New Scientist

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BITTER DEBATE ERUPTS OVER ORIGIN OF CONSCIOUSNESS

HOW A DARK ENERGY BOMBSHELL BLEW UP PHYSICS

WHAT DO MICROPLASTICS DO TO THE BRAIN?

MASTER YOUR EMOTIONS

The scientific ways you can put bad feelings to good use

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

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AN EVENING WITH PRESIDENT

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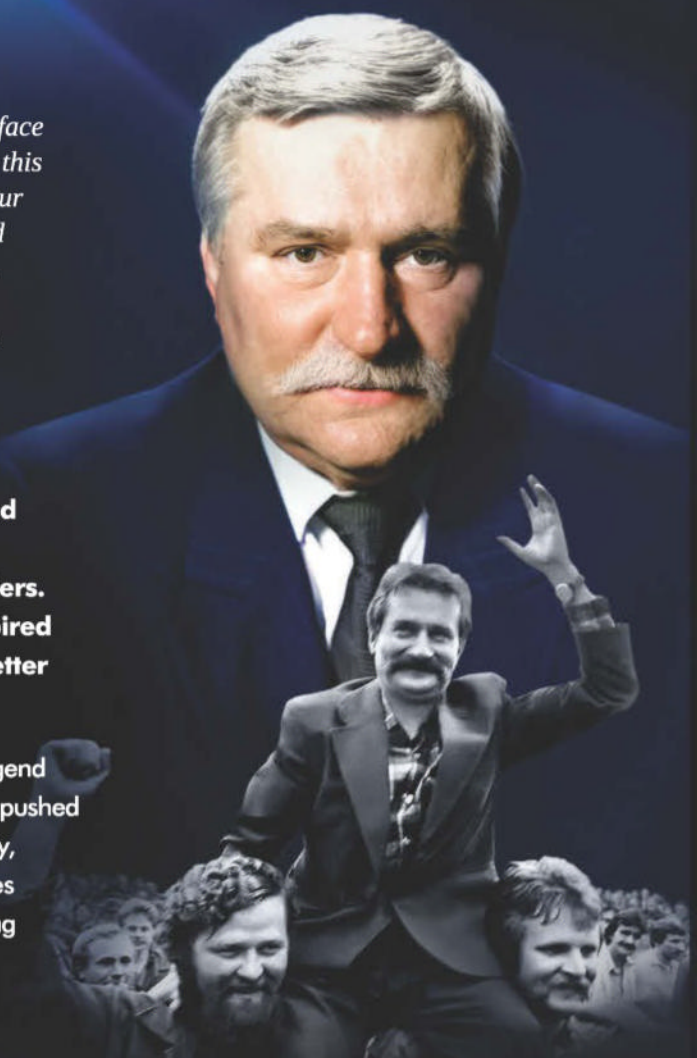

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Online event

Detecting black holes

Despite the mysterious nature of black holes, evidence suggests that they are abundant in our universe. Join theoretical physicist Delilah Gates as she reveals how black holes can be observed and studied using wave-related phenomena, including frequency shifting of light and space-time ripples. This subscriber-only online event takes place on 10 June at 6pm BST/1pm EDT.

newscientist.com/events

Tour

The science of primary rainforests and wetlands: Malaysian Borneo

Explore the wetlands and rainforests of Malaysian Borneo, which are teeming with rare and endangered species. Experience nature resorts and wildlife safaris while looking out for orangutans, sun bears, gibbons, proboscis monkeys, rhinoceros hornbills and much more. This 10-day tour starts on 10 August and costs £5399.

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Podcast

The world, the universe and us

The team are joined by physicists Celso Villas-Boas and Gerhard Rempe to discuss a new interpretation of the double-slit experiment and why light may not be what it seems. Hear about two competing theories of how consciousness arises in the brain. Plus, learn how dolphins communicate via whistling.

newscientist.com/nspod

SIMON R BROWN/ALAMY

Wildlife safari Malaysian Borneo is home to a variety of animals

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY

Into the unknown Black holes' extreme effects help us detect them

Video

Creepy caterpillar

A carnivorous caterpillar species has been dubbed the "bone collector" because it camouflages itself with the body parts of dead insects. It does this so it can live safely alongside spiders, stalking their webs and stealing their prey. The newly described species of *Hyposmocoma* is the only caterpillar known to use this macabre disguise.

youtube.com/newscientist

Newsletter

Lost in Space-Time

For 120 years, space-time has been key to our understanding of the universe. Reporter Karmela Padavic-Callaghan reveals the shocking reasons why some physicists are trying to ditch the concept – and explains why the supposed fabric of physical reality may be a fiction.

newscientist.com/lost-in-space-time

Podcast

"It's hard to shake something we've been taught as hard truths for decades"

Recommended reads

Delve into a wealth of scientific books, including Gina Rippon's exploration of the emerging science of female autism in the recently published *The Lost Girls of Autism*. Find this and more online.

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NewScientist

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- Explore primary rainforests, marine ecosystems and their flora and fauna, including several species of birds of paradise and Wallace's golden birdwing butterfly.
- Gain in-depth insight into the life and work of Wallace, plus the natural treasures of Indonesia.
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Better open than closed

Suppressing scientific ideas for fear of the consequences won't work in the long run

WHETHER it's Pandora's box, Eve's apple or the cat's curiosity, there is no shortage of cautionary tales about the dangers of knowledge – but are there really ideas so toxic that they should be suppressed?

Well, it depends on whom you ask. When faced with Galileo Galilei's heretical concept of Earth not being the centre of the universe, the Catholic church came down hard as the idea threatened its teachings. While this did delay heliocentrism, the church apologised... in 1992.

Suppression, then, can hold back an idea for only so long, especially if it turns out to be true. And yet, as we report on page 10, some researchers are arguing that we should reject a proposed theory of consciousness because of its implications for thorny questions like the rights of fetuses or artificial intelligences, even as evidence points in its favour.

This is a long way from inquisitors' cries of heresy, but there is something uncomfortable about dismissing a scientific idea based on its potential consequences. It is still far from clear whether this idea, known as integrated information theory, is even the right approach to consciousness – but it would be wrong to abandon it prematurely.

> "Ultimately, science is the process of opening a never-ending series of Pandora's boxes"

Maybe researchers should simply pursue the purity of knowledge, without concern for fallout? This too would be an error.

Take the example of physicists whose explorations led to the conception of the atomic bomb. Albert Einstein, working with others, sent a letter to US President Franklin Delano Roosevelt in 1939 to warn him that scientists in Nazi Germany were probably already working to build one, spurring on the Manhattan Project.

Ironically, Einstein regretted sending his letter, feeling that it led to the bombing of Hiroshima and Nagasaki. But it is hard to argue that he shouldn't have issued his warning. Ultimately, science is the process of opening a never-ending series of Pandora's boxes that are home to potential good or ill. Scientists can do their best to shepherd what they have released, but leaving the boxes closed would be a poorer choice. ▮

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Space

A glowing group of galaxies

IN THE darkness of deep space, these glowing galaxies have put on a light show. Captured by observatories including the James Webb Space Telescope, this image contains thousands of galaxies, including the gold cluster near the centre that looks to us as it was when the universe was just 6.5 billion years old. The large purple cloud covering it isn't a printing error – it shows hot gas in the region, as seen by X-ray telescopes.

ESA/WEBB, NASA & CSA, G. GOZALIASL, A. KOEKEMOER, M. FRANCO, AND THE COSMOS-WEB TEAM ACKNOWLEDGEMENT: J. KARTALTEPE AND C. CASEY

Cosmology

Time for a new model of the universe?

'Shocking' results from a major astronomical study are forcing scientists to consider new ways of understanding dark energy and gravity, finds **Alex Wilkins**

IN THE wake of bombshell findings that suggest dark energy might be weakening as the universe expands, physicists are considering replacing the standard cosmological model of the universe with exotic new theories that say gravity works differently to how we thought. Ideas involving string theory, a new fundamental force or even a form of gravity that changes over time are all options on the table.

Our best model of the universe is called lambda-CDM, which splits the cosmos into three parts: the matter we can see, the matter we can't see that still has a gravitational pull – known as dark matter – and dark energy, a persistent repulsive element that is forcing the universe to expand increasingly quickly. In equations first devised by Albert Einstein, the universe is thought to accelerate at a fixed rate, known as the cosmological constant and represented by the Greek letter lambda.

This fits almost all of our observations of the universe so far, but the Dark Energy Spectroscopic Instrument (DESI) in Arizona, which has built the largest 3D map of the cosmos by tracking millions of galaxies across the sky, has called the model into question. DESI precisely measures the distances between galaxies at different times in the universe's history, allowing cosmologists to calculate how quickly the universe is expanding.

Last year, it found the first hints that dark energy isn't a constant and that the universe may be accelerating less quickly over time. These initial results were tentative, but a second release of DESI findings in March, covering three years' worth of data, strengthened those hints, though it still fell short of the required statistical certainty needed for a conclusive discovery. "Everybody was watching this data release from DESI, and it was pretty shocking," says Yi-Fu Cai at the University of Science and Technology of China.

"This is exciting – it might actually be putting the standard model of cosmology in danger," says Yashar Akrami at the Autonomous University of Madrid in Spain.

While researchers from the DESI group suggested tweaking lambda-CDM to fit their findings by adding new adjustable numbers to it, Akrami and his colleagues argue that these tweaks aren't grounded in any physical reality. They instead found that they could better describe the distance changes that DESI is seeing by describing dark energy as a field, similar to the ones that describe light or the nuclear forces, but smoothly changing over time.

"This is exciting – it might actually be putting the standard model of cosmology in danger"

One advantage of this idea, called a quintessence field, is that its existence can be derived from more complete models of the universe, such as certain string theory models. "If you prove that quintessence is dark energy, it's very good for [string theorists]," says Akrami. "That's why the string theory community is really excited now."

It is also good news for other theories of quantum gravity, which have long grappled with the prediction based on lambda-CDM that the universe's expansion will accelerate forever, says Cai. Many of these theories say that, in a constant-acceleration scenario, quantum ripples can expand over time and eventually become as large as the universe itself. This is incompatible with a complete description of the universe, but a changing dark energy would make many of these theories more viable, he says.

LUKE TYAS/BERKELEY LAB

The DESI project has built the largest ever 3D map of the cosmos

A fifth force?

Akrami and his team's quintessence model doesn't interact with gravity in any meaningful way, but other researchers have found that models of dark energy that do interact with gravity fit the data better. Gen Ye at Leiden University in the Netherlands and his colleagues have suggested a model called thawing gravity, which says that gravity as described by Einstein's general relativity will begin to work differently at some point in time through its interactions with the changing dark energy field. This can help explain a problematic new implication from DESI that the energy density of the universe must increase over time if dark energy becomes weaker, says Ye.

Pedro Ferreira at the University of Oxford and his colleagues have found that a different quintessence model of dark energy, one that also interacts with gravity, describes what DESI appears to be measuring. "It seems to be, in my view, the only way that can be done," he says.

This would be a radical change to how we think about the universe, says Ferreira. "We've always grown up thinking about the universe as having the gravitational force, and gravity fuels everything," he says. "But now there's going to be an additional fifth force, which is due to the dark energy, which also fuels everything."

One major problem with this adjustment, however, is

that we should have seen evidence of this fifth force in precise measurements such as planetary orbits and tests of relativity on Earth. So we would also need to invent a physical principle that prevents us from measuring the effects of that fifth force in these systems, says Ferreira. "Physics ends up being even more complicated than we thought it could have been, and that kind of makes you wonder, why do you want to go down that route?"

Unfortunately, the current DESI data isn't precise enough to discriminate between the different models of dark energy interacting with gravity, says Ferreira. "Two or three or four or five people come up with different theoretical explanations for it, and there will be no way, using this data, to distinguish between these theoretical proposals," he says. "What we'll end up doing is having these debates based on opinion on what's the right theory, and we'll never resolve it."

Ye is hopeful that there will be a way to determine which idea is correct. If gravity is altered in subtle ways by dark energy, then it might show up in other observations, such as weak lensing surveys, which measure how light is bent by galaxies as it travels through the universe. "If thawing gravity is correct, it will change how light is bent by big masses," he says. "The bending effect will be different from general relativity."

But concluding that dark energy is changing at all is still premature, most cosmologists agree, until we get more data showing this. Some clarification will come from DESI data, which is due in the next couple of years, and further information will come from other dark energy surveys, such as the European Space Agency's Euclid satellite. ▮

Archaeology

Ancient burial grounds may have really been social spaces

Christa Lesté-Lasserre

PATRYK KOSMIDER/ISTOCKPHOTO/GETTY IMAGES

Poulnabrone dolmen is an ancient tomb in County Clare, Ireland

IRELAND'S megalithic tombs might not have been burial grounds for elite dynasties, as some thought, but rather places of community bonding.

In 2020, researchers found genetic links among dozens of people in ancient tombs scattered across Ireland and evidence of incest in a man buried in an elaborate sepulchre, leading them to conclude that the tombs held members of a hereditary ruling class, somewhat akin to Egyptian pharaohs.

Like many archaeologists, Jessica Smyth at University College Dublin, Ireland, and her colleagues were sceptical. Previous excavations had shown that remains in such tombs were deposited across centuries and were often moved and combined with parts from other individuals, which suggests that their burials were complex and possibly symbolic, rather than based on strict lineages.

"The deep past is fragmentary, so you have to be really careful how you piece that together," says Smyth. "We knew the picture was much more nuanced and that there was a richer story to tell."

While the DNA work in the 2020 study was "world class", it didn't give a full picture, says Neil Carlin, also at University College Dublin, who worked on the new analysis. When Carlin, Smyth and their colleagues re-examined the data, they found that the original researchers had sequenced the genomes of four people at most, usually only one or two, from individual tombs that held around 100 people.

Many of the bones weren't available because they hadn't

"The sheer effort alone to construct these massive monuments suggests they were social projects"

been excavated, had been moved or were in labs for other research projects. A significant number had also been cremated, making them "genetically invisible", says Carlin.

The data re-examination reveals that close biological relationships – like those between parents and children – were surprisingly rare, especially after 3600 BC, says Smyth. Instead, most of the connections were distant, like second or third cousins. Plus, these deaths were often spaced several hundred years apart and about a third of the people weren't related at all (*Cambridge Archaeological Journal*, doi.org/pkhm).

The team argues that the findings don't align with dynasty-like ancestral burial practices. Instead, they paint a portrait of community unity.

The sheer effort alone to construct these massive monuments suggests that they were group social projects, according to the team. Rather than Neolithic Irish equivalents of Egyptian pyramids, these tombs were probably part of a wider megalithic tradition used to build and maintain social ties across communities.

"It may have been a time when there were marriages; it may well have been a time for laying other people to rest," says Vicki Cummings at Cardiff University, UK. "There would almost certainly be feasting and partying. The glue that holds all of that together is monument construction."

Carlin says the genetic similarities among the dead may reflect broader-scale ancestry, shaped by alliances and rituals, rather than immediate family lines.

"This paper is really important because it creates a more holistic understanding," says Cummings. "The original interpretations did cause quite a stir, and I think they were very interesting. But you can't not include the archaeological evidence as part of that narrative. The challenge we had as archaeologists was, it didn't quite fit with our vision of what Neolithic Ireland was like." ▮

Neuroscience

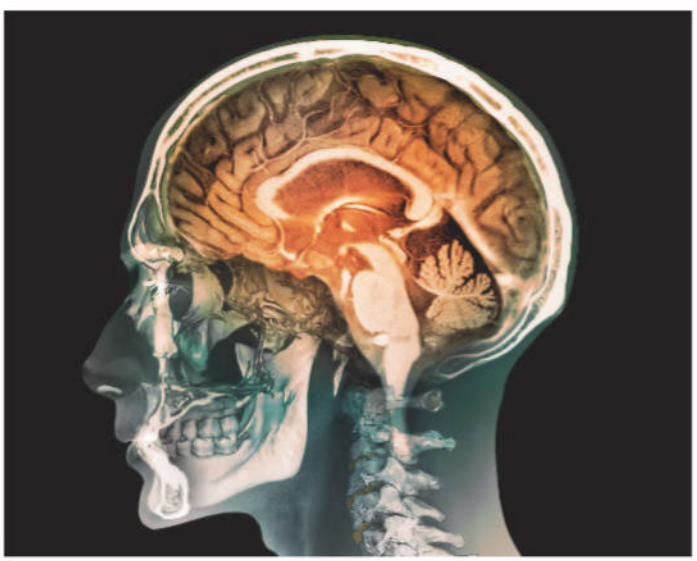
Debate over theory of consciousness

The great mystery of how consciousness arises in the brain is continuing to cause controversy, with arguments over whether one leading idea even counts as science, finds **Helen Thomson**

SUPPORTERS and detractors of a leading theory of how consciousness arises are stuck in an increasingly bitter argument. Opponents suggest that integrated information theory (IIT), which claims that consciousness can be defined on a mathematical spectrum, is pseudoscience that could be misused to influence sensitive debates around abortion and the sentience of artificial intelligences – while supporters say the detractors are just jealous.

Scientists have long sought to explain how the brain gives rise to conscious experience, but two prominent ideas have recently come to the fore: IIT and global neuronal workspace theory (GNWT).

The former identifies five essential features of consciousness and asks what kind of physical system could exhibit them. It suggests consciousness arises from any system whose components exchange information in a mathematically defined way and can be quantified using a measure known as phi. The more integrated information there is, the higher phi's value and the more conscious the system is. IIT links consciousness with posterior brain areas, which have neuroanatomical properties suited to producing high phi values.



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Different regions of the brain have been tied to consciousness

Searching the mind

GNWT, by contrast, suggests that information competes for attention in cortical and thalamic brain regions. If one signal outcompetes another, it is broadcast across the brain, becoming conscious. This transmission happens at the beginning and end of an experience and is tied to the prefrontal cortex, at the front of the brain.

To test both ideas, Lucia Melloni at the Max Planck Institute for Empirical Aesthetics in Frankfurt, Germany, and her colleagues, who included people favouring either IIT or GNWT, scanned the brains of 256 people while they looked at objects such as faces and letters, identifying certain aspects of them. The study, which took seven years, examined which brain regions processed the images, how long they were active and how synchronised the activity was.

The results, which were first presented at a conference in 2023 and were formally published last week in *Nature*, were inconclusive. Some findings leaned towards IIT. For instance, visual features like category and orientation were decoded in posterior brain regions, and brain activity during conscious perception appeared sustained. However, patterns of synchronicity matched expectations predicted by GNWT (*Nature*, DOI: 10.1038/s41586-025-08888-1).

While some researchers have welcomed the work as a vital step towards understanding consciousness, others have been increasingly vocal in rejecting IIT since those initial results in 2023. That same year, 124 neuroscientists signed an open letter branding it as pseudoscience, arguing that, according to IIT, inactive computer logic gates, plants and early human fetuses are likely to be conscious. In a more detailed commentary, published in March, 100 scientists reiterated that IIT's core claims are untestable and fall short of the empirical basis required for scientific enquiry.

> **"There is a long history of scientific ideas being rejected due to their implications"**

Chris Frith at the University of London, a co-author of both critiques, said he and his colleagues had a variety of concerns, from IIT being inconsistent with physical laws to its vague assumptions and its lack of clear, testable predictions. Some of the researchers fear that giving credibility to IIT, or giving the public the idea that it is a leading theory of consciousness, could affect ethical decisions, he says.

"In the cases of coma patients, AI sentience and abortions, we are asking 'how do we know if the patient, the fetus or the AI are conscious?'. We cannot yet use brain activity to answer this question adequately and it would be dangerous, at this stage, to base our answers on any theory that was not empirically validated," says Frith.

But supporters say that many theories of consciousness might affect ethical debates, not just IIT. Christof Koch at the Allen Institute for Brain Science in Seattle, a co-author of Melloni's study, says the backlash stems from jealousy.

"IIT was perceived to be sexier than other theories, getting more attention and money," he says. "The writers [of the open letter] assembled a grab bag of pseudo-arguments – 'IIT receives funding from right-wing philanthropists, IIT is anti-abortion, IIT has panpsychist implications'." None of these is a reason to dismiss the idea, he says. "Any inferences or implications of a theory ought to be irrelevant to the question of whether or not it is correct."

Anil Seth at the University of Sussex, UK, who wasn't involved with Melloni's study or the anti-IIT commentaries, points out that there is a long history of scientific ideas being rejected due to their implications, from the idea that Earth isn't the centre of the universe to Charles Darwin's theory of natural selection. "Consequentialism is not a valid reason to reject a theory as unscientific." ▮

Quantum computing

To make a better quantum computer, just add chaos

Karmela Padavic-Callaghan

EFFORTS to build truly useful quantum computers often come down to making them bigger by adding qubits, the quantum bits that are the basic building blocks of these devices. But creating quantum chaos inside them could have the same effect – and let these computers perform tasks that seem too big to handle.

Creating true quantum randomness – which is distinct from quantum chaos, and can be a useful resource in quantum technologies – usually requires a lot of engineering. But Wai-Keong Mok at the California Institute of Technology and his colleagues have discovered how to leverage chaos to do it for us.

"They found a very efficient way of effectively translating classical randomness – which is something we understand very well, which is very easy to generate – into quantum randomness, which is something that's hard to understand and also much harder to generate," says Pieter Claeys at the Max Planck Institute for the Physics of Complex Systems in Germany.

In a truly random system, there is no way to predict the properties of a quantum object even if you have interacted with it before. Because quantum physics allows for more correlations than exist for non-quantum objects, quantum and classical randomness also aren't equivalent – and the classical kind is much easier to create.

Chaos, on the other hand, can be more predictable, but chaotic systems are extremely sensitive to their conditions, so even slight changes in the environment can change a chaotic object's behaviour.

The researchers analysed how the quantum version of this sensitivity may help quantum objects become more random. They simulated a chaotic system that was made up of many qubits. In their set-up, making measurements on some qubits pushed others into random quantum states and the researchers could quantify the amount of quantum randomness in that final state.

"Quantum randomness is something that is hard to understand and also much harder to generate"

They ran many simulations to determine the initial properties that would result in the system gaining the most quantum randomness after being allowed some time to experience chaos. Ultimately, making the qubits' initial state more classically random turned out to be the best choice (*Physical Review Letters*, in press).

Mok says the team was surprised to find that this conversion turned each unit, or bit, of classical randomness into as much quantum randomness as if they had added a whole extra qubit to the system.

Mok says it may already be possible to concretely test this result because some experiments with extremely cold atoms have previously created chaotic systems like the one his team studied. The next step is to use similar experiments to confirm that a mix of classical randomness and quantum chaos can indeed be helpful for tasks such as benchmarking the atoms' ability to work as qubits. ▮

Zoology

How Greenland sharks live so long without going blind

GREENLAND sharks, the longest-lived vertebrates in the world, show no signs of physical deterioration in their retinas even after living for hundreds of years. The finding is especially surprising as some scientists suspected the animals were functionally blind since they live in such deep, dark waters.

Lily Fogg at the University of Basel, Switzerland, and her colleagues conducted physical studies of the eyes of eight dead Greenland sharks (*Somniosus microcephalus*) and sequenced their DNA.

In humans and most other animals, the light-detecting cells on the retina at the back of the eye degenerate over time, resulting in blurred vision. But even though the sharks in the study were estimated to be centuries old when they died, the team found no signs of retinal degeneration.

Most vertebrates have two types of light-detecting cells: cones, which can differentiate colours, and rods, which don't allow colour vision but work much better at low light levels. The team found that genes involved in cone function were largely inactive, suggesting that Greenland sharks rely mostly on their rods for vision.

FRANCO BANFI/NATURE PICTURE LIBRARY/ALAMY

Greenland sharks live for hundreds of years in deep, dark waters

The researchers attribute the extreme longevity of Greenland shark vision to a gene involved in DNA repair called *ercc1*, which seems to be more active in these animals than in other sharks (bioRxiv, doi.org/pkbc).

They also found that the gene for melanopsin, a light-sensitive protein that mediates the circadian rhythm in vertebrates, has become non-functional in Greenland sharks.

In the absence of melanopsin, it is possible that the sharks use other cues to regulate their life cycle and biological processes, says Ewan Camplisson at the University of Manchester, UK, such as temperature or the need to feed. ▮

James Woodford

Health

Drugs like Wegovy can help treat fatty liver disease

Christa Lesté-Lasserre

A POPULAR drug for treating obesity and diabetes is now showing benefits in fighting a deadly liver disease.

Semaglutide, marketed under names including Ozempic and Wegovy, aids weight loss and blood sugar regulation by mimicking the hormone, GLP-1, which curbs appetite and triggers the release of insulin. Now, researchers have discovered that the medication can also halt – or in some cases even reverse – a condition called metabolic dysfunction-associated steatohepatitis (MASH).

"This potentially offers a foundational approach to the management of this condition," says Philip Newsome at King's College London.

MASH, formerly called NASH, is the severe form of non-alcoholic fatty liver disease. It is marked by increased fat build-up in the liver, which leads to inflammation and fibrosis – the formation of scar tissue – and sometimes cirrhosis and cancer. It is typically linked to obesity and often type 2 diabetes.

In a previous trial, Newsome and his team found that a daily semaglutide injection led to

62.9%

Percentage of people with MASH taking semaglutide who had a drop in liver fat and inflammation

reduced liver fat and inflammation in 59 per cent of those with MASH. But a more recent study in 71 people showed no benefits of a weekly regime.

To get a broader view, Newsome and Arun Sanyal at Virginia Commonwealth University began a bigger trial involving 1195 people with MASH. Participants were 56 years old, on average, with a body mass index of 34.6. About half had type 2 diabetes.

Each received a weekly injection of either semaglutide or a placebo. The dose corresponds to that used in Wegovy. People were also offered counselling to encourage a healthy diet and exercise.

While the full study period is ongoing, after 72 weeks, the team analysed the biopsy results of the first 800 participants, including 266 who had placebo injections. They found that 62.9 per cent of those taking semaglutide had marked reductions in liver fat and inflammation, compared with 34.3 per cent of the placebo group.

Fibrosis improved for 36.8 per cent of the treated group but only 22.4 per cent of the placebo group. About a third of all treated participants, and 16.1 per cent of those receiving placebo, had both benefits (*The New England Journal of Medicine*, doi.org/pkhk).

Weight loss alone may have contributed, as people in the treated group lost an average of 10.5 per cent of their body weight, compared with only 2 per cent of body weight for those taking placebos. But the treatment itself might also target the disease-causing process – although more research is needed to fully understand the mechanisms.

"This is just groundbreaking news," says Jeffrey Lazarus at CUNY School of Public Health & Health Policy in New York, especially following the US Food and Drug Administration's approval last year of resmetirom, a drug for the condition. "We've had no treatment for this disease apart from non-pharmaceutical interventions. And now with both these drugs, there's finally something more we can do." Even so, the medications shouldn't replace lifestyle changes, but complement them, he says.

Microbiology

Washing machines may be leaving some bacteria behind

CLEANING your clothes in a washing machine on even a hot water setting of 60°C (140°F) can fail to remove potentially harmful bacteria.

Research has shown that contaminated fabrics can remain a source of infections for weeks, but also that washing at 60°C with a detergent can rid your clothes of bacteria.

NHS England recommends that its healthcare workers wash their uniforms for 10 minutes at 60°C to remove almost all microorganisms, says Katie Laird at De Montfort University in Leicester, UK. "But my issue has always been that you don't know what the machine is doing."

So, she and her colleagues tested six models of home washing machine to see how well they cleaned fabric samples contaminated with *Enterococcus faecium* bacteria, which can cause a variety of conditions, including urinary tract infections.

Testing both rapid and standard 60°C cycles, the team found that half of the machines didn't disinfect the clothing – defined as cutting bacteria levels by at least 90 per cent – during the former, and one-third still failed during a standard cycle (*PLoS One*, DOI: 10.1371/journal.pone.0321467).

"This is because a large proportion of the machines weren't holding or even reaching the temperatures you think they are, particularly on shorter cycles," says Laird. "We had one machine

SHUTTERSTOCK/PEOPLEIMAGES.COM - YURI A

Your washing machine may not be reaching the temperatures you think it is

that was just functioning at 20°C (68°F) and the person didn't know."

They also found evidence that microorganisms inside washing machines are developing resistance to detergents, after looking at bacteria before and after a series of washes. DNA sampling revealed that the microbes started to develop genes to help them survive.

The results suggest that using home washing machines to clean healthcare uniforms could be contributing to the spread of hospital-acquired infections and antibiotic resistance, says Laird.

To minimise the number of bacteria and viruses in a home washing machine, Laird suggests people regularly use washing-machine disinfectants, run a 90°C (194°F) cycle to clean the machine and use a descaler to prevent the build-up of limescale, which can stop the heating element from working.

Chris Simms

Cell biology

Our cells can divide in an unexpected way

Claire Ainsworth

WHEN cells divide, they can use the information encoded in their shape to direct what kinds of cells their offspring become. This discovery could help to develop ways of engineering tissues and deepen our understanding of how cancers spread.

Until now, scientists thought that most cells in the body become round as they prepare to divide in two. This makes it easier for them to distribute their contents equally between their "daughter" cells, resulting in two cells of the same type.

An exception to this is stem cells, which undergo an unequal, or asymmetric, cell division that produces cells of two different types.

But Shane Herbert at the University of Manchester, UK, and his colleagues noticed that non-stem cells in the developing blood vessels of zebrafish embryos were also dividing asymmetrically. These cells, known as endothelial cells, were migrating to form new blood vessel branches and divided without rounding to create two different types (*Science*, DOI: 10.1126/science.adu9628).

When the team manipulated the shape of human endothelial cells in a lab dish, it confirmed that their shape before division predicted how symmetric that division was going to be. Longer, thinner cells were the most likely to divide asymmetrically, which suggests that cells can fine-tune the nature of their divisions depending on the shape they take between them.

It means cells don't lose information about their structure and behaviour as they would if they underwent rounding, says Herbert. "Very frequently, they actually retain their shape, and that means they can transfer that kind of memory."

This also means that cells don't have to stop what they are doing to divide, but can migrate, divide and generate different cell types all at once. This lets them respond quickly to the dynamic demands of development, such as the need to supply an expanding tissue with blood vessels or nerves.

The discovery could have applications for growing replacement tissues in the lab, where the ability to grow blood vessels is a key limitation. "Our work is showing that there's a really specific environment that's needed to give these cells the kind of shape and behaviour that they need to generate functional blood vessels," says team member Holly Lovegrove, also at the University of Manchester.

Manipulating cell shapes could offer a new way to generate certain cell types, she says. Cancer, meanwhile, spreads by generating clusters of migrating cells, so the new findings could provide further insight into how they do this.

> "The new findings could provide further insight into how cancer spreads"

It is a nice example of how organisms can tweak mechanisms like cell rounding to do different things, such as the multitasking needed to sculpt developing tissues, says Buzz Baum of the MRC Laboratory of Molecular Biology in Cambridge, UK. "It's a clever way to keep the information you need while still growing the network by making more cells." ▮

Climate change

Eurasia has seen a surge in droughts

James Dinneen

ASAAD NIAZI/AFP VIA GETTY IMAGES

Territories across Eurasia, including Iraq, have been affected by drought

OVER the past two decades, swathes of Eurasia – from Ukraine's breadbasket to cities in northern China – have seen a spike in extreme heatwaves followed by droughts. A tree ring record extending back nearly three centuries suggests human-caused climate change is to blame.

This pattern can be especially damaging because high temperatures dry out soil and drought then deprives it of moisture to cool things off during the next heat wave. This vicious cycle has devastating impacts, from lower agricultural yields to higher wildfire risk.

While parts of Eurasia have seen this heatwave-drought pattern before, "the present trend is just way outside of natural variability", says Hans Linderholm at the University of Gothenburg in Sweden.

The full picture only became clear after Linderholm and his colleagues assembled tree ring records, which preserved temperature and precipitation conditions since 1741, from across Eurasia. They used this to reconstruct the large-scale distribution of high and low-pressure systems that naturally drives wet and dry conditions across the continent.

The researchers found a particular scenario in this region, which they call the "trans-Eurasian heatwave-drought train", has markedly intensified since 2000, with the size of heat and precipitation anomalies jumping above those measured at any other time in the record (*Science Advances*, DOI: 10.1126/sciadv.adr7320).

They link this change to disruptions in atmospheric pressure caused by heating in the North Atlantic and increased rainfall in parts of northern Africa, both of which are associated with anthropogenic climate change.

Rising local temperatures can also directly exacerbate extreme heat and drought. But the new finding shows how climate change is also shifting relationships between distant parts of the atmosphere – known as teleconnections – to disrupt things even more, says Linderholm.

The team's projections, based on climate models, suggest things will get worse under all but the lowest-emission scenarios. ▮

Zoology

Best evidence that dolphins communicate a bit like us

Chris Simms

DOZENS of dolphins have been recorded making specific whistle sounds that seem to have a shared meaning, expressing either questioning or alarm. Some researchers are claiming this hints that these intelligent marine mammals have a language-like communication system.

We know that dolphins make many "information-carrying" whistling noises, and may communicate extra detail by changing the volume of their whistles, but researchers have avoided claiming any non-human animals have a language.

Dolphin studies are particularly hamstrung because the animals' marine environment makes it difficult to pinpoint a sound to a specific animal, says Laela Sayigh at the Woods Hole Oceanographic Institution in Massachusetts.

So, Sayigh and her colleagues have been using data from the Sarasota Dolphin Research Program in Florida. For decades, the project has been identifying individual common bottlenose dolphins (*Tursiops truncatus*) using photographs of their markings and, since 2012, recording them with individually attached underwater microphones.

This has resulted in a vast pool of information on a community of about 170 wild dolphins in the waters around Sarasota Bay, spanning six generations and including individuals of all ages.

Researchers have previously catalogued "signature" whistles that seem like they are unique identifiers or names of dolphins that their podmates learn, but Sayigh and her colleagues are studying noises they call non-signature whistles.

They have so far identified 22 other whistles made by multiple dolphins. The most widespread is produced by at least 35 different animals, followed by one shared by 25 dolphins (bioRxiv, doi.org/pkfp). "Those numbers keep climbing the more analysis I do," says Sayigh.

She and her colleagues speculate that the first call is a query used when dolphins see or hear something unexpected or unfamiliar. These whistles have a flat component and the team has mostly seen them made by males. "They may make this whistle and they're kind of like 'What was that?'," she says.

> "I definitely think they're communicating, but I don't think we could call it language"

The second is a jarring whistle, reminiscent of alarm signals in other animals, and the dolphins seem to use it for the same warning purpose. To test this, the team played the sounds to six wild dolphins and found that five reacted negatively by moving away. This contrasts with a control test, in which 19 wild dolphins were played their own signature whistle; seven reacted negatively, a response rate less than half that of the alarm whistle.

Sayigh and her colleagues say these signals are the first evidence found in dolphins of a wider repertoire of shared, context-specific signals.

Sayigh is comfortable with calling it a language-like communication system, but says there isn't yet enough evidence to say dolphins definitely have language.

"It's really interesting to see that different individuals are producing whistles that are quite similar to one another," says Julie Oswald at the University of St Andrews, UK. "I definitely think they're communicating, but at this point, I don't think we could call it language." ▮

WIM VAN DEN HEEVER/NATURE PICTURE LIBRARY/ALAMY

Bottlenose dolphins make various whistling sounds

Health

Dark chocolate ingredient may have an anti-ageing effect

Michael Le Page

A KEY component in chocolate may have anti-ageing properties – but don't start stuffing your face just yet as it remains to be seen whether chocolate is good for you overall.

The chemical in question, theobromine, has been shown to extend the lifespan of one strain of worm, and there is some evidence of health benefits in people.

SHUTTERSTOCK/LESZEK KOBUSINSKI

The main source of theobromine in the diet is cocoa solids

To learn more, Ramy Saad at University College London and his colleagues analysed data on 500 women from a study called TwinsUK. This measured levels of a number of components in blood, including theobromine.

It also looked at epigenetic changes – the presence or absence of chemical tags on DNA that alter the activity of genes – in blood cells. Some of these changes are associated with ageing and can be used to estimate whether a person's "biological age" is higher or lower than their chronological age.

The team found that people with higher theobromine levels in the blood were more likely to have a biological age that was lower than their chronological age (bioRxiv, doi.org/g9gfx7).

The main source of theobromine in the diet is cocoa solids, says Saad. Dark chocolate is high in cocoa solids, milk chocolate has lower levels and white chocolate none.

Saad stresses that the findings don't mean that eating more dark chocolate will make you live longer. It could be that the negative effects of other components, such as sugar, outweigh any beneficial effects. ▮

Microbiology

Can mood affect your microbiome?

We already know the gut can change how the brain works, but the opposite could also be true

Grace Wade

THE brain appears to directly influence the gut microbiome, an effect that appeared in mice in as little as 2 hours. The finding strengthens the notion that communication along the gut-brain axis goes both ways.

It is clear from previous studies that gut microbes can influence brain function and mood, but whether the brain could alter the gut microbiome was less apparent.

Marc Claret at the August Pi i Sunyer Biomedical Research Institute in Spain and his colleagues used a technique called chemogenetics to activate specific neurons in the brains of 16 mice with specialised drugs. They targeted a subset of neurons in the hypothalamus known to regulate hunger. They then collected and analysed samples from four sections of the gut – 2 hours after neuron activation in half the mice and 4 hours later in the rest – and compared them with samples from a separate group of 16 mice that didn't receive the drugs.

The mice with activated neurons had an increase in the diversity of microbes in some regions of their guts, sort of like a microbial bloom. The effects were most pronounced in the duodenum – the first part of the small intestine – 2 hours after neuron activation. In this region, mice that underwent chemogenetics had microbiota five times more diverse, on average, than the control group.

The team then repeated the experiment in a separate group of mice, this time inhibiting the same neurons. This also led to significant changes in the gut microbiome, with some bacterial families declining more than 99 per cent, particularly in the middle part of the small intestine 2 hours after inhibition and in the final section of the intestine 4 hours later.

The intestinal lining of a mouse, with bacteria shown in green

IKELOS GMBH/CHRISTOPHER B. JACKSON/SCIENCE PHOTO LIBRARY

Further experiments in which the researchers injected hormones that regulate appetite into the brains of mice also revealed substantial changes to the gut microbiome in as little as 2 to 4 hours, with some bacterial families substantially increasing and others decreasing, depending on which portion of the gut samples came from (*Nature Metabolism*, doi.org/g9f9wf).

These results suggest that the brain can rapidly modulate the composition of the gut microbiome.

It isn't clear why these changes occur, but Claret suspects it may be that when the brain detects hormones related to food intake, it relays signals to the gut, instructing microbes to ready themselves for digestion. While these findings haven't been confirmed in people, brain circuits regulating appetite and digestion are quite similar between humans and rodents, he says.

If our brains can rapidly alter our gut microbes, this has significant implications for how we study the microbiome, says Christoph Thaiss at Stanford University in California. First, it suggests that researchers should account for peoples' mood and mental state when analysing microbiome samples. Second, we must start thinking of microbiota changes on an hourly scale, he says.

These findings also indicate there could be many more pathways linking the brain to the gut. "It could be that other brain regions, and neuronal types located in other areas that perform other functions, such as memory, may also have influences on gut microbial composition," says Claret. "So I think that [these findings] open a new avenue of research in microbiology." ▮

Technology

Hijacked cicadas play music like a cyborg loudspeaker

THE chirp of the cicada – the sound of many summers – has received an electronic upgrade that turns the insects into speakers playing anything from Pachelbel's Canon to the theme from *Top Gun*. The researchers behind the work say it could be used to spread warning messages during an emergency.

Naoto Nishida and his colleagues at the University of Tsukuba, Japan, were inspired by previous research in which cockroaches were remote-controlled by electrodes that triggered muscle movement. Nishida says that, while sitting in their woodland campus and hearing cicadas chirping nearby, the researchers decided to "borrow their chirp" using a similar approach.

Cicadas make noise with organs called timbals that have thick ribs joined by thin membranes that, when flexed, create a click. Doing this hundreds of times a second creates a continuous noise, with the pitch determined by the frequency of the flexes.

To take control of the timbals, the researchers implanted electrodes into seven large brown cicadas (*Graptopsaltria nigrofuscata*) and used signals from a computer passed through an amplifier to induce noises at precisely controlled pitches (arXiv, doi.org/pkhc).

The team was eventually able to induce the cicadas to accurately play music, with the insects capable of reproducing tones over more than three octaves, from a musical note A at 27.5 Hz to a C at 261.6 Hz.

"The modified insects were able to reproduce tones over more than three octaves"

Nishida, who is now at the University of Tokyo, says the animals were relatively unharmed by the experiments and some were released back into the wild. "Some of them wanted to run away," he says. "Some of them were like 'OK, use my abdomen!'"

The team claims in its paper that cyborg insects could be used in emergency situations such as earthquakes, where they could be more energy-efficient, durable and agile than electronic robots. ▮

Matthew Sparkes

Climate change

Extreme heat risks UK blackouts

Energy infrastructure will struggle to cope with high temperatures due to global warming

Madeleine Cuff

RISING summer temperatures pose a blackout threat to the UK's electrical grid, with crucial equipment ill-suited to cope with the climate of the future. In a worst-case scenario, extreme heat could trigger widespread power outages similar to those seen last week in Spain and Portugal.

The UK's Met Office predicts that temperatures of 40°C (104°F) or more could be recorded in the country every three to four years by the end of the century unless action is taken globally to reduce emissions. The UK's energy infrastructure is largely not equipped to handle such extreme temperatures, according to an analysis published in March by the consultancy Ricardo, produced in partnership with the UK government.

The analysis rates crucial elements of the power network – including underground cabling, transformers, service lines and circuit breakers – as among the most vulnerable parts of the system. UK transformers, for example, are designed for ambient temperatures of up to only 40°C before they lose capacity and become vulnerable to failure.

PETER LANE/ALAMY

The UK's energy infrastructure is vulnerable to heat waves

The report warns of the potential of "high impact" failures of energy assets at warming levels of 2°C, particularly in East Anglia and the South East, where future summer temperatures are expected to be the most extreme. "Some of these components, when there are faults, they can cause blackouts," says Ryan Hogarth at Ricardo.

The UK's electricity system is designed to operate within temperature ranges that cover the winter and summer seasons. But recent years have brought sharp spikes in temperatures that are outside the country's norm. For example, in July 2022, UK temperatures exceeded 40°C for the first time in its history. This put the power grid under strain, with the network running at lower capacity because of the high temperatures while trying to meet increased demand for cooling. Analysts at Cornwall Insight warned the system came "very close" to a shortfall of electricity.

Managing such extreme heat is expected to become harder in the UK, as more people install cooling systems such as air conditioning in their homes and offices.

The causes of the blackouts in Spain and Portugal were still unclear as *New Scientist* went to press, but they look likely to have been triggered by generation loss from multiple electricity generators simultaneously that caused a collapse of the wider system, showing the damage this kind of cascade effect could inflict.

The Ricardo study looked only at the vulnerability of individual grid components in the UK to extreme heat. But if many pieces of equipment fail at the same time, that could trigger a widespread power failure, says Keith Bell at the University of Strathclyde, UK. "It is the combination of outages that you're most worried about." ▮

Environment

Microplastics found at every depth of the ocean

A GLOBAL survey of microplastics reveals they are prevalent throughout the water column, which could affect the ocean's ability to capture carbon.

"It's millions and millions of metric tonnes of this stuff throughout the interiors of the ocean," says Tracy Mincer at Florida Atlantic University.

Mincer and his colleagues have reviewed microplastic measurements taken over the past decade from nearly 2000 sites around the world. While most microplastic measurements focused on the surface of the ocean, the dataset included samples from a range of depths, including the deepest parts.

They found that microplastics have been recorded virtually everywhere people have looked, including the Mariana trench, where more than 13,000 microplastic particles per cubic metre were measured nearly 7 kilometres down (*Nature*, doi.org/pkhn).

The researchers were surprised to see that the smallest particles are distributed almost evenly throughout the water column. "We expect to find plastics at the bottom of the ocean, and at the top of the ocean. But not everywhere," says Aron Stubbins at Northeastern University in Massachusetts.

They also found that the polymers in these plastics account for a significant proportion of the carbon particles floating around. At depths of 2000 metres, where there is less biological activity than nearer to the surface, they make up as much as 5 per cent of the carbon.

"Buoyant plastic consumed by plankton could reduce the volume of carbon that sinks to the ocean depths"

The ecological consequences of this are largely unknown, but one concern is that buoyant plastic consumed by plankton could reduce the volume of carbon that sinks to the depths in their faecal pellets and dead bodies. That could hamper the ocean's ability to take up carbon dioxide from the atmosphere, says Stubbins. ▮

For more on microplastics, turn to page 38

James Dinneen

Technology

Housework robots are a step closer to reality

Alex Wilkins

AN AI enabling robots to do chores like making the bed or cleaning up spills in homes it has never seen before could allow many more robots to become generally useful, its creators say.

Large language models (LLMs) that power tools like ChatGPT have improved robots' ability to carry out spoken requests. However, most robots work well only in environments in which they have been trained.

Now, Sergey Levine at robotics company Physical Intelligence in San Francisco and his colleagues have developed an artificial intelligence model called π0.5 that allows robots to work in real homes that they have never seen before (arXiv, doi.org/pkbb).

The model is trained using data from an unusually wide range of sources, including many different kinds of robots working in lab and home settings, as well as extensive data scraped from the web, such as image and object databases.

When Levine and his team tested the AI model on robots they had built using off-the-shelf components, 97 per cent of the training data came from sources other than the robot itself. "Because π0.5 can leverage other data sources, from the web and other kinds of robots, then it can have this broader generalisation," says Levine.

The team tested how well the robots performed when instructed to do chores such as putting plates in the sink, putting shopping away in drawers and placing dirty clothes in a basket.

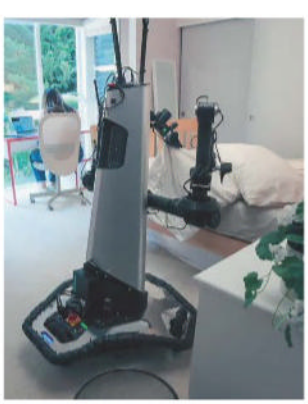
They didn't work perfectly every time. "When it comes to the practical utility of this model, it's definitely not there yet, in the sense that this is not a home robot that somebody could buy and put in their home," says Levine.

But he says that the robots' performance appears to improve in a predictable way as they are tested in increasing numbers of homes. This trend, called a scaling law, is similar to how language AI performance was found to predictably improve as more data was added.

For instance, when a robot gets to around 100 homes, it can perform a task as well as a robot that has been trained and tested in a specially designed testing facility. "What we have established, and that I think is very, very promising, is the beginnings of these kinds of scaling laws [for robots]," says Levine.

"The videos they show are quite impressive," says Pedro Lima at the University of Lisbon in Portugal. However, the robots perform their tasks at least five times slower than a human, sometimes taking 10 to 15 minutes to finish, which could be difficult to improve, he says. ▮

The robot can do household chores like making the bed



PHYSICAL INTELLIGENCE (Π)

Health

A single antivenom for 19 deadly snakes

James Woodford

A SNAKE antivenom based on antibodies from a hyperimmune man seems to be effective against the bites of multiple species, raising the possibility that a universal treatment may be within reach.

Snake bites cause up to 137,000 deaths a year and around three times as many amputations and disabilities. Antivenoms are currently created for individual snake species using antibodies from sheep or horses that have been exposed to their venom.

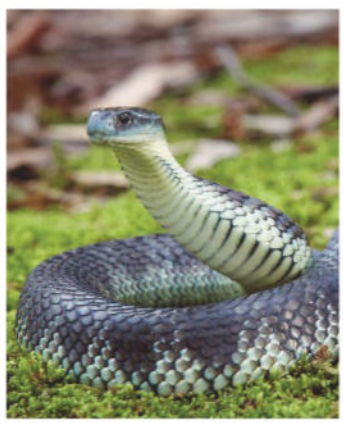
But the infusion of non-human antibodies can cause severe side effects, such as life-threatening allergic reactions. It also means that the snake responsible for a bite needs to be identified before an antivenom can be delivered.

Jacob Glanville at biotechnology firm Centivax in San Francisco, California, and his colleagues are looking for broadly neutralising antibodies that could be developed into an antivenom that works against many, or even all, venomous snakes. "Although there are 650 species of venomous snakes, all of their venom uses the same 10 general classes of toxins," says Glanville.

The researchers first sought out someone who had been bitten multiple times by different snakes. "Perhaps a clumsy snake researcher," says Glanville. Then he heard about Tim Friede, who, according to his online biography, has "self-administered over 700 escalating doses of snake venom from the world's deadliest snakes".

"If anyone could have generated broadly neutralising antibodies against snake venom, it would have been Tim Friede," says Glanville.

From 40 millilitres of Friede's blood, the team turned his "immune memory into a library of billions of antibodies", he says. Promising candidates were then tested on mice that had been exposed to venom from 19 of the most dangerous species from the Elapidae family, according to a list by the World Health Organization, including several cobra species.



MARTIN WILLIS/MINDEN PICTURES/ALAMY

Tiger snakes are one of the most dangerous species in the world

Eventually, two antibodies from Friede's blood, called LNX-D09 and SNX-B03, along with a toxin inhibitor called varespladib, were made into a treatment (*Cell*, DOI: 10.1016/j.cell.2025.03.050). When this was tested on mice, it provided full protection against 13 species, including several types of cobra, the tiger snake (*Notechis scutatus*) and the common taipan (*Oxyuranus scutellatus*). It also provided partial protection against the remaining six species.

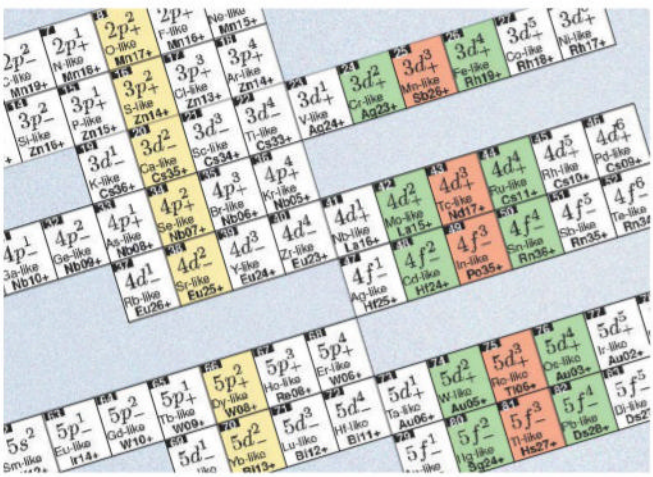
Tian Du at the University of Sydney, Australia, says that "finding just two antibodies (with an inhibitor) that can cover such a spectrum of snakes gives hope for a universal treatment in the near future".

But Du, who found that the blood-thinning drug heparin could prevent people losing limbs after cobra bites, wants to know if the team's treatment can prevent necrosis of the skin and muscles. ▮

Chemistry

Alternative periodic table could change how we measure time

Chris Simms



CHUNHAI LYU ET AL. (2025)

A new table orders ions according to the number of electrons

A NEW version of the periodic table of elements has predicted hundreds of highly charged ions that could be used to create the next generation of optical atomic clocks.

The periodic table, invented by Dmitri Mendeleev in 1869, now groups the 118 known chemical elements according to their chemical properties. Because elements in the same parts of the periodic table share similar characteristics, this ordering enabled chemists to identify gaps in the table decades ago, and has since helped them discover the elements to fill these holes.

But for some physicists, who are more interested in finding high-energy ions, it doesn't do the job they want. Such particles are used to test fundamental physics theories, and in X-ray lasers, tumour therapy, plasmas and optical clocks.

"We wanted to search for highly charged ions for atomic clocks, to make them much more stable and much more accurate," says Chunhai Lyu at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany.

Atoms consist of a nucleus containing protons and neutrons, with electrons arranged in shells and subshells outside the nucleus. In an atom, there are equal numbers of positively charged protons and negatively charged electrons. But atoms can gain or lose electrons, forming charged ions. An atom that loses many electrons becomes a highly charged ion.

"This periodic table could be used to make more accurate optical atomic clocks"

The original periodic table is ordered according to the number of protons there are in an atom of each element. Lyu and his colleagues instead arranged their table according to the number of electrons in ions. Once the atom of an element has lost one or more electrons, it can have the same number of electrons as an atom of another element. This means that each cell of the table can contain ions of multiple elements sharing the same configuration of electrons, says Lyu.

It results in a table in which each row represents an electron shell and each column is a subshell. The layout has allowed Lyu and his colleagues to predict what are known as forbidden transitions (arXiv, doi.org/pj78).

If an atom absorbs energy – for example, by colliding with another atom – electrons can move from one shell or subshell to another. According to quantum theory, some of these transitions are likelier than others, depending on the shells where electrons start and finish.

But there are rare transitions that aren't strictly impossible, just highly improbable and slow to occur. These are known as forbidden transitions and because they take longer, they are very stable, which makes them ideal for designing optical atomic clocks.

Lyu and his colleagues have used their table to predict the existence of 700 highly charged ions that could be used for these transitions to make more accurate optical atomic clocks.

Such precise timepieces could aid navigation for spacecraft, help coordinate satellites and run quantum communications networks.

"This is very far from the main idea of the periodic table. It's a configuration of highly ionised elements," says Guillermo Restrepo at the Max Planck Institute for Mathematics in the Sciences in Leipzig, Germany. "But they have found interesting and forbidden transitions, which opens a new path for improving atomic clocks, which is really important." ▮

Health

Our cuts and scrapes heal slower than in other primates

Human wounds take almost three times as long to heal as the injuries of other mammals, including chimpanzees, which are among our closest living relatives.

To see just how slow human healing is, Akiko Matsumoto-Oda at the University of the Ryukyus in Japan and her colleagues turned to four other primate species: velvet monkeys (*Chlorocebus pygerythrus*), Sykes' monkeys (*Cercopithecus albogularis*), olive baboons (*Papio anubis*) and chimpanzees (*Pan troglodytes*).

The researchers anaesthetised at least five of each kind of primate, shaved off a small patch of their hair and created a circular wound 40 millimetres across, which they treated with an antibiotic ointment and covered with gauze for a day to protect against infection.

Photographs and measurements of the wounds, taken every couple of days, revealed that they all the healed at about 0.61 millimetres per day.

Next, Matsumoto-Oda and her colleagues looked at 24 patients at the University of the Ryukyus Hospital after they had skin tumours removed, finding that these wounds healed at a rate of just 0.25 millimetres per day (*Proceedings of the Royal Society B: Biological Sciences*, doi.org/pj77).

The researchers also conducted studies on mice and rats, and found pretty much the same healing rate as in the non-human primates. This suggests that there may be an evolutionarily optimal healing rate for most mammals, but not humans, says Matsumoto-Oda.

Why this happened isn't known, but Matsumoto-Oda says it may be linked to how early humans adapted to hot environments and the reduction in body hair. "A higher hair density leads to an increase in stem cell numbers, which results in faster healing," she says. ▮ CS

Geology

Earthquakes could be hydrogen source

Efforts to exploit underground hydrogen may be boosted by a newly analysed chemical reaction

James Dinneen

HUGE volumes of hydrogen may be generated by shifting tectonic plates, as fracturing rocks react with water molecules during earthquakes. This could be an overlooked source of the gas for people aiming to extract it as an alternative fuel.

Most companies searching for large deposits of hydrogen gas underground to use as a clean-burning fuel have focused on "geologic hydrogen" generated by water that either reacts with iron-rich rock – a process called serpentinisation – or is split by radioactive minerals.

Nicolas Lefeuvre at Grenoble Alpes University in France and his colleagues became curious about other natural ways the gas is made after they measured high concentrations of hydrogen in soil samples from the Pyrenees. They couldn't explain its source. One possible hydrogen-generating mechanism was silicate minerals crushed by earthquakes. "When you break the silicate-oxygen bond, you will produce a highly reactive [quartz surface] that can interact with water to produce hydrogen and a free radical," says Lefeuvre. The reaction happens in just seconds after the rock is fractured.

Other researchers had proposed that this "mechanoradical" reaction could generate hydrogen, and hydrogen has been measured in soils above a number of active faults. But no one had calculated the total amount of the gas that might be generated this way.

To get a better estimate, Lefeuvre and his colleagues used a ball milling machine, a device used to break down rocks, to crush pieces of quartz of varying silica content in water. They then measured the amount of hydrogen that was produced. By changing the speed of the ball mill, they could simulate how the quartz would fracture during earthquakes of different magnitudes.

Based on these measurements, they estimated that, in any given year, quakes over magnitude 4 cumulatively produce as much as 29 million tonnes of free hydrogen gas (*Earth and Planetary Science Letters*, doi.org/pj7w). That is a maximum estimate and relies on a few big assumptions, such as that every fault is entirely covered in quartz. But it suggests that earthquakes may be just as large a source of the gas as the other water-rock reactions, and that faults could be a good place to search for hydrogen deposits, says Lefeuvre.

"Perhaps part of this hydrogen will be trapped in the fault plane," he says. The team's next step is to test hydrogen production from rocks made up of different mixes of minerals, says Lefeuvre.

Geoffrey Ellis at the US Geological Survey, who recently published a map of where geologic hydrogen deposits are most likely to occur in the US, says this is the "most rigorous" study of mechanoradical hydrogen he has seen. However, he is sceptical that faults are likely to form deposits of the gas. "By definition, you have a lot of fluid moving in these places," he says. "It's going to be difficult to trap much generated hydrogen in these settings." ▮

Rich hydrogen deposits may lie beneath earthquake faults

SHUTTERSTOCK/NIDO HUEBL

Health

Air filters in classrooms cut sick days

SCHOOL attendance increased markedly when five elementary schools in Milan, Italy, introduced air filters into classrooms, in the first randomised controlled trial of its kind.

"It's the first experimental evidence," says Stefania Renna at the Polytechnic University of Milan. Her team installed high-quality portable air purifiers in 43 randomly chosen classrooms in the schools.

Renna describes these as being better than HEPA filters.

The researchers recorded an increase in attendance of 1.3 days per pupil per year in the classrooms with air filters, which corresponded with a 12.5 per cent fall in absenteeism. "It's a pretty large effect," says Renna, who presented the results at a meeting of the European Geosciences Union in Vienna, Austria, last month.

They also found there was a 32 per cent reduction in tiny particulate matter known as PM2.5 in these classrooms, but Renna can't say for sure whether the fall in absenteeism is due to the reduction in air pollution, lower levels of pollen or pathogens such as viruses, or perhaps some combination of these factors.

A trial in 10 schools in the UK in 2021 and 2022 found that HEPA filters reduced sick days due to covid-19 by 20 per cent, for instance. But Renna's team did find the effect was weaker when air pollution was especially high, which she thinks is because the air filters can't keep up in such conditions.

12.5%

The fall in absenteeism in classrooms with air filters

Because the trial wasn't blinded by, say, the control group consisting of classrooms that were also given air purifiers but with the filters removed, the researchers can't rule out a psychological contribution to the findings, either. Larger randomised trials of air purifiers in schools are under way elsewhere, says Renna.

Milan has a particular problem when it comes to air quality because mountains around the city can trap atmospheric pollution, she says. ▮

Michael Le Page

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Views

Comment

Child benefits

Rather than banning kids from social media, we need a child-orientated option for them. This is how it should look, says **Michael Marshall**

WE NEED a social media site that is designed specifically for children and teenagers. And we need to do it as a non-profit, because there is no way that any of the big tech companies would ever build the sort of system that is required.

At this point, the problems with social media are all too familiar. Some concerns may be overhyped, notably the claim that social media is responsible for an epidemic of mental health conditions in teenagers. Complaints about "too much screen time" are also simplistic. But many common critiques do stand up.

Anti-feminist content has also proliferated, spread by users like Andrew Tate. This messaging has driven some young men to believe hateful things about women and steered them towards the extreme right. While certain sites have tried to stop their algorithms pushing this material, it is still common.

Meanwhile, online advertising is largely unregulated, so torrents of dodgy ads are targeted at users. There is evidence photo-editing, combined with diet and fitness influencers, are harming young people's body image, which could lead to disordered eating. As some social media companies step back from more robust forms of content moderation and fact-checking, disinformation and other harmful content is likely to become ever more common.

At root, the problem is simple: no social media site to date has been designed with kids and teens in mind. Most of the early ones, like Facebook, were created by students in their 20s. Some have tried to adapt – witness YouTube Kids and Instagram's new Teen Accounts – but these are the exceptions, and far from perfect.

ELAINE KNOX

Yet banning children from social media would be a misstep. They have every right to be online and, given they are growing up in a world where these sites exist, they must learn how to deal with them. But we won't achieve that by throwing them in the deep end of adult social media.

What would a child-orientated social media site look like? First, it would have strong controls so a parent or guardian can limit with whom a child interacts and view all conversations. These restrictions need to be adjustable, so kids can be given more independence and responsibility as they get older. Perhaps there could be a limit on how often a child could post. It may be necessary to pre-moderate every post, at least for the youngest children. And there would be no advertising.

My model for this new social media site is, essentially, British children's television. Every British parent swears by CBeebies, the BBC's channel for young children. It has no ads, the programmes are suitable for the youngest children and the entire vibe is lovely. My daughter has long since grown out of it, but it was a fabulous presence in her early childhood. Later, she joined the Blue Peter Fan Club, essentially a tiny social media site for kids, with strict pre-moderation and anonymity rules. She never had a bad experience on there.

This goes to show that safe and enjoyable media experiences can be built for even the youngest kids. But you can't do it by fiddling with an adult-centric model: you must aim it entirely at children.

Who could create this? No profit-making company would attempt it. In the US, Sesame Workshop (the producers of *Sesame Street*) might have been well-placed – if it hadn't recently lost its distribution deal. There are also open-source, non-profit organisations like the Mozilla Foundation and Wikimedia Foundation, but they have less expertise with children.

So my pick would be the BBC. It has already done it on a small scale with its fan clubs, its kids' department is unparalleled, and it has a track record of technological innovation. Like it or not, our kids are growing up in a world with social media. We need to teach them how to navigate it. ▮

Michael Marshall is a science writer based in Devon, UK

Future Chronicles

Through their eyes What if we could experience life as another species? In this latest instalment of our imagined history of future inventions, **Rowan Hooper** explores the pros (and cons)

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

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

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

IN T. H. White's series of novels *The Once and Future King*, the wizard Merlyn turns the young Arthur, future king of England, into a variety of animals. As a small fish, Arthur swims in a moat and is terrorised by a stronger pike; as a hawk, Arthur learns to respect the dominant old falcon. In giving him these experiences, Merlyn aims to educate Arthur and make him a good king.

By the 2040s, it had become possible, to a limited extent, to achieve with science what Merlyn managed with magic: to give humans the direct experience of being another species (although not without controversy).

The method, of course, was via neuroscience. Our understanding of the brain progressed rapidly in the 21st century, and highly detailed maps of brain networks became available for a range of animals. In 2024, the first wiring diagram of all the neurons in the brain of an adult fly was produced, and in 2025 a highly detailed map of a mouse brain was created.

Alongside this mapping, the recording and stimulating of neurons became accurate and repeatable. We started to understand what different regions of the mammalian brain did, as well as how to control them. In 2015, scientists wove together the input and output signals of the brains of four rats. Each rat had electrodes implanted in regions of the brain involved in movement. By sending electrical signals to the rats, the team could join together the rodents' brains.

Methods to monitor, stimulate and engineer brains progressed. In 2035, a scientist in Seattle decided to attempt to network his own brain with that of a lab rat. Wireless electrodes were used on the man's scalp, while the rat, with a smaller brain, underwent invasive implantation. The optical region of the brain was selected for testing, as this was well understood and was relatively simple. A computer acted as intermediary between the human and the rodent, smoothing the signals passing in both directions. When connected, the man closed his eyes and saw through those of the rat.

In some ways, the experience was a bit of a letdown. Rats have poor vision, with only two types of cone cell in their eyes, compared with our three, so the scientist perceived a more limited palette than he was used to. Yet he was the first human in history to experience the world as another species.

"In 2035, a scientist networked his own brain with that of a rat. In some ways, the experience was a bit of a letdown"

Refinements soon allowed improvements as more brain regions became accessible. A human mind-melded to a rat could move with the rodent, and smell and feel what it sensed. Where there were things that the human brain hadn't evolved to interpret, such as input from the rat's whiskers or the presence of ultrasound, artificial intelligence adapted the signals to make them available to humans.

One immediate consequence was around ethical considerations for animals. After experiencing the world as a rat, researchers stopped keeping them in cages and gave them larger, more complex areas to live in.

Should the brains of animals be exploited in this way? Scientists argued that mind-melds were simply the modern equivalent of using domestic animals. When we ride a horse, for example, we are controlling it with a bridle and stirrups, which are removed at the end of the ride. Researchers who entered the brains of horses to "be" them as they galloped said this was a similar action, and when the electrodes were removed, the horses' brains returned to a singular, independent state.

The zebra finch – the bird about which most was known from a neurobiological point of view – was another organism to get the mind-meld treatment. The great appeal of being a bird, of course, was flight. When electrode technology had been miniaturised enough to fit a bird and still allow it to fly, humans connected to the animal could, it was hoped, experience the thrill of cheating gravity.

However, the avian brain is very different to the mammalian brain, lacking the cerebral cortex, and mind-melding was glitchy and less successful here. But people still desperately wanted to fly, so pipistrelle bats were selected.

When humans mind-melded with bats, enacting Bram Stoker's imagined transformation of Count Dracula into bat form, one wit remembered an old argument over the "hard problem of consciousness": Thomas Nagel's 1974 essay, "What is it like to be a bat?". Even if we could fly, Nagel argued, even if we could squeak in ultrasound and catch moths with sonar, we would never know what being a bat feels like. Well, in the early 2040s, we did.

The mind-meld technology was phased out not long afterwards, however, as people decided it was unethical to forcibly take control of the brain of another animal. Perhaps then, like Merlyn with Arthur, there had been some educational value in the project. ▮

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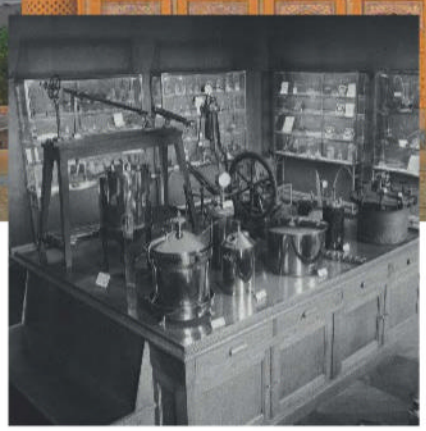

The birth of modern medicine: Paris, France

20 July 2025
5 days

Discover the foundations of medicine in Paris, where the 'Paris School' of hygiene and hospital teaching flourished. From mummified écorché figures to bone-lined catacombs, the early history of medicine is sometimes gruesome but always fascinating. Be introduced to key figures including Louis Pasteur, who pioneered the first vaccines and Rene Laennec, whose stethoscope is still a symbol of medical professionals today.

- **Discover Paris's role as the leading European centre of 18th century medicine, from the churches that administered the first hospitals to medical developments during the French Revolution**
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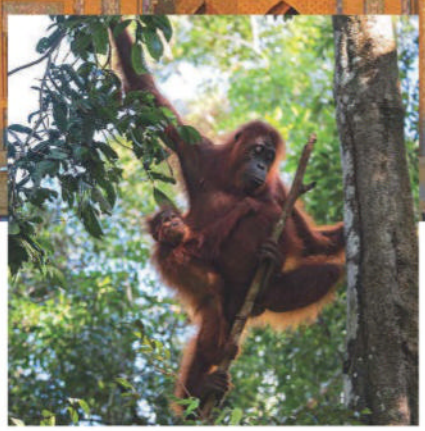

The science of primary rainforests and wetlands: Malaysian Borneo

10 August 2025
10 days

Discover Malaysian Borneo's amazing flora, fauna and geology and learn firsthand from local conservationists how it is being protected. Explore primary rainforests and wetlands, including the iconic Kinabatangan river, Tabin rainforest and Danum valley, home to some of the world's most biodiverse habitats.

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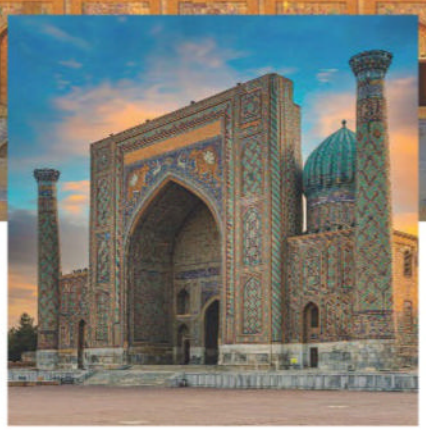

Astronomy and culture through Silk Road cities: Uzbekistan

23 August 2025
14 days

Embark on a fascinating journey through Uzbekistan, where the rich history of astronomy intertwines with vibrant cultures and vast landscapes. Explore the pivotal role the Silk Road played to astronomy as the historical trade route that facilitated the exchange of scientific knowledge and astronomical advancements across Eurasia.

- **Visit the enchanting cities of Samarkand, Bukhara and Khiva, each a jewel of Uzbekistan's rich history**
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Ancient arts

Matteo Fagotto and Matilde Gattoni

FOR millennia, the Maya people of Guatemala have been practising a unique agricultural system that fuses sustainability, climate resilience and environmental preservation. Based on the interconnections between plants and the surrounding elements, the "milpa" system combines nature with various managed crops such as corn, squash and beans (top far-left).

Rather than extracting everything from the land, the milpa approach focuses on the long-term benefits of sustainable land management. The United Nations recently included it in a report on eight Indigenous food systems that can help the world stem the worst effects of climate change and achieve the UN's 2030 Sustainable Development Goals.

This renewed recognition of ancient agricultural techniques is part of a broader movement by the Indigenous Maya people to reclaim their past and find their place in modern Guatemala. This revival also includes the promotion of traditional arts, such as basket-weaving, seen here carried out by 61-year-old Valeriano López Méndez from the Suchiquer community (top near-left), traditional Mayan clothing (bottom near-left) and spiritual practices and languages.

One of the bedrocks of the ancient Maya civilisation, Lake Atitlán (bottom far-left), has become a central fixture of this new trend. In these lakeside communities, the past and the present blend into a way of life that preserves and promotes all aspects of their civilisation.

Matteo Fagotto

A bundle of nerves

An authoritative look at the vagus nerve and its amazing healing potential is comprehensive and compelling, cutting through the hype, finds **Grace Wade**

Book
The Great Nerve
Kevin Tracey
Penguin
On sale 13 May (US); 15 May (UK)

AS A health reporter, I constantly come across promising new medical treatments. Many are exciting, but few have intrigued me as much as vagus nerve stimulation.

To understand why, you first have to grasp just how remarkable the vagus nerve is – and there is probably no one better to explain that than Kevin Tracey. A neurosurgeon at the Feinstein Institutes for Medical Research in New York, he has been at the forefront of research into this key part of the body for decades. In his book, *The Great Nerve: The new science of the vagus nerve and how to harness its healing reflexes*, he deftly explains what the nerve is, how its stimulation works and how you can tap into the vagus to improve your own well-being.

Social media is full of posts claiming ice baths enhance vagal function

I have interviewed Tracey multiple times over the years, and his passion for the vagus nerve is infectious. It is easy to see why. This bundle of more than 200,000 nerve fibres connects the brain to nearly all of our internal organs, ferrying signals back and forth that regulate everything from heart rate and breathing to digestion and mood. It is so essential that it is the only nerve in our body that, if cut, we die.

Given this importance, Tracey believes it is the key to controlling our health. Electrical devices called vagus nerve stimulators are already treating epilepsy, depression, migraines, opioid withdrawal and the longer-term effects of strokes. Yet, as Tracey argues quite convincingly, this is just the tip of the iceberg.

Some of the book's most compelling moments are when he describes his team's discoveries. A pivotal breakthrough came in the 1990s, when Tracey and his colleagues learned that the vagus nerve helps control inflammation. At the time, it was widely thought the brain and the immune system didn't communicate. So when the researchers accidentally injected an inflammatory toxin into a rat's abdomen, they didn't expect an anti-inflammatory drug administered in its brain to have an effect. Because the drug didn't enter the bloodstream, its effects should have been confined to the brain. But they weren't. The brain communicated with the immune system via the vagus nerve to control inflammation.

"Electrical vagus nerve stimulators are already used to treat epilepsy, depression, migraines and other conditions"

Modest bouts of inflammation help fight infections and heal injuries. But in excess, it can damage the body and contribute to chronic illness. Because the vagus nerve regulates this immune response, stimulating it could reduce harmful inflammation.

Much of the book explores this exciting possibility. Weaving together patient anecdotes with scientific studies, Tracey explains how this stimulation may alleviate symptoms of chronic inflammatory conditions, including multiple sclerosis, inflammatory bowel disease and Alzheimer's. Some of the results are astounding. Take Pero Dragoje, a father of two whose rheumatoid arthritis rendered his hands too stiff and swollen to pick things up. After several weeks of vagus nerve stimulation, he returned to work as a truck driver and began playing tennis. While this is enticing, Tracey points out the limitations of such research, namely that many studies are in animals or involve small samples of people.

Most readers will probably be drawn to the book's final section, which explains how to stimulate your own vagus nerve. Social media is flooded with posts promoting ice baths, massages and other at-home interventions as ways to enhance vagal function.

Tracey unpacks these claims with appropriate scepticism, showing that the little evidence so far is mixed. "A clinical trial of one or two subjects is more like a fairy tale with a happy ending than scientific proof that the cold makes you healthier and stronger," he writes. Still, he admits to adopting some of the methods himself. "Since I don't mind doing them most days, then I may be blessed with better health along the way," he explains.

The Great Nerve is a comprehensive guide for anyone curious about their vagus nerve. At times, the narrative felt as wandering as the nerve itself, bouncing between concepts, stories and time periods. But overall, it succeeds in cutting through the hype to reveal what is truly backed by evidence – and how the vagus nerve could revolutionise medicine.

ULDIS LAGANOVSKIS/ALAMY

The numerical arts

Marcus du Sautoy's new book is lyrical when it comes to maths, but falls a bit flat when he takes on the arts, says **Christie Taylor**

Book

Blueprints

Marcus du Sautoy

Fourth Estate (UK, out now); Basic Books (US, 16 September)

CHRIS HELLIER/ALAMY

Le Corbusier used Fibonacci sequences in his building designs, like this one in Marseille, France

MARCUS DU SAUTOY wants us to see mathematics and art as inextricably connected. "Both are creating ways to interpret, understand, and navigate our place in the universe," he begins his new book, *Blueprints: How mathematics shapes creativity*.

I'm not sure who still doubts this, nearly a century after Albert Einstein and his violin; this book feels a little redundant in a time of ample high-profile collaborations between du Sautoy's "two cultures" of emotions and logic that the author bemoans as ever at odds. But if you still need it, du Sautoy, a professor of maths at the University of Oxford, is here to convince you that artists are "secret mathematicians", while mathematicians prove theorems with creativity.

The evidence? The stories of dozens of musicians, painters, architects, some poets, a dancer and a lone crocheter, detailing how their work aligns with what he calls "blueprints" – structures of the universe that mathematicians try to explain. Du Sautoy finds connections to enduring mysteries like prime numbers, symmetry and randomness across a wide array of artistic crafts.

For example, the architect Le Corbusier's use of Fibonacci sequences in his buildings worked well because these numbers encode optimal patterns of biological growth. Jackson Pollock's signature paint splatters reflect the fractal, a geometry of nature seen in mountains and coastlines; you can tell if a painting is his by measuring its degree of fractal-ness. Imitations of his work lack this complexity.

Does du Sautoy support his point about arts as unconsciously maths-based, or "reveal that mathematics is at the heart of many artistic practices", as he writes? Not so much. Instead, most of his examples feature single artists who had a conscious fascination with mathematics, or practices where the mathematical tie-in feels incidental, not central.

Still, *Blueprints* sings as a book about maths that is also grounded in art. Du Sautoy is skilled at bringing numerical concepts to life, whether explaining the Golden Ratio with help from a creatively structured novel (Eleanor Catton's *The Luminaries*), or demonstrating the power of prime numbers through composer Olivier Messiaen's *Quartet for the End of Time*. I left it better understanding, and enjoying, the problems pondered by mathematicians, helped by the creations of artists like J.S. Bach and Jorge Luis Borges. I can picture a hypercurve while looking at a sculpture, and rotational symmetry in 1000-year-old tiles at Spain's Alhambra.

But while du Sautoy writes elegantly about mathematics, his evocation of music, sculpture and dance is flat in comparison, with few descriptions of colours, shapes, moods or the experience of an artist's work. I wanted more feeling from his stories of artists' ties to history – like how the Dadaist Jean Arp channeled randomness in his collage pieces as a response to the horrors of the first world war. How did that choice serve his inner life, coping with that horror? This silence has the effect of leaving the arts subservient to mathematics, rather than a space where people explore a staggering variety of questions about being human while sometimes also leaning on maths.

With those gaps in mind, I'm dubious this book will bring a maths-lover closer to appreciating art if they don't already. But the many stories within *Blueprints* help us understand why so many mathematicians have dedicated their lives to considering questions, even whole dimensions, that don't quite seem to touch our own worlds. And why many artists follow.

Christie Taylor is a science journalist based in New York

New Scientist *recommends*

Rowan Hooper
Podcast editor
London

Winner of this year's Academy Award for best animated feature, **Flow** is the story of life on a post-apocalyptic world, where all humans have vanished and only animals remain. It is a fable about the importance of cooperation, of working together despite your differences. And it is an animal adventure, starring a delightful cat.

Flow opens as the cat wakes in an abandoned building and notices that the river nearby is flooding. The waters rise, but the cat jumps into a passing boat. Inside is a capybara. And so the adventure begins.

Latvian director Gints Zilbalodis made the film on free, open-source 3D software called Blender. In its treatment of climate change, the film has been compared to the work of Hayao Miyazaki at Studio Ghibli. Zilbalodis's budget of £3 million, however, was tiny in comparison.

There is so much to enjoy and ponder in the film. I particularly liked how the animals were uncomprehending in the face of climate disaster – just like so many of us.

DREAM WELL STUDIO/JANUS FILMS

The TV column

Shock waves A disturbing new Danish climate drama, which follows a wealthy family as rising seas force the evacuation of Denmark, is wildly popular in its home country and deserves a much wider audience, says **Bethan Ackerley**

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

BBC/ZENTROPA ENTERTAINMENTS/STUDIOCANAL/CANAL+/TV 2/PER ARNESEN

Laura (Amaryllis August) and her parents set out for Paris when floods hit

I RECENTLY wrote a piece for *New Scientist* lamenting the lack of a wildly popular TV drama about climate change. A few short weeks later, along comes *Families Like Ours* (BBC iPlayer), a wildly popular (in its native Denmark) TV drama about climate change. Patience was never my strong suit.

While I climb down from my high horse, let me tell you a little bit about it. It is the first series from director Thomas Vinterberg, co-founder of the stripped-back, low-budget Dogme 95 film movement. It is about a wealthy family during a nationwide evacuation of Denmark, as rising seas are about to drown the country. And it could well be the climate drama I was hoping for, one to shock us all into some semblance of action – if it can reach a wider audience.

Nineteen-year-old Laura (Amaryllis August) is in her final year of high school and lives in a leafy suburb of Copenhagen with her father Jacob (Nikolaj Lie Kaas) and stepmother Amalie (Helene Reingaard Neumann). Her future looks bright: she is a good student and is in a new relationship with Elías (Albert Rudbeck Lindhardt). But when Amalie's brother Nikolaj (Esben Smed) learns that, in a week, the government will announce a total evacuation of the country, her life is turned upside down.

Armed with their insider knowledge, Jacob and Nikolaj scramble to sell their properties

> **"This could well be the climate drama I was hoping for, one to shock us all into some semblance of action"**

and obtain cash from foreign banks before the announcement. Nikolaj and his husband Henrik (Magnus Millang) have a safe route to the UK. Jacob sets up a business to allow his family to move to Paris on work visas – even Laura's mother Fanny (Paprika Steen). The future still looks bright, relatively speaking – until their money and connections can no longer protect them, and Laura is forced to choose between her father, her mother and Elías.

There are no scenes of bursting sea defences or flooding homes here. Instead, wealth – or the lack of it – propels almost all of the drama. Time and again, the family decide to exploit the inequalities that have made them comfortable for so long. Life has always tended to work out, so they approach the crisis with the same hubris.

That's one reason why a teenager is the perfect protagonist for this story. When Laura makes impulsive, selfish decisions under the assumption that the world will be kind to her, it is far more palatable than when her older relatives do the same thing. And with Denmark soon to vanish from the map, staying in the comfort of childhood is no longer an option. Every available path into adulthood means losing one thing or another to survive.

Families Like Ours has been called unrealistic in some quarters. It is true that neither Denmark's drowning nor its mass evacuation is terribly likely. But that certainly isn't the case for the Kiribatis and Vanuatus of the world. Those of us in higher-income nations shouldn't need to see the suffering of wealthy, white Westerners to understand the situation facing small island states – but, sadly, that may be exactly what is required.

In that sense, *Families Like Ours* has pretty much everything I wanted from a climate change drama – including enough hope to keep you watching. Without more publicity, though, it is unlikely to attract a large audience in the UK (and there are no announced plans to air it in the US). So if you do watch the series and like it, tell your friends – let's make this a word-of-mouth hit. ▮

TV

Families Like Ours

BBC iPlayer (UK); no US release date yet announced

Bethan also recommends...

TV

Years and Years

Netflix (UK); Max (US)

I have recommended this dystopian series before, but it is a great counterpart to Families Like Ours. *It follows one family over 15 years as the UK slides towards fascism and climate change intensifies.*

Film

The Hunt

Directed by Thomas Vinterberg

A teacher becomes a pariah in his community after being wrongly accused of abusing a child in this heart-wrenching film about mob mentality.

Editor's pick

Meeting Heisenberg and reconsidering Schrödinger

19 April, p 29

From Maggie Cobbett, Ripon, North Yorkshire, UK

Your special issue on quantum theory took me back to 1974, when I had the honour of shaking Werner Heisenberg's hand. He was guest of honour at the new Heisenberg Gymnasium in Dortmund, Germany, where I was teaching English.

As I joined the line of staff to be presented to him, I was hoping for a few words to treasure. After all, he was the first – and, so far, only – Nobel prizewinner I have met. Introduced to the great man by the headmaster as "our English colleague", I was full of anticipation, only to hear him say: "Oh, so you teach English, do you?" Then he moved on. Such is life!

From James Edmondson, Ilchester, Somerset, UK

I have always loved Carlo Rovelli's brilliant writing. Doesn't his book *The Order of Time* move you to tears in the final chapter? And his history of quantum theory was illuminating, but Erwin Schrödinger might be turning in his grave as a result. However, I suspect if we flipped up the lid and looked inside, maybe he wouldn't be.

Thinking about how the classical world emerges

12 April, p 8

From John Bell, Berkhamsted, Hertfordshire, UK

Your article about quantum Darwinism delved into a new attempt to explain how a classical reality common to us all emerges from the quantum realm. It seems to me that our subjective experience of living in this universe can give us great insight.

It appears self-evident that the future is unknown and the past is known. As many perspectives interact, future possibilities are constrained more and more, so the classical world we all experience in the here and now emerges as a shared one.

How the dinosaurs finally met their end?

19 April, p 15

From Alex Bowman, Glasgow, UK

"Rethinking dinosaurs' decline" looks at their state prior to an asteroid strike that is thought to have wiped them out. But is it possible that, even after this event, dinosaurs made a slow population recovery? Could small, burrowing, rodent-like mammals, our ancient ancestors, scavenging for whatever they could eat – rotten flesh, plant roots and dinosaur eggs – have finally doomed them to extinction? Even today on remote islands, rats from ships can wipe out ground-roosting birds.

Cooperation may be key to cultural gains

5 April, p 36

From Andrew Edgar, Cardiff, UK

Colin Barras's intriguing article on the relationship between human and non-human culture may have missed a significant difference. Human cultures, and the development and manufacture of technologies within them, depend upon a division of labour. No one person is typically responsible for the whole thing.

To take the example of the violin used in the article, the instrument-maker relies on a forester for wood; a carpenter, no doubt, processes the wood into a form in which it can be used by the instrument-maker; a sheep farmer supplies the gut for strings; and at the end of the process, someone else actually plays the violin, typically using music composed by yet another specialist. So, could the reason why human cultures develop so swiftly be down to this exploitation of specialisation and cooperation?

From Terry Klumpp, Melbourne, Australia

How to explain the difference between non-human animals and ourselves? Easy: humans are hubristic. We are the pinnacle of evolution! The crown of creation! Are we not? Truly, dear reader, we are the most magnificent creatures on Earth. And soon we will fly to other planets where we will copulate and populate the universe itself! Yea! Hallelujah!

A willing blood donor seeks new recipient

22 March, p 18

Name/address withheld on request

I have been a blood donor since I was 17 (I am 63 now). I was recently told that I no longer needed to give regular donations, as they have sufficient supplies of my blood type. I have always felt it to be a good thing to donate, not only ethically but also physically, as suggested by your article on post-donation regeneration. Is there a useful alternative way of giving blood, whether it be for research purposes or such like?

Semaglutide side effect: The hangry man theory

Letters, 19 April

From Paul Davis, Maidencombe, Devon, UK

I read with interest about the "middle-class microdoser" of the weight-loss drug Wegovy, who lost 20 kilograms of body weight over nine months. That is a long time to be eating less than his body needed each day. He reflected on becoming grumpy over that time and wondered if it was a side effect of the drug. Could the reason be simpler? As the father of an always-hungry teen, I know that when my son is low on nutrition, he gets grumpy. I see the same reaction in myself too.

If we don't try a Mars colony, we'll never know

Letters, various dates

From Michael Wigley, Bissoe, Cornwall, UK

There has been a lot of coverage, mainly negative, on the idea of humans colonising Mars.

However, there is a long history of scientists saying something is impossible, only for it to be achieved. And even if we try and fail, it is likely to be worth the effort. We all know about the spin-offs from the Apollo missions, such as CT scans. To successfully colonise Mars, we may have to conquer cancer (there is no protective magnetic field on Mars), and have full closed-loop waste and water recycling, similarly efficient food production and more. Progress was never won by not attempting something.

SOS appeal to coders: Save our 'smart' TVs

Letters, 12 April

From Don Taylor, Cheadle, Staffordshire, UK

If Mel Earp's old code is running in my smart TV, could they pop round and fix it so I can keep watching Netflix? The screen is perfect, the 5.1 sound is impeccable, and digital TV, satellite and BBC iPlayer are all fine, but Netflix isn't working and there is no update available. This is obsolescence gone mad! ▮

For the record

▮ **Any given number between 0 and 1023 can be stored using a maximum of 10 conventional computer bits; a quantum device with 10 qubits could store all the numbers at once (19 April, p 32).**

Want to get in touch?

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No hard feelings

Emerging research is revealing that our emotional states are more in our control than we might think, finds **David Robson** – with major implications for our longevity, relationships and mental well-being

ETHAN KROSS always shared a special bond with his grandmother, Dora, whom he considered a "second mom". She lived just a few blocks away from his childhood home, and when he came by each day after school, she would shower him with kisses and lavish him with food – matzo balls, chicken broth and noodle pudding.

Despite their closeness, she would barely ever talk about the horrors she had endured during the Nazi occupation in Eyshishok, modern-day Lithuania, before she had emigrated to the US and found a home in New York. How did she rebuild her life to become such a stable figure for her family? And why did she never discuss her trauma, except on specific occasions like Holocaust Memorial Day? "I found it puzzling, how she could mostly avoid speaking about those events but still be OK," says Kross.

Such questions would follow Kross through his adolescence; as an experimental psychologist and director of the Emotion and Self Control Lab at the University of Michigan, he has spent his career seeking an answer. "Emotions are full of richness and utility, but they can also get the better of us when we are most vulnerable," he says. "So why does that happen? And what can we do to handle them more effectively? That's what I went to graduate school to figure out."

Kross's new book, *Shift: How to manage your emotions so they don't manage you*, is the product of all he has learned. He also isn't the only psychologist fascinated by the idea of mastering our emotions. From mental exercises like reappraisal and self-distancing to changing our environment and hacking our senses, the latest research offers a toolkit of strategies for controlling our feelings. This emerging body of evidence suggests that our emotions are more elastic than we realise – and by learning to harness them, we can enhance our health, happiness and longevity.

Our emotions are our thoughts' constant companions. When people are asked to describe the contents of their head at random points throughout the day, they report feeling at least one emotion for 90 per cent of their waking lives. And many of us are ill-equipped to deal with these feelings – as a landmark study shows.

Impulse control

Around 50 years ago, scientists selected a sample of just over 1000 babies born in the city of Dunedin, New Zealand, between April 1972 and March 1973, whose progress they have followed ever since. Early on, the children were assessed by parents, teachers and independent psychologists on their emotional regulation, based on factors like the frequency of their tantrums and how well they managed to master their impulses. This detailed information allowed the researchers to examine the links between those skills and the participants' future prospects, while controlling for factors like family background and socioeconomic status.

Children who struggled to keep their emotions in check tended to do worse at school – but the consequences went far beyond their academic success. By the age of 32, the people with the lowest levels of emotional regulation tended to struggle financially and were about four times more likely to be convicted of a crime compared with those with the highest levels of emotional regulation. They were also at greater risk of substance abuse.

By age 45, the effects could even be seen in their biological ageing. During various follow-ups, researchers have assessed 19 markers of physical health, including blood pressure, cholesterol levels, white blood cell count, lung capacity and tooth decay.

As many of us know all too well, these parameters tend to shift as we get older, but for some individuals, the changes happen more rapidly – and a 2021 paper on the Dunedin study found that the speed of that decline could be linked to the participants' emotional regulation. "The individuals with poor self-control were ageing more quickly than their peers," says Leah Richmond-Rakerd at the University of Michigan, who worked on the paper. They even looked older, according to independent judges asked to guess their ages from photographs.

The people with better emotional regulation may have been eating better, exercising more and cleaning their teeth regularly – all factors with specific effects that should help to keep people healthy. Crucially, however, they may have experienced less stress overall, which – over extended periods – might have led to less general wear and tear on their organs. People who are less impulsive are better able to stick to plans, which helps create long-term stability. "And when crises arise, they are better able to navigate them," says Richmond-Rakerd.

There is also an obvious link to mental health. The causes of mental illness are complex, but impaired emotional regulation is a common risk factor for many conditions, including depression, anxiety and disordered eating. ›

PETER STRAIN

"If you can change how you think about a situation, you can change how you feel"

The trillion-dollar question, then, is whether we can learn better ways to manage our feelings. A good place to start looking for answers is with the Dunedin participants. While many had a constant level of emotional regulation over time, others improved as they got older. "And the individuals who changed did better in adulthood," says Richmond-Rakerd.

The biggest barrier to better emotional regulation may be a set of underlying beliefs – known in psychology as "implicit theories" – about our capacity to change the contents of the mind. In the mid-2000s, Maya Tamir at the Hebrew University of Jerusalem and her colleagues asked first-year university students to rate some statements on a scale of 1 (completely disagree) to 5 (completely agree). These were: everyone can learn to control their emotions; if they want to, people can change the emotions that they have; no matter how hard they try, people can't really change the emotions that they have; and the truth is, people have very little control over their emotions. The first two statements were designed to reflect the view that our feelings are malleable, while the last two reflected the view that they are fixed.

Over the following 10 weeks, students who held the fixed theories of emotions tended to have lower well-being and poorer social relationships than those who believed they had conscious control over their feelings. They were considerably more likely to report feeling anxious, angry, lonely or depressed, for example, and less likely to report feeling happy, proud, loved or stimulated. Overall, it seemed that the people with fixed beliefs were struggling to cope with the uncertainty they were facing, thanks to the major life shift of starting university, preventing them from making the most of their time there.

In other words, these students' beliefs were a self-fulfilling prophecy that in turn affected their behaviour. Someone who believes their emotions are beyond control won't even try to change how they are feeling, shutting off potentially useful emotional regulation strategies.

One such strategy is a highly intuitive technique known as "cognitive reappraisal". "If you can change how you think about a situation, you can change how you feel," says Christopher Shum, who recently completed a PhD in emotional regulation at the University of Limerick, Ireland.

Changing patterns

Shum gives the example of facing a difficult exam and focusing solely on the possibility of failing, increasing anxiety. With cognitive reappraisal, you could remind yourself that the worst-case scenario is only one of many possible results, breaking out of doom-laden thoughts and easing some of your worrying.

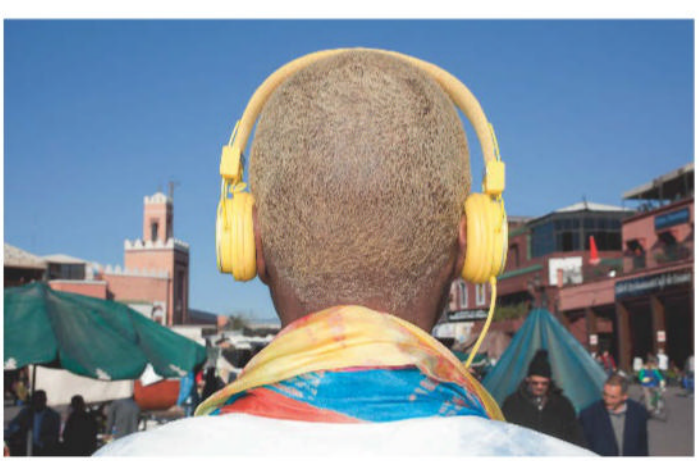
Cognitive reappraisal can also amplify welcome emotions. "When we're feeling good, we can actually make ourselves feel even better," says Shum. If you are at an exciting sports game, for instance, you can remind yourself how lucky you are to be witnessing the action.

In a review of the evidence to date, published last year, Shum found a clear connection between adolescents' use of cognitive reappraisal and their psychological well-being, which included a reduced risk of mental illness and an increase in overall life satisfaction.

"Cognitive reappraisal is a very good form of emotion regulation, but many people don't use it as often as they should," says Ronnel King at the Chinese University of Hong Kong – and his work suggests that this is a direct result of the implicit theories that Tamir studied.

Working with Elmer Dela Rosa at Central Luzon State University in the Philippines, he surveyed 355 college students about their emotional lives – including a section on cognitive reappraisal, in which they had to rate their agreement with the statement "when I want to feel more positive emotion, such as joy or amusement, I change what I'm thinking about". As expected, people who think emotions are malleable enjoyed greater psychological well-being – and this was partly explained by their use of cognitive appraisal. Those with fixed views tended to dwell on their bad feelings without seeking to change their thinking patterns.

After accepting that emotions are within our control, anyone can learn to apply



MARTIN PARR/MAGNUM PHOTOS

Listening to music is an underused – and accessible – way of manipulating our emotions

STR/AFP VIA GETTY IMAGES

cognitive reappraisal, along with many other strategies to cope with negative feelings and boost positive ones . "We have lots of tools at our disposal; different tools will work for different people," says Kross.

Some of these instruments are within our grasp – we simply forget to use them. Kross points to using music to shape our mood. There are many biological pathways through which music can turn the dial on our emotional experiences. Brain scans reveal that it alters the expression of dopamine, a neurotransmitter associated with expectation and reward in the brain, and affects our physical stress response, including heart rate, blood pressure and levels of the stress hormone cortisol. We might use some energetic tracks to pump ourselves up before a big event, or slower, softer music to wind down afterwards.

We can reap music's benefits only if we remember to use it, however. In his book, Kross reports a series of studies, pending publication, which he conducted with his colleague Micaela Rodriguez, to examine the various means people use to "turn the volume down on their negative emotions". Fewer than 30 per cent reported actively using music to quieten their sadness, anxiety or anger. "It's a tool that is right there in plain sight that can powerfully reroute how we are feeling," he says. Other "sensory shifters" might include the soothing acts of baking, petting a dog or soaking in a hot bath.

Changing our environment is another possibility. Spending half an hour in a natural space, like an urban park, has been shown to lift people's moods, compared with walking the streets. And the latest research suggests we may not even need to leave our homes to feel restored. A recent study by Liesbeth Bogaert at KU Leuven in Belgium and her colleagues found that watching short clips of wildlife documentaries helped participants reduce negative repetitive thinking over a week-long trial. The benefits lasted a further seven days.

Kross's primary line of research concerns a strategy known as self-distancing, which involves taking an outside perspective on our problems. We can do that by considering how we would view our situation in the future, or by imagining how we might advise a friend feeling the same things that we are. Simply talking about ourselves in the second- or third-person (you or he/she/they) can do the job.

In multiple studies, Kross and his colleagues have found that self-distancing can soothe our pain or anger, helping us find greater feelings of closure. "It's my go-to when I need to manage my emotions," he says. "When I find myself dealing with a thorny interpersonal issue at work, I'll use distanced self-talk to give myself advice like I would a friend, and then jump into the mental time travel machine to both think about how I'll feel about his problem a few years from now – to highlight its impermanence – and also think about how it compares to other issues I've endured."

Mixed feelings

Kross emphasises that context is key, since a little discomfort can sometimes be helpful. Consider envy. Jealous of a friend who has just been promoted to a stellar new role? You could brew in bitterness – or see your envy as a form of motivation. Your friend proves that success is possible, which might spur on your own ambition. Anger, meanwhile, might push you to fight for your rights, achieving a fairer resolution to a disagreement.

In such situations, you may even choose to amplify those feelings a little, by focusing on the things that made you jealous or angry. Kross's studies show that people tend to be more satisfied with outcomes when they use their "bad" feelings to their advantage in this way. "Negative emotions are functional; they can serve a purpose," he says.

It all depends on balance and proportion. Are we experiencing those feelings to such a degree that they are no longer useful? Or are they so damaging that we need to regulate them using the strategies described above?

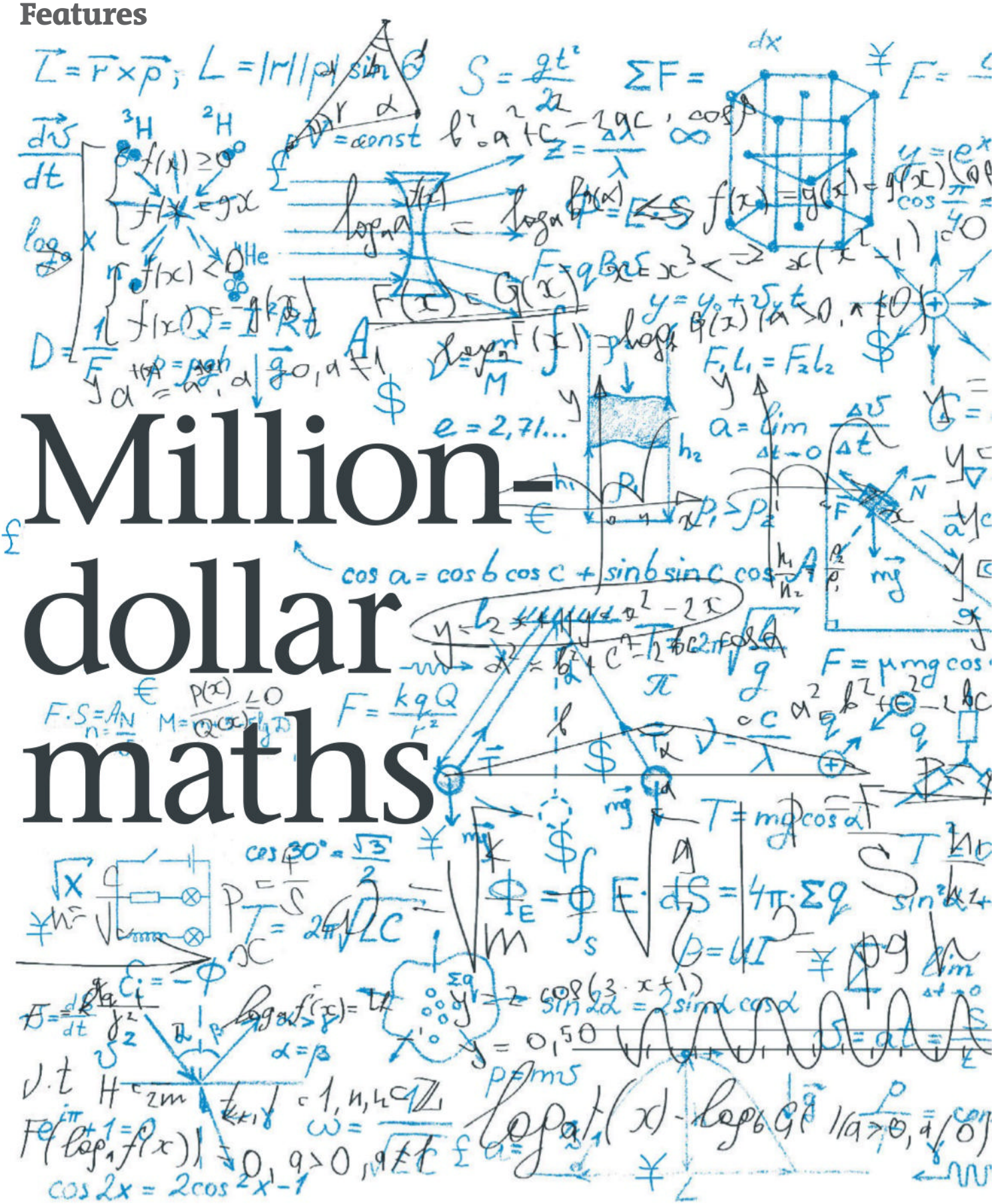
Occasionally, the best solution may be to turn away from them entirely. We are often told that hiding from difficult feelings will only make things worse – but Kross argues that there is nothing wrong with emotional avoidance to provide short-term relief, provided that it is used sparingly. He points to research into bereaved partners: people who turned their thoughts away from their grief and actively avoided reminders reported less negative emotion in the long term. "I think this notion that avoidance is always harmful is, in and of itself, a harmful notion," he says.

This brings us back to Kross's grandmother, and the questions he wanted to answer all those years ago. He says she didn't undergo any formal therapy, but – from his perspective, at least – Dora appeared to have found relief in compartmentalising her trauma and facing it only sporadically, when she needed to honour her experiences. Knowing what he now knows about human psychology, he suspects that she "stumbled" into a way to "regulate her emotions adaptively".

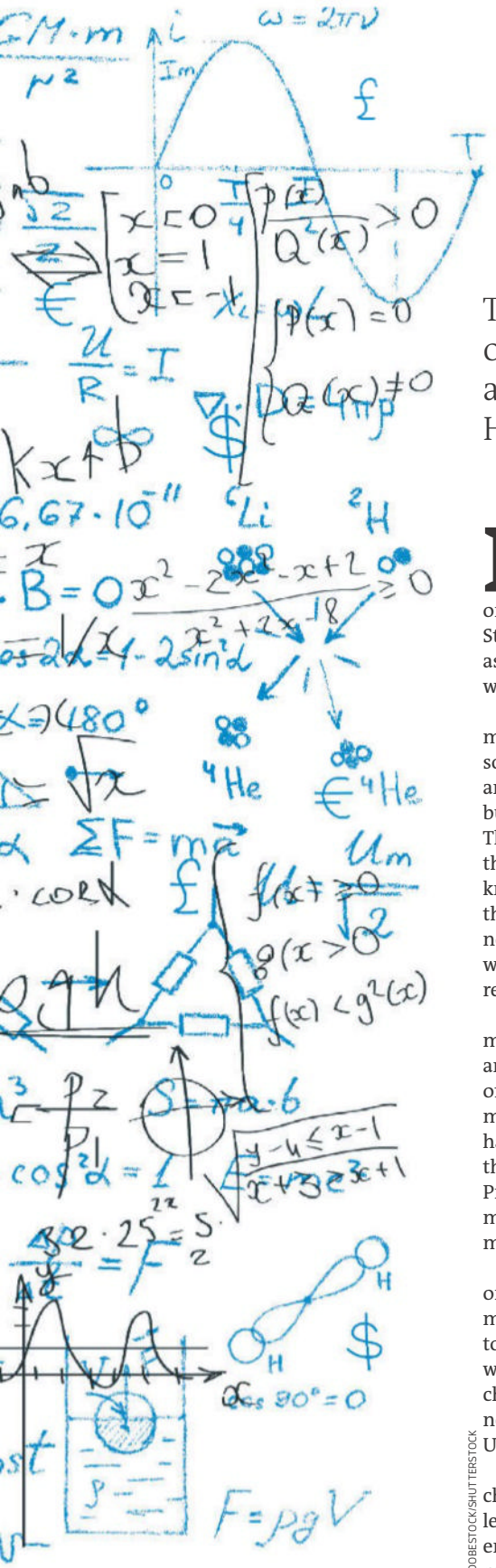
The same approach wouldn't work for everyone. That is precisely Kross's point. "Science has identified dozens of tools that can push our emotions around," he says. "And once you have familiarised yourself with those tools, you can start self-experimenting to learn what combinations work best for you, given your unique emotional makeup."

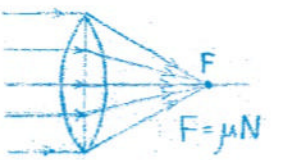
He practises what he preaches: "Once I detect the emotional response that I want to manage, I know exactly what to do to rein it in." And with a little effort – and faith in our abilities – we might all do the same. ▮

David Robson is an award-winning science writer. His latest book is *The Laws of Connection: 13 social strategies that will transform your life*



Million-dollar maths





Twenty-five years ago, tantalising prizes were offered to mathematicians who could solve any of seven monumentally difficult problems. How have they done, wonders **Michael Brooks**

HOW times have changed since the year 2000. In that year, there were a billion fewer people living on the planet. The International Space Station hadn't yet housed any resident astronauts. Brad Pitt and Jennifer Aniston were in love and got married.

And on 24 May that year, a group of mathematicians took to a stage in Paris to set some problems. They used acetate sheets and an overhead projector in their presentation, but this was no high-school maths challenge. These were the seven Millennium Problems, the hardest mathematical puzzles then known. The exercise was organised by the Clay Mathematics Institute, a US-based non-profit foundation that promised anyone who could solve one would have their grit rewarded with a $1 million prize.

Twenty-five years later, how have mathematicians got on? At first blush, the answer seems to be: not brilliantly. Only one of the challenges has been solved, which might make you wonder whether the maths world has lost its mojo. Delve below the surface, though, and the story of the Millennium Problems can teach us a lot about the state of modern mathematics and what progress really means in this most abstract of disciplines.

Plus, there is reason to believe progress on these puzzles could soon become much more exciting, as machine learning begins to make its mark. "I'll be very intrigued to see whether the way we do mathematics might change in the next 25 years because of these new tools," says Marcus du Sautoy at the University of Oxford.

Mathematicians have always enjoyed a challenge. Through the 20th century, many leading figures, from Paul Erdös to André Weil, enjoyed posing them for others to solve. The most influential examples were set in 1900 by David Hilbert. He outlined 23 problems that he felt should be the focus of everyone's efforts. "He made them to try to shape 20th-century maths – very explicitly and successfully," says Colva Roney-Dougal at the University of St Andrews, UK. Today, just a few remain unsolved – though one was only put to bed in March.

The Millennium Problems were a nod to Hilbert's programme in that they used the turn of a century as an opportunity to highlight a set of puzzles. In contrast, though, these were ones that mathematicians were already well aware of. For the Clay Mathematics Institute, it was more about raising the profile of maths than setting an agenda. Even so, the prizes still generate great excitement because they call attention to puzzles mathematicians genuinely want to solve, whether that is for the pure thrill of mastering a landmark problem that has eluded countless others or the possibility of making a breakthrough that could have transformative effects on wider science and engineering. "Hilbert's problems were good problems, and the $1 million problems are good problems too," says William Gasarch at the University of Maryland.

Huge fanfare

That was clear when Grigori Perelman proved the Poincaré conjecture, the only Millennium Problem to tumble so far. A conjecture in maths is a statement thought to be true but not yet proven. In 1904, Henri Poincaré had made a suggestion about the topology of a sphere in 4-dimensional space. Perelman's proof came almost exactly 100 years later, and was reported with huge fanfare – especially when he turned down the prize money, protesting that one of his peers had made an equal contribution. ›

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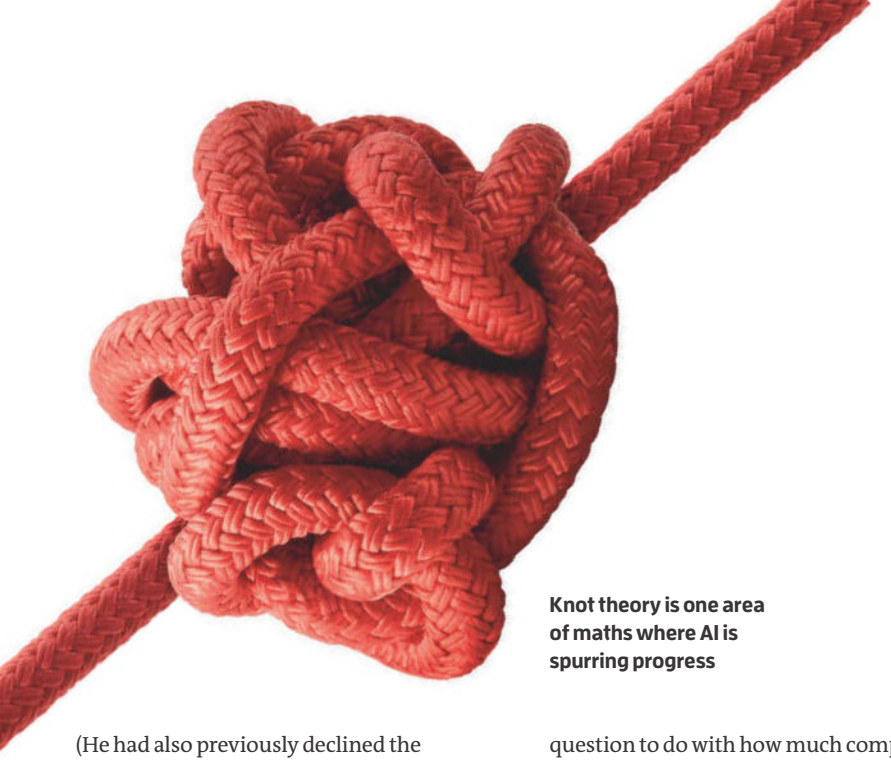

Knot theory is one area of maths where AI is spurring progress

"AI is a really good telescope for seeing deeper into the world of numbers"

(He had also previously declined the prestigious Fields medal, saying: "I'm not interested in money or fame; I don't want to be on display like an animal in a zoo.")

So one problem has fallen. But what are the six that remain? One is the Hodge conjecture, a bridge between two branches of maths – topology and algebra – that seeks to find reliable ways to approximate complicated shapes, representing them using mathematical objects called algebraic cycles. There has been precious little progress here in 25 years, according to Pierre Deligne at the Institute for Advanced Study in Princeton, New Jersey. "We have little to no idea how to attack the problem," he says.

Another is an open conjecture from two mathematicians, Bryan John Birch and Peter Swinnerton-Dyer. In the early 1960s, they made a suggestion about certain properties of the solutions of equations that define what is known as an elliptic curve. These curves can be described by algebraic equations and have properties that have made them useful in a wide variety of contexts. They crop up in the process behind factorising large numbers into primes, and in various types of cryptography. They also feature in the proof that Andrew Wiles delivered out of the blue in the early 1990s to a legendary maths problem known as Fermat's last theorem.

Then there is the Yang-Mills mass gap problem, related to elementary particle physics. A fundamental entity such as an electron can be thought of as a particle, which has a mass, or as a wave that travels at the speed of light. However, things that travel at the speed of light don't have mass – the conceptual gap here is one whose existence physicists would love to justify using some clever mathematical innovation.

Next up is the P vs NP problem, an open question to do with how much computational effort is required to solve certain types of mathematical problem – and whether those solutions can be easily checked. There are myriad types of problem that seem hard and are classified as "non-deterministic-polynomial", or NP, indicating the huge amount of computer time it takes to find solutions. Often, those solutions can be checked in "polynomial" time – it doesn't take a computer long at all. Finding the prime number factors of a very large number, for instance, is NP, but once you are given the solution, it is very easy to check that the solution is correct: you just multiply the primes – which are numbers only divisible by themselves and 1 – together. What we don't know is whether, if the solution to a problem can be verified in polynomial time, the solution itself can also be found in polynomial time via some as-yet-undiscovered algorithm.

There is also the "Navier-Stokes existence and smoothness" problem. This probes the reliability of the Navier-Stokes equations, which are widely used to predict how fluids flow in various circumstances, whether that is air going over the wings of an aircraft, blood moving within your arteries or atmospheric currents hurtling around the globe. Besides earning you $1 million, solving this problem would earn you a million thank-yous from the world's engineers, medics and climate scientists.

Riddle of the primes

Finally, the longest-standing problem, dating back 116 years, is the Riemann hypothesis. This relates to the distribution of prime numbers. This is the only Millennium Problem that was also on Hilbert's list. First asserted in 1859, it claims there is a way to predict where in the number line prime numbers will show up.

So, which of these will fall next? Perhaps the Riemann hypothesis, reckons du Sautoy. But solving it is proving hard. Mathematicians got excited in 2019 when they made progress with the "twin prime conjecture". This suggests that there are infinitely many prime numbers that are separated by only one integer on the number line: examples include 3 and 5, 5 and 7, and 17 and 19. Work by a number of mathematicians has made progress towards proving this conjecture, but they haven't got there yet – and it won't necessarily help with the Riemann hypothesis anyway.

What about P vs NP? "It's a really hard problem," says Gasarch. "No progress has been made on the problem in a long time, and perhaps there has not been any progress – I certainly don't think we'll solve it anytime soon." Although its inclusion among the Millennium Problems has attracted more mathematicians to work on it, Gasarch doesn't believe that the right tools are in place to even begin to make progress here.

In fact, tools are everything for mathematicians: if the right mathematical techniques haven't been developed, there is just no way to make progress in an area. That, after all, is why Isaac Newton and Gottfried Wilhelm Leibniz each developed calculus in the late 17th century. Back then, there was no technique for describing properties that change over time or space. But once the right tool is in the right hands, progress is almost inevitable: with calculus, Newton performed mathematical miracles such as describing the motion of the planets under gravity.

Having the right tool was crucial for finding a proof of Fermat's last theorem. Andrew Wiles was working on something called the Taniyama-Shimura-Weil conjecture – then, in 1986, someone pointed out that a partial

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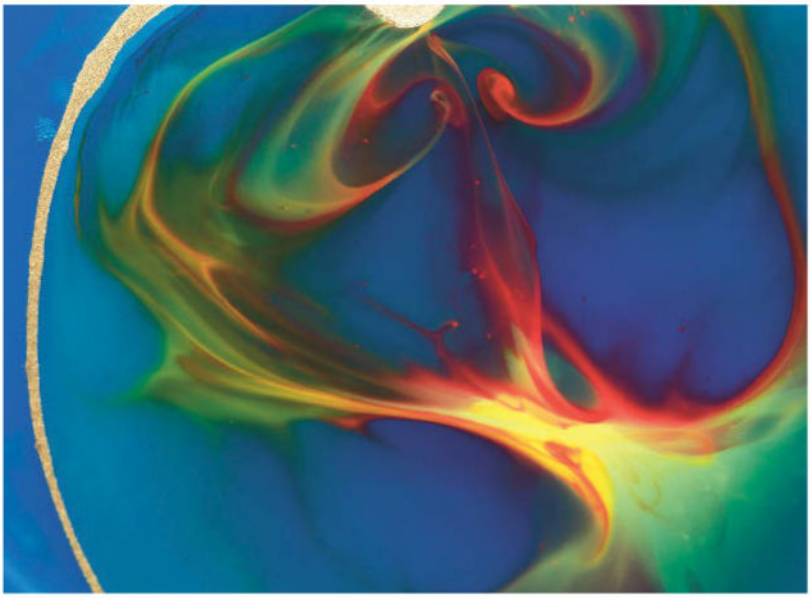


PERY BURGE/SCIENCE PHOTO LIBRARY

The Navier-Stokes equations describe turbulent fluid flows

solution of this conjecture was equivalent to a proof of Fermat's last theorem. "Suddenly, you connected Fermat's last theorem to a bit of mathematics which had a whole lot of machinery that you could start to work with," says du Sautoy.

Perelman's success with the Poincaré conjecture is another case in point, says Roney-Dougal. "A whole body of theory got developed, which flipped it from not doable to doable." Perelman was among those who developed that groundwork – he was offered that Fields medal in recognition of developing techniques that were closely related to the things that he ultimately used to prove the Poincaré conjecture. But that doesn't mean others couldn't have picked up the tools and done something similar. "Perelman's a genius, and was working in the right bit of maths, but it's probable that if he hadn't done it, somebody else might have," says Roney-Dougal.

Given what it takes to make significant progress in maths, perhaps we shouldn't be surprised that only one of the Millennium Problems has been conquered. But that doesn't mean there is no hope of another breakthrough. Du Sautoy reckons the right tools might be emerging to get a good handle on elliptic curves, for instance. Because of their value in cryptography and other applications, elliptic curves have attracted a lot of attention. That means the Birch and Swinnerton-Dyer conjecture might well be the next to fall. "Elliptic curves has got enough people working on it, and there's machinery there to get your teeth into," says du Sautoy.

Having enough people in the field matters. Some of the Millennium Problems – the Hodge conjecture, say – might be too obscure to attract the critical mass of researchers required to make a dent in their armour. Others, though, seem to have benefited from the publicity. "Certainly, more people are working on the mass gap problem," says Karen Uhlenbeck at the University of Texas at Austin, who works in Yang-Mills theory.

But there is a new tool that might make quite a difference; some of the problems might be amenable to a little machine-led nudge. "AI is beginning to be useful for maths," says Roney-Dougal. We aren't generally talking about large language models, the technology that lies behind chatbots such as ChatGPT (though chatbots are getting better at solving exam-style maths questions). Instead, what is at play here are different types of neural network, adapted to work on mathematics. Given certain kinds of training data, these networks can spot hidden patterns in our mathematical knowledge that might be of interest.

Untangling knots

One area where AI has already made a difference is in knot theory. Researchers were able to feed descriptions of mathematical knots into a neural network and then prompt it to find interesting connections between them. Eventually, it led them to a new and interesting piece of maths.

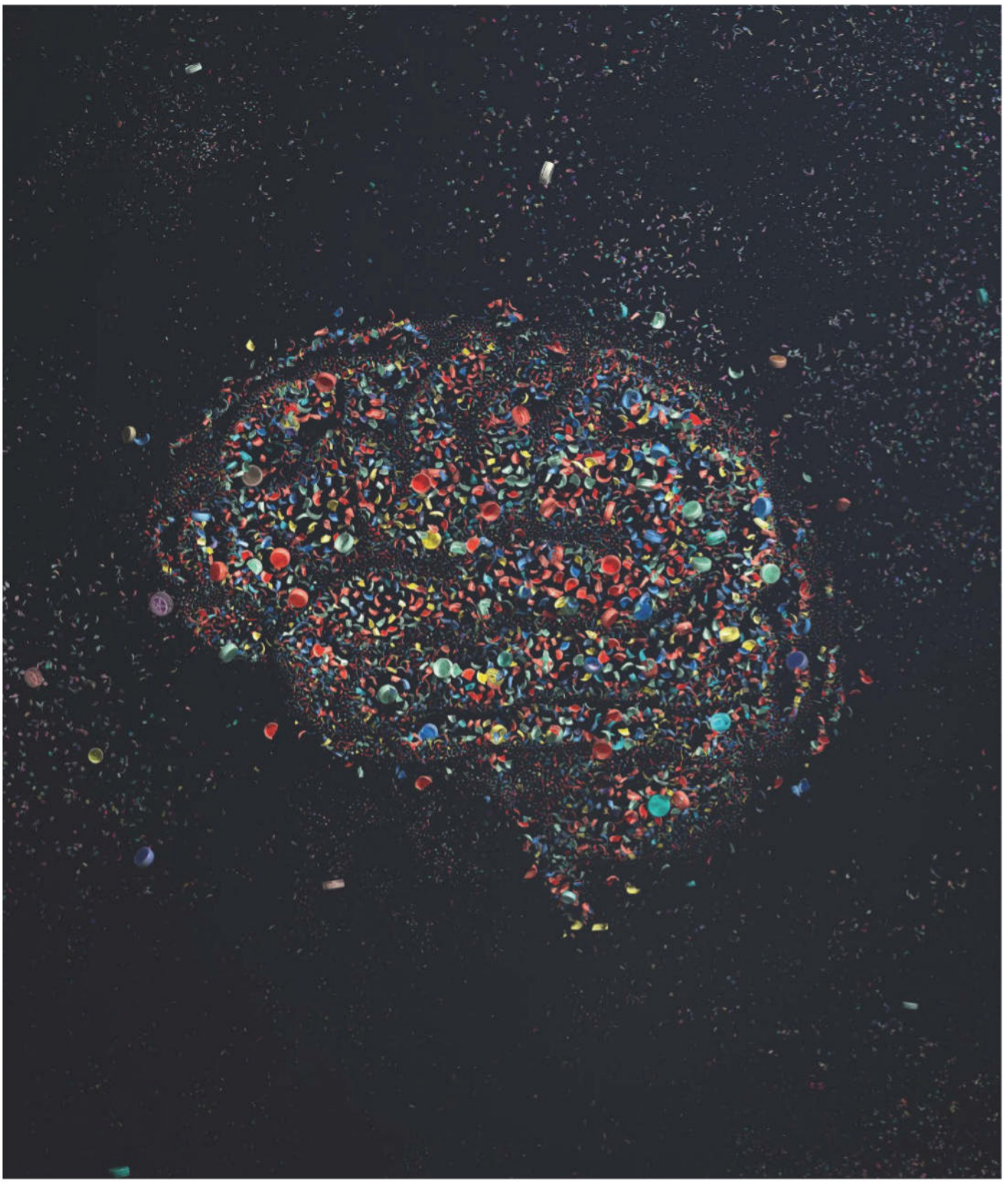
AI is also being used to help narrow down the search for answers to the Navier-Stokes existence and smoothness problem. "Machine learning is quickly developing as another tool in the toolbox," says Dan Freed at Harvard University. But, he adds, it won't work for every Millennium Problem: "Some of them might be less amenable to using machine learning."

That is because AI relies on being fed lots of data – catalogues of knots, for example. In many fields, large volumes of useful data simply don't exist. That said, current limitations may not apply for long. "People are quickly finding creative ways to really expand the scope and the use and application of machine learning," says Freed.

Even in the absence of large datasets, for instance, there might be scope for AI to burrow usefully into convoluted mathematical arguments. "I think one of the very interesting things about these millennium challenges is that the problems can be simple enough for us to pose, but might have a complexity to the proof that is beyond the human mind to navigate," says du Sautoy. AI might have the required tenacity to find buried links, which mathematicians can then pick up and work with. "I suspect that, over the next decade, we might see some interesting new conjectures emerging that we wouldn't have been able to see without the use of this tool," he says. In other words, just as Galileo was able to see more of the heavens using a telescope, AI could give a deeper view of numbers. "This is a really good telescope into the world of data," says du Sautoy.

Whether the Clay Mathematics Institute would accept an AI-led solution to one of its problems depends on mathematicians' willingness to see it as solved. The stipulation is that it must have received "general acceptance in the global mathematical community". In 2000, when the prizes were announced, Alain Connes at the Collège de France in Paris, one of the four advisors to the institute, said the seven problems were "totally inaccessible to computers". But with mathematicians now open to working with AI, that seems like one more conjecture that might fall. ▮

Michael Brooks is a consultant for *New Scientist* based in the UK



SIMON DANAHER

Mind-bending material

Tiny bits of plastics get into the brains of animals, changing their behaviours. What could this mean for us, wonders **Marta Zaraska**

GIVEN a choice between two sea snail shells, hermit crabs know which will make a better home. That is, unless their thinking has been muddled by ingesting microplastics. Then, they struggle with a decision that could be crucial for survival. They aren't alone: across the animal kingdom, it appears, tiny bits of plastic change behaviours and mess up cognition. Exposure to these particles makes mice more forgetful and less social. Bees have trouble learning. Zebrafish act more anxious.

Such discoveries sound a warning bell for people, too. These so-called microplastic fragments are everywhere, from Arctic snow to the Amazon rainforest. Perhaps worse, they are in our foods: from beer and table salt to seafood and honey. "If you turn the top of your plastic bottle, you shower tiny pieces of plastic down into the water," says Tamara Galloway, an ecotoxicologist at the University of Exeter, UK, whose work focuses on the environmental and health effects of pollutants like microplastics. People consume around 52,000 microplastic particles per year – or around 121,000 if you include those we inhale. What's more, recent research shows that some of these can cross the barrier designed to stop toxins from getting from blood vessels into brain tissues.

Exactly if and how this might mess with our minds is unclear because we can't subject people to the sorts of experiments we do with the likes of mice – though Galloway's opinion is that the effects on humans could be serious.

We do however, have animal studies to illuminate how microplastics affect the brain and behaviour of other species. Plus, there is an emerging picture of evidence about the volume of microplastics in the human brain – with some data pointing to a link between higher levels and a greater risk of neurological conditions, such as dementia. So, how worried should we be?

The current situation's origins lie in 1907, when a Belgian chemist named Leo Baekeland invented the first synthetic plastic using phenol and formaldehyde. He named it Bakelite after himself. Soon, commercial production began – initially for use in insulating electrical cables – in Baekeland's home lab in New York. Plastic flowed out into the world.

By the late 1950s, humanity was producing around a million tons of various plastics a year. Today, our output is 400 times that. Between the 1950s and 2017 we created 9.2 billion tonnes of the stuff. In its multitude of forms, this material is now found in everything from clothing and disposable diapers to teabags and toothpaste. Recycling helps reduce the amount that goes to waste, but we manage to recycle only a mere 9 per cent of plastic each year. Most plastic still ends up in landfill or goes directly into the environment, washed into rivers and oceans or contaminating fields and wildlands.

Assailed by sun, water and wind, plastic disintegrates into ever smaller pieces. Once it is smaller than 5 millimetres in diameter, we call these microplastics. Those smaller than 0.001 millimetres are referred to as nanoplastics. The tinier the fragments, the easier it is for them to get swallowed by aquatic organisms, taken up by plants through their roots and inhaled by insects. "They can become part of the food chain," says Galloway. We now know that some of them end up in the brains of animals and, if a slew of recent studies is anything to go by, that is a problem.

Bad decision!

Take those hermit crabs. When Andrew Crump at London's Royal Veterinary College set out to study how microplastics might affect their behaviour, he didn't expect to uncover anything startling. It was an enthusiastic undergraduate student who convinced him to do the experiment, which entailed keeping dozens of the crabs in various tanks with either clean water or water polluted with tiny pieces of polyethylene — a common component of grocery bags and packaging. After five days, each crab was offered a choice of two shells – these animals occupy the empty shells of other species to protect themselves, routinely trading up to a new one as they grow. In this ›

TIMUR MATAHARI/AFP VIA GETTY IMAGES

More than 90 per cent of the plastic we produce ends up in the environment

case, one shell was smaller than their current one – a downgrade – and the other larger – an upgrade. "The results were quite striking," says Crump. The animals kept in clean water tended to make good assessments and opt for the better shell. But crabs exposed to microplastics seemed confused: they would often choose the worse option.

This was one of the first pieces of work indicating that microplastics might be getting into the brains of animals and affecting their behaviour. Other examples have followed, many involving rodents. For instance, it has now been shown that ingesting microplastics compromises the ability of mice to navigate mazes. And there is more evidence that this makes learning and remembering more difficult. Show normal mice a wooden block, and 24 hours later they tend to recognise it as something they have seen before. Not so for microplastic-exposed mice: a single day is enough for them to forget they have seen the block, evidenced by the fact that they sniff it for just as long as an object that is new to them.

Mice dosed with microplastics are also more reckless when faced with predators. This became clear when groups of the animals were put into a large, rectangular box with a copper-coloured North American corn snake – a natural enemy (the snake was kept well-fed to ensure it didn't attack the mice). Control mice not exposed to microplastics were added to the box. When faced with the reptile, they did what they normally do – huddled together for security and retreated into a corner. But when the researchers tried the same thing with mice fed polystyrene microplastics, they seemed fearless. Instead of bunching up into a tight group, they kept exploring and even boldly approached the snake. In nature, such behaviour would have been disastrous.

Recent studies with other animals are producing similar results. One found that after ingesting tiny bits of polyethylene, a species of black-and-white striped fish called a convict cichlid have trouble swimming through a simple maze towards an appetising odour of fish food. Another found that freshwater shrimp become hyperactive. A third showed that microplastics hamper memory in honeybees. David Baracchi at the University of Florence, Italy, and his colleagues made this discovery when they trained bees to respond to certain aromas. To do this, the insects were restrained inside a narrow tube where they could smell the scent, and then the researchers touched their antennae with sugar, which taught them to associate the aroma with the sweet reward. "They start responding to the odour after a few trials, and this is the proof that the bee has learned," says Baracchi. At least, that is how it worked with regular bees. However, those that had eaten a solution of sucrose laced with microplastics for several days had trouble learning. They also quickly forgot any lessons they had learned, which could lead to problems in the wild. "They need to go around and look for flowers. They need to recognise and remember which type of flower is more rewarding. They also need to be able to go back home," says Baracchi.

The conclusion that such behavioural changes are caused by consuming microplastics is strengthened when you look inside the animals' brains. Baracchi and his colleagues fed honeybees fluorescent microplastics and later saw the tiny particles embedded in their brains. Perhaps that is to be expected given that bees, like other invertebrates, lack a vertebrate-style blood-brain barrier – the special buffer between blood vessels and brain tissue that is supposed to keep toxins and pathogens at bay. But the discovery of microplastics in the brains of fish is more surprising. And it has been shown that they appear in the brains of mice just 2 hours and 20 minutes after being eaten.

As to a possible impact in humans? Recent work is showing that our brains aren't immune to the plastic invasion. In a study published in February, tissue was taken from the brains of dozens of dead people and soaked in potassium hydroxide to make it transparent. Examining samples under a microscope, the team behind the research found they contained tiny pieces of plastic – mostly minuscule, shard-like fragments of polyethylene. "One of the big findings from our study was how many of the plastic particles were in the nanoscale," says lead author Matthew Campen at the University of New Mexico. What's more, the brains of people who had died in 2024 contained around 50 per cent more microplastics than the brains of those who had died in 2016. For that earlier group, it came to around 7 grams of plastic per brain, or a few water bottle caps. "That's troublesome," says neuroscientist Jaime Ross at the University of Rhode Island. "It tells me that we are being exposed to more."

Crossing the barrier

It seems that the blood-brain barrier isn't much of an obstacle to microplastics. In fact, there is evidence that the fragments make it leakier – at least in mice. "We had this assumption that the blood-brain barrier stopped everything, but the more we look, the more we find [microplastics] in brain tissue," says Galloway.

If that barrier is compromised, what might happen afterwards? Once it is breached and microplastics are in the brain, they

"Microplastics hamper the memories of honeybees"

Hermit crabs find it hard to choose a good home after ingesting microplastics

JOHNER IMAGES/ALAMY

encounter microglia, the organ's own immune cells, which gobble up and destroy invaders.

Here things go from bad to worse. A recent study found that when microglia consume microplastics, they tend to swell up and can obstruct blood flow in the human brain, potentially leading to neurological problems.

After mopping up microplastics, microglia also set off inflammation in surrounding neurons, damaging them. Several animal studies have linked such inflammation to behavioural issues. In zebrafish, for instance, it undermines swimming ability and produces depression-like behaviour. In addition, research on newborn mice found that microplastics mess up the way microglia prune connections between neurons — a process that normally helps shape the developing brain and make it more efficient. As a result, the animals grew up struggling with social interactions.

Animal studies also indicate that microplastics in the brain can reduce levels of neurotransmitters, including acetylcholine, which is important for memory and learning, and oxytocin, often called "the love hormone". In a study on mice, after long-term intake of microplastics, the animals not only had lower levels of oxytocin in their brains, but were also less social.

It also turns out that microplastics don't even have to enter the brain to jumble up animals' minds. They can wreak havoc at a distance, by affecting the gut-brain axis – a two-way communication network between these body parts. One way they do this is by upsetting the balance of friendly gut bacteria. It has been found that, as a result of this, mice become asocial. And it can cause problems with short-term memory.

Once again, hard evidence of specific effects in living brains comes via experiments of the sort we can't do on people. However, we can see what happens when our brain cells are exposed to microplastics in a lab dish. For example, when researchers dumped large amounts of microplastics – they called it "a year exposure" – on nerve cells, they all died. At smaller doses, the neurons accumulated the particles inside, becoming damaged and misshapen. Other lab dish experiments, meanwhile, confirm a key finding from animal studies: that human microglia eat up microplastics, resulting in increased inflammation.

Despite the experimental restrictions, there are some hints of effects on living people. Work published in 2024 found that people in China aged 60 and older who reported higher potential exposure to microplastics – from things like using plastic tableware and regularly drinking water from plastic bottles – had a raised risk of mild cognitive impairment. That was especially true for regular users of plastic utensils, whose risk increased by 24 per cent. This fits with another finding from Campen's work: people diagnosed with dementia had more microplastics in their brain than others, which has worrying echoes of the findings in animal experiments. Research with mice shows that exposure to microplastics can lead to changes in the brain that resemble those seen in rodents bred to have a version of Alzheimer's disease. And Ross's team found that dosing mice with microplastics altered their behaviour in what she describes as "a way that is akin to dementia". They were unusually restless and careless for their own safety.

Such findings raise concerns as to other possible neurological impacts of microplastics in humans, though solid research investigating further links is pending. Although many lab animal studies use levels of microplastics beyond those currently in the environment, Galloway points out that the effects on human brains could be even worse than in other species because we are so much more exposed to plastic. We even wrap food in it.

Even with research into microplastics' impact on humans still in its early days, there are steps people can take to reduce their intake. "I do everything I can to avoid undue exposure," says Galloway. She doesn't use plastic containers for cooking or storing food. She also buys organic produce because it is less likely to come from farming that uses sewage sludge for irrigation – a mud-like residue from wastewater treatment that has been shown to contain high levels of microplastics. And research suggests a few other measures that might limit the potential risks we face. These include the discovery that taking probiotics can reinforce the blood-brain barrier. Another study, in mice, found that memory troubles triggered by exposure to tiny pieces of polystyrene went away after treatment with vitamin E, which is an antioxidant and so reduces inflammation. Foods such as almonds, spinach and broccoli are good sources of this vitamin.

It may be premature to panic but, amid all the uncertainty, one thing is for sure: "We're full of plastic," says Galloway. "We're not really sure what the risks are, but we need to understand them." ▮

Marta Zaraska is a science writer based in Vexin, France

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Delilah Gates,
Postdoctoral fellow, Center for Astrophysics, Harvard & Smithsonian and Black Hole Initiative, Harvard University

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Dear David

Liar liar

A reader wonders if they can get better at spotting deception. Our advice columnist **David Robson** has some surprising answers

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

Further resources

Aldert Vrij explains his results in this fascinating (if a little academic) talk: youtu.be/An-cqxmUsYO

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

Next week

Stargazing at home

DISTINGUISHING fact from fiction is one of the great tests of human communication. Little wonder that some people agonise over their capacity to sniff out a fishy story. "My friends say I'm a real mug," one reader tells me. "What can I do to be less gullible?"

I can't help but wonder if our reader's friends are being a little too harsh. Countless studies have shown that most of us are pretty abysmal at lie detection. When asked to discern whether people are telling truths or falsehoods, the average person performs no better than chance.

In face-to-face conversations, we may rely too heavily on body language, facial expressions and vocal mannerisms – none of which are reliable indicators of deception. This leads us to overestimate how good we are at judging others' dishonesty.

In general, we would do far better to focus on people's words, which can betray the effort that is required to concoct their cock-and-bull story. Aldert Vrij at the University of Portsmouth, UK, has shown that liars tend to use fewer details than people recounting real events. They'll mention fewer complications or nuances, and offer fewer verifiable sources that could back up their account.

Even if the person has carefully rehearsed their story, cracks will soon appear under some subtle questioning that gently increases their cognitive load. Asking them to describe an event in reverse chronological order can expose inconsistencies, for instance.

CHLOE IMAGES/ALAMY

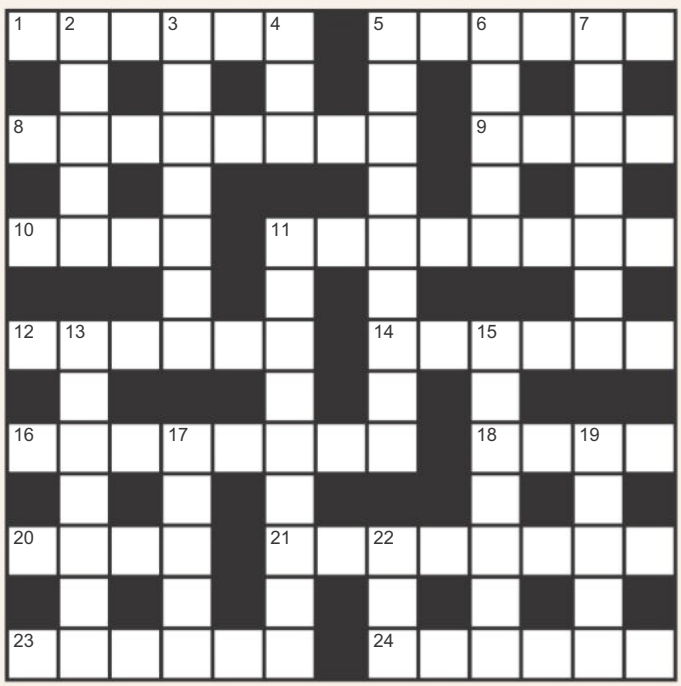
We mustn't allow a fixation with the truth to morph into a deep-set cynicism, however. This may be a particular problem for people who act dishonestly themselves. According to recent research by Sarah Ying Zheng at University College London and her colleagues, people who lie frequently tend to be the most suspicious of others – and this "self-projection" means they are less adept at assessing others' motives and behaviour.

Paradoxically, it seems that the most trustful and trustworthy people are also the least gullible. In 2010, researchers at the University of Toronto measured participants' assumptions about human nature, asking them to rate statements such as "most people are basically good-natured and kind" on a scale of 1 (completely disagree) to 5 (completely agree). The volunteers then had to judge a series of video clips of people telling facts or fibs about themselves. The less trusting participants were worse at identifying both the liars and the truth-tellers; their general misanthropy tended to make them worse judges of character across the board.

No one likes being taken for a fool – and a healthy scepticism is essential for navigating the complexities of our social world. In many cases, however, it is perfectly rational to give people the benefit of the doubt. ▮

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

Cryptic crossword #161 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 React badly after beginning to nibble something sweet (6)
5 Class primarily reinvents wheel (6)
8 Fellow had gutted endless sea creatures (8)
9 Evaluate rodent bite on the rear (4)
10 Unfinished dish of greens sent back, regrettably (4)
11 Aggressively promoting fine industry for lumberjacks (8)
12 Stereotypically, 14 thanks Tesla as well (6)
14 Key person employed by branch organisation (6)
16 Ask about hacker dropping her fraudulent ways (8)
18 Every bit of pit removed from fruit (4)
20 Head of biology touching sick bird's beak (4)
21 Nearly collapse along with English palaeontologist (8)
23 Managed detectives gone bad (6)
24 Poke holes in extremely delicate camper's bed (6)

DOWN

2 Messages bring up trace of arsenic in calcium compound (5)
3 Travel periods interrupted by unexpected rains (7)
4 Speaker's grimly humorous spirit (3)
5 California's very skittish bird (9)
6 Cropped garment she almost set on carpet (5)
7 Gradually deplete fantastic tin o' tea (3,4)
11 Rearing howler breed ruined garden (6,3)
13 Abrasive former student in area (7)
15 Bleach spilled outside entrance to my science classroom (4,3)
17 Company half-licked infant ailment (5)
19 We hear pirate weapon works (5)
22 Chew poutine topping with no end of fervour (3)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #301
set by Corryn Wetzel

1 What is the chemical symbol for the element tungsten?

2 What is the study of mosses and liverworts called?

3 What does "HTTP" stand for?

4 Which pepper is currently rated highest on the Scoville scale?

5 In what year was the World Health Organization founded?

Answers on page 47

BrainTwister
set by Christopher Dearlove
#72 Match up

Consider a game where two players, A and B, play a sequence of rounds. After each round, one of them wins a point. Player A is the better player, winning 2/3 of all rounds, while player B only wins 1/3 of all rounds, all rounds being independent. The game is won by the first player to have won two more points than the other.

Starting level, after two rounds, what is the probability of player A having won the game?

What is the probability of player A eventually winning the game? (Hint: After two rounds, either player A has won, player B has won or the players are back to level.)

If, at some point in the game, player B is one point up, what is the probability that player B will win the game?

Solution next week

Green goodbye

How can I ensure that most of my body is used after my death and what is left over can be turned into something like compost?

Stephen Johnson
Eugene, Oregon, US
There are many ways in which your body can be useful after your death. First, there is organ donation, and there is a continuous need for human organs. There is no age limit for becoming a donor, and even older bodies still have useful organs.

In addition, science has a perpetual need for human bodies for research. In the US, there are state and national organisations that take donations of human bodies and place them where they are needed. After the body is used for science, the remains can be returned for burial or the person's family can receive cremated remains. Arrangements are best made in advance with such organisations.

Finally, in around a dozen US states, including where I live in Oregon, there are companies that will actually compost your body and return soil to your family. In many cases, the family will only want a portion of the soil since composting a human body produces around a cubic yard (0.75 cubic metres) of soil, enough for a small truck load.

"In around a dozen US states, there are companies that will actually compost your body and return soil to your family"

The remaining soil can then be used in gardens, natural areas or for conservation projects. In some cases, it may be possible to compost someone's remains after their body has been used for scientific research. However, this depends on what use was made of the body and the possible toxins in the remains.

Katrina Spade
Seattle, Washington, US
Human composting is a relatively new death care option developed by my company, Recompose. It mimics the process that happens on the forest floor, where sticks, leaves and other organic materials decompose naturally to form the basis for all life on Earth – soil.

Here's how human composting works at Recompose: when someone dies, their family calls us to plan logistics and a memorial service if they choose. Once our team has received the person's body, we lay a carefully calibrated mixture of wood chips, alfalfa and straw into a stainless steel composting vessel. We place the person's body on top of that mixture and cover it with more of the same. A basic fan system pulls air through each vessel – this is an aerobic process, meaning oxygen is a necessary ingredient. Each vessel has temperature probes telling our team how warm the material is becoming because of all the microbial activity. About once a week, we rotate each vessel slowly, ensuring, like in any good composting process, that there is plenty of oxygen. Most bodies take between 30 and 40 days to transform into soil. It then takes a few more weeks for that soil to cure. Once it's ready, friends and family can come to Recompose to pick up the soil for use in their gardens, or they may decide to donate it to our Land Program for use on conservation projects. Whether it is donated or used by loved ones, the soil is nutrient-rich and ready to grow new life.

STEFAN GIFT THALER/MILLENNIUM IMAGES, UK

This week's new questions

Under pressure **Does car tyre pressure affect the radius of the wheel, or the speedometer or milometer (odometer) readings?** ***Bryn Glover****, Kirkby Malzeard, North Yorkshire, UK*

Up in the air **Would the Amazon turning to savannah significantly reduce the oxygen in our atmosphere?** ***Tony Lang****, Stoneleigh, Surrey, UK*

Does the pressure in car tyres affect the wheel's radius, and thus speedometer readings?

Patchy puzzle

Why do many animals, such as mammals and birds, have white underbellies? (continued)

Anne Barnfield
London, Ontario, Canada
That many animals and birds have white undersides and coloured backs is probably for the same reason that fish are often paler underneath than on top – to make themselves less visible to predators or prey. Imagine a hawk flying over an animal that is on the ground or on a tree branch. A grey or brown topside would blend in more with the environment and be more difficult to spot. Conversely, an animal with a lighter underside would be less visible against the lightness of the sky when viewed from underneath. In the same way, a predator that was darker on top and paler underneath would also blend in more with their surroundings when moving toward a prey animal.

Derek Bolton
Sydney, Australia
Dark above, lighter below is a near-universal arrangement in animals, most likely to reduce visibility to prey and predator. The transition tends to be sharper in well-lit environments and more gradual in shady ones. There is also an energy cost in producing the pigment melanin, which is part of the reason why human hair whitens with age.

Dyane Silvester
Arnside, Cumbria, UK
I suspect that mammals' and birds' white bellies are for camouflage: as potential prey (or predator) on the ground will be looking up at the creature against the relatively pale sky. This is also common in marine creatures.

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Tom Gauld
for New Scientist

Two of a kind

Binocular vision gives us a 3D perspective, and two ears let us locate the direction of a sound. But why two nostrils? (continued)

Matthew Ravosa
Johns Hopkins University School of Medicine, Baltimore, Maryland, US
There are several reasons why two nostrils or "nares" are beneficial in terrestrial vertebrates. In contrast to fish, where the nostrils open to sensory cavities lined with chemoreceptors for detecting waterborne odours, the nostrils of terrestrial vertebrates are "doors" to both sensory cavities and passageways connected to the lungs. Accordingly, they serve multiple functions: they are involved in both chemosensation of airborne scents and inspiration (also called inhaling).

In humans, there is evidence that at any given time, one nostril is differentially focused on facilitating airflow into the nasal cavity as part of the initial phase of the breathing process.

"Because bilateral symmetry is such a successful body plan, it must convey significant selective benefits"

Simultaneously, the other nostril is tasked with sampling airborne odours and chemical cues, more colloquially referred to as smelling or olfaction. The dominant nostril devoted to breathing inhales air more rapidly, with this asymmetry in functional patterns switching between left and right sides every few hours.

Jonathan Wallace
Newcastle upon Tyne, UK
It should be borne in mind that we have evolved from an extremely long lineage of bilaterally symmetrical animals extending right back to distant invertebrate ancestors. Bilateral symmetry in animals gives rise to paired organs on either side of the longitudinal axis, as we can see when we look at the wings and legs of an insect or most of the organs in the human body. It might be more appropriate, therefore, to ask for an explanation for those cases that diverge from this symmetry, such as toothed whales with their single nostril, as such instances require a break away from the ancestral body plan.

Because bilateral symmetry is such a successful body plan, evolutionarily speaking, it is reasonable to conclude that it must convey significant selective benefits. Animals with symmetrical, paired body parts may benefit in various ways, such as the binocular vision and stereo hearing suggested by the questioner, redundancy (lose one kidney to injury or disease and you can still function with the other), ability to fly and development of a streamlined body shape, among others. But the adaptive benefits of bilateral symmetry that we see in extant animals may mostly be secondary benefits that weren't involved in the original evolution of our first bilaterally symmetrical ancestor. ▮

Answers

Quick quiz #301 *Answers*

1 W
2 Bryology
3 Hypertext Transfer Protocol
4 Pepper X
5 1948

Quick crossword #182 *Answers*

ACROSS 1 Biopsy, **4** Airborne, **10** Soda lye, **11** Pit stop, **12** Blue, **13** Tube alloys, **15** Bubble, **16** Demerol, **20** Fractal, **21** Isobar, **24** Psychiatry, **26** Acme, **28** Maxilla, **29** Corolla, **30** Assassin, **31** Degree

DOWN 1 Bushbaby, **2** Odd number, **3** Silt, **5** In pieces, **6** Betelgeuse, **7** Ratio, **8** Expose, **9** Venus, **14** Black holes, **17** Orbicular, **18** Nagasaki, **19** Freeware, **22** *Ipomea*, **23** Bract, **25** Y-axis, **27** True

#71 Dip die *Solution*

You need 5 × 5 × 5 = 125 cubes. Of these, the central 3 × 3 × 3 cube of cubes will be unpainted, so 125 – 27 = 98 cubes will have some paint on.

There are 125 × 6 = 750 total faces, of which 25 × 6 = 150 are on the outside of the cube. Since picking a cube and rolling it is equivalent to picking a cube face at random, the probability of a red face is 150/750 = 1/5.

This can also be seen by observing that if the cubes are laid out with each in its original orientation, 1/5 of the faces pointing in each direction are red.

How the whale crumbles

More on the topic of unusual units of measurement, in particular how to communicate the size of information. Attentive readers will recall Christopher Dionne's suggestion that the scale of large datasets could be conveyed by comparing them to the genome of the blue whale (12 April).

Bruce Horton writes in with a firm riposte. "The whole point of using blue whales to measure the size of things is that everyone knows how big a blue whale is, so we can easily visualise the length of anything measured in blue whales," he writes. "But most people cannot visualise the size of blue whale DNA, so that idea won't work well."

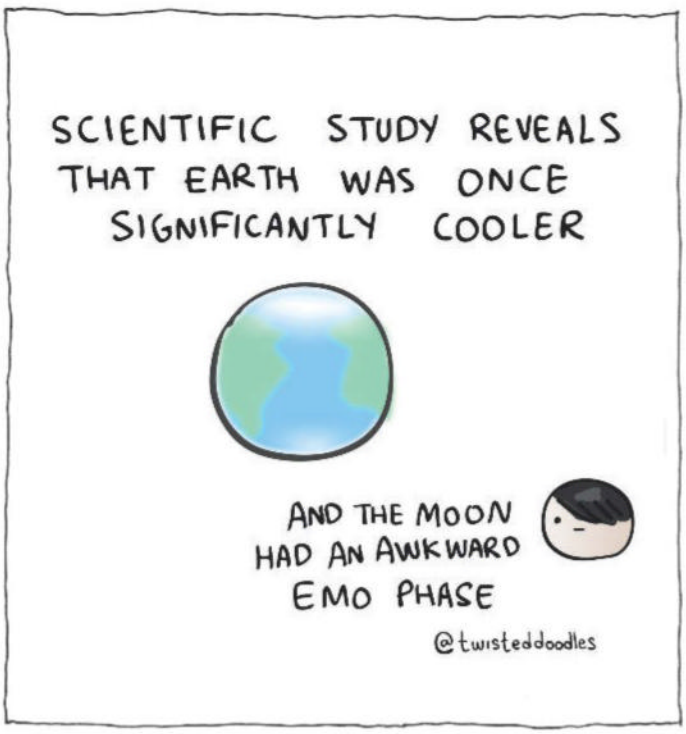
He has a point. Feedback is still scarred by the era of the Human Genome Project in the early 2000s, when we had to find comparisons to get across how much information is carried on our DNA. These often involved stacks of Bibles reaching halfway to the moon. Nowadays, we would just use the collected *Wheel of Time* books.

Fortunately, Bruce has a solution. He points us to a 2005 study in the parody scientific journal *Annals of Improbable Research*, which describes SNAP: SNAil-based data transfer Protocol. The researchers attached a giant African land snail to a two-wheeled cart, the wheels of which were CDs or DVDs. While the snail moved slowly, the data nonetheless travelled at 37,000 kilobytes per second – meaning the snail-based system transferred information quicker than existing broadband connections.

SNAP, Bruce argues, "is a standard unit of measurement of data transfer that is easy for anyone to visualise and understand and is recommended for common use".

Perhaps. While we await further correspondence, we wish to recommend a new unit developed by Ken Taylor and his wife. They have an orchard that includes some damson trees, which Ken describes as "notoriously variable in yield from year to year". Hence they have established "the crumble", which is a measure of how many desserts they can make per harvest. Ken reports: "2024 was a very bad year – just 3 crumbles."

Twisteddoodles *for New Scientist*



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

Shock findings

"Well who would have thought it," says news editor Alexandra Thompson. "Stop the press." She was drawing Feedback's attention to a press release with the title: "Being hit by an SUV increases the likelihood of death or serious injury, new research shows".

Compared with smaller cars, one of those great hulking SUVs is more likely to kill you if it hits you. Now, you might expect Feedback to snark at the sheer obviousness of this: yes, heavier objects hit harder than lighter ones, if they arrive at the same speed. But of course, one of the main virtues of science is the refusal to accept common sense for an answer, but instead to check things.

We hereby invite reader contributions in the category of "no shit, Sherlock". The more painfully obvious the discovery and tediously long-winded the experiment, the better. Do people enjoy picnics less if they're overrun by ants? Does your water bill go up if you have a leaky tap? At least one enquiring mind wants to know.

Licking badgers

Historian Greg Jenner made a noteworthy discovery in April. Writing on Bluesky, Greg says: "you can type any random sentence into Google, then add 'meaning' afterwards, and you'll get an AI explanation of a famous idiom or phrase you just made up".

Greg's invention was "You can't lick a badger twice", which Google's AI informed him meant "you can't trick or deceive someone a second time after they've been tricked once". Um, first of all, the US electorate begs to differ. Second, this is, and we can't stress this enough, completely made up. Yet that didn't stop the AI spooling out a detailed explanation. "'Licking' in this context means to trick or deceive someone," it says, and "the phrase likely originates with the historical sport of badger baiting". Badger baiting was a real thing; this etymological link is not.

In the replies, people submitted their own made-up phrases and Google's "interpretations". Kit Yates came up with "You can't run a mile without hitting it with a hammer", which is apparently "a motivational phrase often used to emphasize the difficulty or struggle involved in achieving a goal". Feedback was particularly delighted by the use of "often" in that torrent of nonsense.

Kai Kupferschmidt offered "It's better to have a tentacle in the tent than a rat in the rattan chair". Google informed him that this is "a humorous idiom that suggests it's better to be in a situation that is initially uncomfortable or unusual than a situation that is undesirable and/or dangerous". Feedback has a number of thoughts on this, not the least: why should a rogue tentacle be considered uncomfortable but not dangerous? We've read H. P. Lovecraft: tentacles are a bad sign.

Alas, the "meaning" function seems to have been deactivated. We tried to persuade Google to give us a definition for "never rub a roe deer's cabbages", and it wouldn't do it.

Of course, it's mean to pick on the AI for doing what it was built to do: generating responses to questions. And it's not like we haven't met any humans that would rather spew nonsense than admit they don't know the answer to a question.

But it perhaps highlights the issues with adding this technology to a page meant to be a source of accurate information. Feedback now no longer entirely trusts the results on Google, which ironically means the AI was right: you really can't lick a badger twice.

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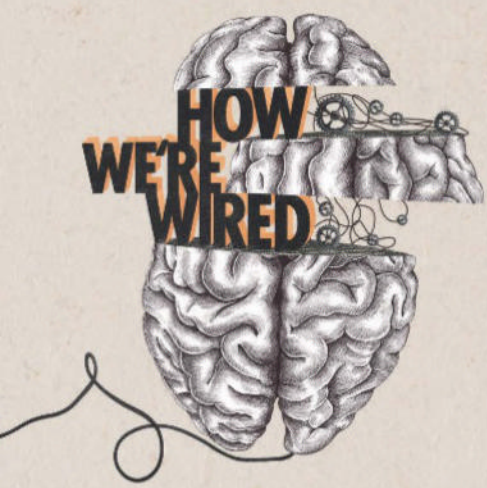

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locommotion?

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