalogue them.

The innately colourful Diane Tunnell says: “I have the ability to carry a colour shade accurately in my head so I don’t have need for swatches when looking for a match.”

Celia Berrell says: “My husband has what I call ‘Theodolite Eyesight’. At ten paces from an item of clothing, he will point and say ‘that’ll fit you’ whilst viewing a skimpy dress, well-fitting pair of jeans or whatever is on display at a market or hanging on a rack (usually in a second hand clothes shop). He’s been correct, time and time again for over 30 years now. But unfortunately he often underestimates his own waistline dimensions when applying this superpower to himself.”

## Stoney superpower

Dianne Scetrine, too, claims mastery of a rare trivial superpower. She says: “I discovered I am possessed of a trivial superpower some years ago when my ex husband told me he and his brother would throw a beach pebble into the air away from them and then throw another and try to hit the first. They never succeeded. I tried and repeatedly hit the first pebble with the second. Totally useless talent.” ■

Marc Abrahams



# GALAXY

ON GLASS

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