New Scientist

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NS Live

Probiotics: Separating fact from fiction for our gut health

Dietitian and nutritionist Megan Rossi will delve into the complicated, much-debated world of probiotics on 18 October at London's ExCel Centre. Rossi will highlight the most common myths and misconceptions, why consumers are confused in the supplements' aisle, and the actual science behind live bacteria.

newscientist.com/nslive

Tour

Astronomy and culture through Silk Road cities: Uzbekistan

Embark on a captivating journey across Uzbekistan and explore how astronomy was part of the cultural exchange that took place along the Silk Road. Along the way, you will visit ancient observatories and go stargazing in the desert. This 14-day tour starts on 23 August and costs £3195.

newscientist.com/tours

Podcast

The world, the universe and us

The team are joined by science journalist Olive Heffernan and professor of environmental studies Dustin Mulvaney to discuss deep-sea exploration. They explore the idea of biophotons – photons that are emitted from all living things. Plus, they listen to some drumming chimpanzees to find out more about how they communicate.

newscientist.com/nspod

RAGA JOSE FUSTE/PRISMA BY DUKAS PRESSEAGENTUR GMBH/ALAMY

Ancient wonder Visit the beautiful city of Samarkand, Uzbekistan

NICOLAS SAINT-MAUR/LORIENT AGGLOMERATION

All aboard This floating laboratory is headed to the Arctic

Video

Arctic voyage

Tara Polar Station, a new long-term drifting observatory and laboratory designed to study the central Arctic Ocean, is pushing the boundaries of research in the region. This vessel, specially adapted to the harsh polar conditions, will shelter scientists as they embark on a transpolar drift, monitoring the sea ice year-round over multiple years.

youtube.com/newscientist

Newsletter

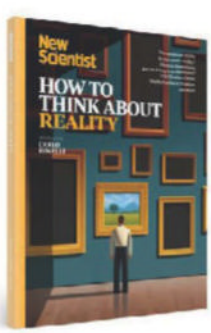
Our Human Story

One of the most vexing unsolved problems in human evolution is identifying the last common ancestor we share with chimpanzees and bonobos, our closest living relatives. Michael Marshall explores how complete ape genomes could help us finally solve this long-running mystery.

newscientist.com/our-human-story

Podcast

"Rhythm was a part of our social world long before we became human"



How to think...

In the second issue of our new *How to Think About* series, we dive into the mind-bending concept of reality, with the world's best scientists and philosophers as our guides. Together, we'll explore groundbreaking ideas that bring us closer than ever to unravelling the true nature of the universe.

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Research imbalance

The complexities of female sex hormones call for more science, not less

IN 1977, the US Food and Drug Administration (FDA) imposed a ban on women of childbearing age being included in early drug trials – even if they used contraception or had vasectomised partners. This was a reaction to harms caused by drugs like thalidomide, which can lead to birth defects.

Even before the ban (which was lifted for non-pregnant women in 1993) women and female animals were regularly excluded from research – their fluctuating hormone levels seen as complicated noise. Female data is still often extrapolated from research on male animals.

The cost of this lack of inclusion is clear: it has skewed our understanding of health and disease and left us woefully ill-informed about conditions that predominantly affect women.

A classic example of this came in 2013, when more than 20 years after the sleep aid zolpidem was approved, the FDA halved the recommended dose for women as evidence emerged they experienced more daytime drowsiness than men,

"If these conditions predominantly affected men, there would be more treatments available"

leading to more driving accidents.

Progress is being made. Increasingly, researchers are considering sex as an important biological variable, leading to recent discoveries that women are twice as likely as men to be diagnosed with depression, for instance, and that they get cardiovascular disease at lower levels of blood pressure.

But there is still work to do. While many funders now insist that research includes two sexes, conditions that mostly affect women – such as migraine, endometriosis and premenstrual dysphoric disorder (see page 38) – continue to attract much less funding in proportion to their burden on the population. That hormones and their actions make research more complex should be a reason to invest more, not less.

Had these conditions predominantly affected men, there would no doubt be more treatments available. The stories of people living with PMDD should be read as a stark reminder of the cost of this inequality. ▮

Podcast

NewScientist

The world, the universe and us

Listen to our brand-new podcast, The world, the universe and us, for your essential weekly dose of science and wonder in an uncertain world. Hosted by journalists Rowan Hooper and Penny Sarchet and joined each week by expert scientists, the show draws on *New Scientist*'s unparalleled depth of reporting to put the stories that matter into context.

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News

Early warning
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Useful after all
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Family values
Superb starlings are upending our idea of shared parenting **p19**

RYAN JENKINSON/GETTY IMAGES

Environment

Reservoir running low

THE UK's driest start to spring in 69 years has seen water levels in reservoirs drop, including here at Woodhead Reservoir in Derbyshire. Woodhead is one of several reservoirs that supply water to north-west England, and these are now at just 69 per cent capacity, compared with 90 per cent at the same time last year. The low levels are raising fears of drought conditions over the summer.

Evolution

Clues to the origin of complex life

Strange microbes called Asgard archaea living in wetlands in China are helping unravel the history of the cells that make up all plants and animals, finds **Michael Marshall**

CHRISTIAN JEGOU/SCIENCE PHOTO LIBRARY

The first of the Asgard archaea may have lived somewhere like this

HOW complex eukaryotic cells, of the type found in all plants and animals, evolved is shrouded in mystery. Now, unusual microbes have helped to narrow this down – and the oxygenation of Earth's atmosphere may have played a key role.

The new data brings us a step closer to understanding "an event which happened billions of years ago", says Burak Avcı at Aarhus University in Denmark. This event was the origin of complex eukaryotic cells, of the type found inside our bodies and other complex organisms. The first living cells were small and had few internal structures. They are represented today by bacteria and their sister group the archaea.

In contrast, eukaryotic cells are many times larger – though still microscopic – and have many internal structures. These include a nucleus, where the DNA is stored, and sausage-shaped mitochondria that supply energy.

Since the 1960s, it has become clear that eukaryotes formed when one cell somehow came to live inside another. The energy-giving mitochondria were once free-living cells, which ended up living inside a larger host. Genetics suggests that the host cell was an archaean, while the original mitochondrion was a bacterium, says Avcı.

Not a myth

A big break came in 2015, when researchers drilling into the Atlantic seabed discovered a new group of archaea, called the Asgard archaea after the home of the gods in Norse mythology. The Asgard archaea have many genes that were previously only found in eukaryotes, and they are the closest living relatives of eukaryotes. It seems the archaeal host that took in a bacterium to become the first eukaryote was an Asgard archaean, or something closely related.

But which Asgard archaean, and when, and how? There are many subgroups, all with Norse-inspired names like Lokiarchaeia, Thorarchaeia and Heimdallarchaeia.

To find out which one gave rise to eukaryotes, a team led by Hongpo Dong at East China Normal University in Shanghai took samples from 14 coastal wetlands in China. The researchers sequenced all the DNA they could find, and identified 223 new Asgard archaea, including 16 new subgroups.

"The Asgard archaea have many genes that were previously only found in eukaryotes"

"This is a big number," says Avcı, who wasn't involved in the research, and means we now have a much broader picture of the diversity within the group.

A 2023 study concluded that eukaryotes emerged from the Heimdallarchaeia subgroup. However, Dong's team found that eukaryotes as a group are older than Heimdallarchaeia, so they couldn't have emerged from within that group. Instead, eukaryotes and Heimdallarchaeia are closely related "sister" groups.

Dong says that previous studies inadvertently went wrong by including a group of Asgard archaea called the Njordarchaeales. These, it turns out, carry a lot of DNA from non-Asgard archaea, throwing off the analyses.

The new genomic data also allows Dong and his team to estimate when the different groups emerged. They say the last common ancestor of Asgard archaea lived 3.72 billion to 3.06 billion years ago. Then the Heimdallarchaeia group diverged 3.12 billion to 2.26 billion years ago,

3.72
Earliest date that the last common ancestor of Asgard archaea lived, in billions of years ago

2.5
When oxygen appeared in the atmosphere, in billions of years ago

1.89
Oldest known eukaryotic fossil cell, in billions of years, thought to have formed from Asgard archaea and oxygen-tolerant bacteria

Fossil tracks rewrite history of animals leaving water to live on land

Evidence of the earliest known reptile-like animal, an ancestor of many four-limbed creatures including birds, reptiles and mammals, has been found in Australia. The discovery could push back the timing of when these animals began to emerge from the water to live solely on land, one of the most important events of life on Earth.

In 2021, two amateur fossil enthusiasts found a slab of sandstone, around 40 centimetres wide, along the Broken river, near Mansfield, Victoria. It had three sets of tracks that appear to have been made by the same species of tetrapod, or four-legged animal. Two of the sets show signs of five digits, with curved claws.

The fossil was brought to the attention of John Long at Flinders University in Adelaide, Australia, and his colleagues, who dated the slab to around 356 million years ago. This is more than 35 million years earlier than the previous oldest clawed fossils, which were found in Nova Scotia, Canada (*Nature*, DOI: 10.1038/s41586-025-08884-5).

"We can see beautiful, five-fingered hands and hooked claws in these new trackways," says Long. These are a "dead giveaway" that this was an amniote, or creature whose young develop inside amniotic fluid, he says. This category includes those that grow inside an egg, as with reptiles, or inside the body, as in mammals.

It also rules out the possibility that it was an amphibian, says Long. The first four-legged land animals are thought to have been amphibians, but their young would have had to pass through a larval stage, forcing them to return to water rather than living out their whole life cycle on land. "None of the early amphibians have well-developed claws at the end of their fingers and feet," he says.

That means the tracks are likely to be the earliest known example of a reptile living on land, says Long. "This was a very big turning point in evolution because, with a hard-shell egg, amniotes weren't bound to go back and reproduce in water," he says. "Instead, they could invade dry land, invade continents."

Other evidence suggesting that the tracks were made on land, rather than in water, is that the small slab is pocked with raindrops, says Long. While the researchers are still being cautious, they are "99 per cent sure it is an early reptile", he says.

Blake Dickson at the University of New South Wales in Sydney, Australia, says he is convinced from the images and analysis that the fossils were made by animals with claws. "This is the earliest evidence of advanced terrestrial locomotion that we know about," he says.

However, two trackway researchers, Steven Salisbury and Anthony Romilio, both at the University of Queensland, Australia, say that, while the new fossil is undoubtedly an important find, they have questions about whether the claws are true claws rather than just pointed digits.

"This discovery is hanging by the claws," says Romilio. "They are relying on them being claw marks to carry their case. If they are claw marks, then hats off to them, as that would be extraordinary to have such a find." Long says he believes it is "clear" the footprints have claws.

Salisbury also says that just because raindrops are recorded on the slab when the surface was exposed to air doesn't mean that the tracks were definitely made at that same time, as water levels could have come and gone.

In response, Long says: "We show that raindrops fell and left impressions on the surface. Then the creatures walked across it, leaving crisp prints over the raindrops. Raindrops are hard to preserve underwater, after a flow of water as the river rises."

James Woodford

The new fossil tracks show front foot prints (in yellow) and rear footprints (blue)

GRZEGORZ NIEDZWIEDZKI

suggesting the eukaryotes emerged during the same period (*Nature*, doi.org/g9hrqn).

Dong says this fits with several previous studies. Research from 2018 suggested that the ancestors of eukaryotes split from other Asgard archaea around 2.7 billion years ago. However, they didn't acquire mitochondria and become "true" eukaryotes until much later, perhaps 1.84 billion years ago.

Perhaps in line with that, a review of fossil eukaryotes, published in March, found that the oldest confirmed examples are 1.89 billion years old. Likewise, a 2023 analysis found that mitochondria split from other bacteria 2.58 billion to 2.12 billion years ago.

Switch to oxygen

From about 2.5 billion years ago, oxygen appeared in the air, released by photosynthetic bacteria. Dong says this was key to the evolution of eukaryotes. Some bacteria could tolerate oxygen, so the Asgard archaea formed partnerships with them. "As atmospheric oxygen levels continued to rise, the symbiotic relationship became increasingly integrated, ultimately resulting in the fusion of the partners," says Dong.

"Some bacteria could tolerate oxygen, so the Asgard archaea formed partnerships with them"

We can't be too confident about any of these specific findings, because of our limited sampling of Asgard archaea, says Avci. "I think we just see the tip of the iceberg now," he says, so additional genomes could change the picture again. ▮

Analysis Health

Does intermittent fasting improve gut health?

Restricting when you eat may have health benefits, but the question is far from settled, finds **Grace Wade**

CHERYL RAMALHO/ALAMY

THERE is evidence that intermittent fasting alters the gut microbiome, and while this is often believed to improve gut health, some studies are now raising doubts about whether that is always the case.

The idea behind intermittent fasting is relatively straightforward: instead of focusing on what you eat, you focus on when, cycling between periods of fasting and eating. The most popular approach limits all meals and snacks to the same 8-hour window each day.

Proponents claim it can slow ageing, prevent overeating and boost immunity. Many of these benefits are believed to stem from its impact on the gut, particularly the trillions of microbes residing within it. But how intermittent fasting affects gut health is far from settled.

For instance, in a new study, Guodo Cao at Anhui Medical University in China and their colleagues found that intermittent fasting exacerbated colon inflammation in mice. Compared with five mice that ate freely, an equal number that fasted had significantly more signs of colon inflammation. Levels of one inflammatory molecule were 27 per cent higher in the fasted mice, for instance. The animals on a restricted diet also had significantly shorter colon lengths and lower body weight – both indicators of gut inflammation (*Research Square*, doi.org/pmg2).

Further experiments revealed intermittent fasting inhibited the rodents' gut bacteria from producing indoleacrylic acid, a molecule that helps regulate immune responses in the gut. When the team supplemented the diets of a separate group of fasting mice with this molecule, it alleviated intestinal inflammation.

These results suggest intermittent fasting can influence the gut microbiome in ways that aren't always conducive to health, says Christoph Thaiss at Stanford University in California, who wasn't involved in the study.

However, Satchidananada Panda at the Salk Institute for Biological Studies in California has "some serious concerns" with the study, namely its small sample size, omission of dietary information and the fact that it used five-week-old mice. "This is akin to putting a toddler on an 8-hour feeding without mentioning what and how much food was given," he says.

"We don't know what a healthy gut microbiome looks like, as it depends on the context"

Still, the results could explain why some animals don't always benefit from intermittent fasting. In a 2024 study, Thaiss and his colleagues found various fasting regimens extended the lifespan of most – but not all – mice. "We had a few mice that developed complications that actually died earlier, despite the fact that they're on an allegedly beneficial intervention," he says. "I think this [most recent] study is providing one possible mechanism by which this might be the case."

Intermittent fasting focuses on when, not what, you eat

Part of the challenge in disentangling how intermittent fasting affects gut health is that most research is conducted in rodents, which have different metabolisms and eating behaviours than humans.

Another challenge is that we still don't know what a healthy gut microbiome looks like, as "healthy" depends on the context. What's more, there is little consistency between study results. A 2024 review of eight studies in people found that while intermittent fasting seems to improve the diversity and richness of their gut microbiome, changes in microbiota composition varied between studies, with some even showing opposing effects.

However, of the limited evidence available, most suggests intermittent fasting is beneficial for gut health. Yet "how much this can be generalised to a wider population is, I think, an open question", says Thaiss. ▮

Space

Alien Dyson spheres may self-destruct before we spot them

Alex Wilkins

IF ALIEN civilisations are building vast satellite swarms to harvest a star's energy, we should be able to see them – so why haven't we? It may be that these structures, known as Dyson spheres, would destroy themselves once they are no longer used.

Astronomers have theorised that Dyson spheres, if they exist, should give off a telltale signature of light, but searches so far have been at best inconclusive. Now, Brian Lacki at the Breakthrough Listen initiative in Oxford, UK, has calculated that Dyson spheres, in the form of swarms of satellites, would probably be plagued by an avalanche-like cascade of collisions, eventually destroying themselves.

"When you have a whole bunch of things moving together like that in a swarm, a natural question is going to be, do they sometimes bump into each other?" says Lacki. "At their orbital speeds, that can be disastrous."

Lacki calculated that a swarm of satellites orbiting a star at random would destroy itself in hours or days through chain reactions. He found that even a swarm made of fewer, larger satellites, or those placed in thin orbital shells to avoid satellites crossing paths, couldn't last much longer than a few million years before descending into chaos (arXiv, doi.org/pmg3). The only way to avoid total destruction would be to employ some sort of active management system, says Lacki.

This means we are unlikely to come across Dyson spheres once the alien civilisation has gone extinct, says Jason Wright at Pennsylvania State University. "One argument that was sometimes made about Dyson spheres is that maybe a species would build it and then long after the species was gone, it would persist, but what Lacki is showing is that they're only visible as long as they're being used." ▮

Biology

We emit a ghostly glow that gets snuffed out when we die

Alex Wilkins

ALL living things, including humans, constantly emit a faint glow – and it appears to vanish very soon after death.

The existence of this glow has been controversial, but it is thought to be the result of a process called ultraweak photon emission. In mitochondria and other energy-producing machinery in our cells, molecules gain and lose energy, in turn emitting the equivalent of a few particles of light a second per square centimetre of skin tissue.

However, these "biophotons" are extremely difficult to detect and disentangle from other biological processes or light sources, such as the radiation produced by any warm object.

Now, Dan Oblak at the University of Calgary in Canada and his colleagues have isolated what happens to these biophotons when an animal dies, imaging ultraweak photon emission across an entire mouse before and after its death. "The fact that ultraweak photon emission is a real thing is undeniable at this point," says Oblak. "This really shows that this is not just an imperfection or caused by other biological processes. It's really something that comes from all living things."

"Ultraweak photon emission is undeniable at this point. It really comes from all living things"

Oblak and his team used digital cameras that were capable of detecting single photons to produce two, hour-long exposure images of four hairless mice, one before and one after death. The animals were kept at the same temperature to exclude heat as a factor and in a dark box to avoid light pollution. They found that biophoton emission significantly decreased after death across the whole mouse.

They also took pictures of umbrella tree (*Heptapleurum arboricola*) leaves they had cut, and found that the plant's injury repair mechanism increased biophoton emission, while various drugs applied to the plant surface, such as the numbing drug benzocaine, also appeared to do the same (*The Journal of Physical Chemistry Letters*, doi.org/pk8j).

It isn't surprising that biophotons stop being emitted when you die because they are a byproduct of metabolic cellular processes that cease after death, says Alasdair Mackenzie at the Central Laser Facility in Oxford, UK, and previous research has shown this for individual cells and smaller body parts. However, it hasn't been done for a whole animal before, and because Oblak and his team have been careful to exclude other potential light sources, we can be confident that we are really seeing biophotons, says Mackenzie.

Michal Cifra at the Czech Academy of Sciences in Prague says the absence of biophotons after death is mainly due to the lack of blood flow around the body, because oxygen-rich blood is one of the key drivers of metabolism, which produces biophotons. If the blood had been kept artificially circulating, says Cifra, then they would still observe the same biophoton emission. "It's not related to the systemic liveliness, it's related to the liveliness of the optically accessible tissue."

The technology could one day be used to monitor living tissue without performing invasive tests, or monitoring forest health from afar at night, says Oblak. ▮

Technology

Faster way to locate landslides could help rescue efforts

WHEN a dangerous landslide hits, rescuers scrambling to assist need to know exactly where to look – and now a new technique for analysing seismic data can do just that, by traceing the source of the disaster to within a few kilometres in seconds.

Existing methods can only narrow down locations to within tens of kilometres, says Stefania Ursica at the Helmholtz Centre for Geosciences in Germany. In remote areas, this can lead to delays if rescuers are sent to the wrong place. "That time loss can be crucial," Ursica told a press conference at a meeting of the European Geosciences Union in Vienna, Austria, last month.

XINHUA/ALAMY

Local people search a landslide site in Papua New Guinea

Many countries have a network of seismic monitors to record activity related to earthquakes and volcanoes. This data can also be used to detect landslides – the risk of which is increasing due to climate change – but the data from these kinds of events is much harder to analyse, says Ursica.

There are two novel aspects to her team's approach, she says. The first is to analyse five different aspects of the seismic waveform to pick out from the noise exactly when an event occurred.

This information is then fed to a dozen or so mathematical agents that search for the location of the event by estimating what waveform would have been produced if the event had happened in a particular spot and comparing it to the recorded waveform. If it doesn't match, they try a different spot.

Each agent "moves" in a pattern inspired by animal behaviour, from the spiralling of a falcon to the long migrations of elephants. The entire process takes only around 10 seconds (*EGU General Assembly 2025*, doi.org/pk8x). ▮

Michael Le Page

Space

The supernova from another galaxy

Kepler's Supernova may have come from outside the Milky Way – and it isn't alone

Alex Wilkins

ONE of the most famous exploding stars ever recorded by humanity may have been an invader from another galaxy, according to an analysis of its movements.

In 1604, astronomers saw a new, incredibly bright star appear in the sky, outshining any other. German astronomer Johannes Kepler, who also derived some of the first laws of planetary motion, observed it for a year to track its brightness as it faded, and the star was later named after him.

Astronomers later realised that the sudden brightness and subsequent dimming meant Kepler's Star must have been a supernova – the explosion of a dying star. In the 1970s, they found that the explosion's leftover bubble of expanding gas – the supernova remnant – was moving away from the galactic centre of the Milky Way at high speed. "It was known for a few decades that it has this peculiar motion," says Ping Zhou at Nanjing University in China. "It's escaping the galaxy and it's moving towards us at a high speed."

Now, Zhou and her colleagues have reanalysed Kepler's Star's movements and concluded it is likely it came from another galaxy, making it the first example of what they call an alien supernova.

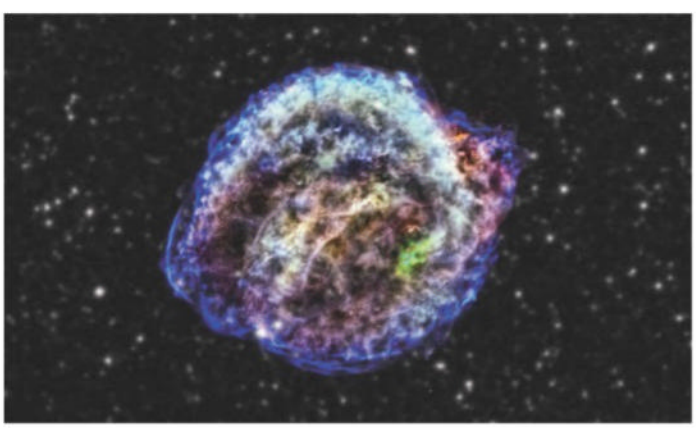
Zhou and her team first reconstructed Kepler's Star's motion using past measurements of the gas in its remnant. They then compared this with its neighbouring stars' movements, using data from the Gaia space telescope, which tracks billions of stars across the Milky Way. They found that Kepler's Star would have been moving much more quickly and in a different direction of the sky than its neighbours, which are all likely to have had a similar origin to each other, implying that Kepler's Star came from a smaller satellite galaxy that merged with the Milky Way, says Zhou.

They also calculated how often these alien supernovae might happen, based on how many smaller galaxies the Milky Way has gobbled up and the rate at which their stars form. They found there should be a few alien supernovae every 60,000 years, which corresponds to around 1 per cent of the supernovae we see in the Milky Way (arXiv, doi.org/pk86).

"The idea that some supernovae in our galaxy should come from stars that belonged to satellite dwarf galaxies that had been swallowed by the Milky Way is sound," says Or Graur at the University of Portsmouth in the UK.

The rate of alien supernovae also makes sense, but whether Kepler's Star itself is one of these is less convincing, says Graur, because the authors relied on older measurements of it from the 1970s and 1990s. "You can see the huge difference in precision that comes from switching from the 1970s measurements to the ones from the 1990s," says Graur.

"We should not assume that the old data is wrong," says Zhou. "They are measured with larger uncertainty, but this is still relevant. At only 400 years old, it is evolving very quickly. If there is any historic data of it, it is still very valuable." ▮



NASA/CXC/NCSU/M.BURKEY ET AL.

The remnant of Kepler's Supernova, which was first seen in 1604

Health

Parkinson's could be detected by listening to someone's voice

AN AI-based approach to screening for Parkinson's disease via a person's voice could identify the condition earlier than current methods.

Parkinson's is characterised by the proliferation of a misfolded form of a protein called alpha-synuclein. It has been suggested that tests could look for clumps of this protein in spinal fluid or in skin biopsies.

Looking for a low-cost, non-invasive alternative to this, Aniruth Ananthanarayanan at the University of North Texas and his colleagues collected 195 voice recordings from 31 people, 23 of whom had been diagnosed with Parkinson's. Some of the recordings were then used to train four AI models to detect the condition, based on vocal features such as hoarseness and an irregular pitch.

Up to 90 per cent of people with Parkinson's disease develop dysarthria, defined as difficulty speaking because the muscles used for speech are weak, says Christopher Bishop at Binghamton University in New York state, who wasn't involved in the study.

After the models were trained, different voice recordings from the participants were used to validate them. When put to the test on the remaining recordings, the models demonstrated more than 90 per cent accuracy at identifying people with Parkinson's disease (medRxiv, doi.org/pmhb).

Dysarthria seems to be caused by damage to separate neural pathways than those that can affect movement, and this damage can arise earlier in Parkinson's progression, says Bishop, which makes such vocal changes "an intriguing early marker for Parkinson's disease".

This voice-based approach "shows real promise", says Aiden Arnold at Rune Labs, a software and data analytics company for precision neurology in California. But he cautions that the dataset used in this study was small, so further work is needed before it can be used as a standard diagnostic. ▮

Clarissa Brincat

90%

The accuracy with which AI models could identify Parkinson's disease

Health

Migraine drug eases early symptoms like dizziness

Chris Simms

A DRUG called ubrogepant, which is already used to treat migraines, has been found to reduce the non-headache symptoms that precede a migraine itself – making it the first medicine known to work on these symptoms.

Before the debilitating headache of a migraine hits, many people experience a prodrome phase where they get warning signs, such as sensitivity to light or sound, dizziness and neck stiffness. So far, no therapies have been effective at alleviating these early symptoms.

But ubrogepant has shown promise in stopping migraine headaches if taken when early symptoms strike, prompting Peter Goadsby at King's College London and his colleagues to look at whether it can dispel these, too.

They ran a study with 438 people, aged between 18 and 75, who had a history of migraines. Half took a 100-milligram dose of ubrogepant when they felt symptoms suggesting a migraine headache was on its way, while the other half unknowingly took a placebo. Then, the next time prodromal symptoms hit, the participants took the opposite pill.

After taking ubrogepant, they self-reported improvements in their ability to concentrate an hour later, as well as reduced sensitivity to light 2 hours later, and less fatigue and neck pain after 3 hours, compared with when they were taking the placebo. Participants reported that dizziness and sensitivity to sound also lessened when they took ubrogepant (*Nature Medicine*, DOI: 10.1038/s41591-025-03679-7).

"Given that common prodromal symptoms are often functionally disabling, the potential to intervene earlier in the migraine cascade is clinically meaningful," says Parisa Gazerani at Oslo Metropolitan University in Norway. ▮

Archaeology

How ancient humans survived a global climate catastrophe

Christa Lesté-Lasserre

ESTEBAN DE ARMAS/ALAMY

Cold snaps forced ancient communities to adapt quickly

ROUGHLY 4000 years after the last glacial period, hunter-gatherers faced another bout of sudden climate change that forced them to rapidly adapt to a much colder world.

While not as frigid or long-lasting as the final stages of the last glacial period, which ended about 11,700 years ago, the cooling event 8200 years ago still caused temperatures to plummet by as much as 6°C (10.8°F) within decades. At the same time, a land mass the size of Scotland broke away from the Norwegian continental shelf, triggering the powerful Storegga tsunami, which delivered the final blow to Britain's separation from Europe.

Through it all, people across the northern hemisphere survived, some by packing up and moving, others by sticking it out, says Rick Schulting at the University of Oxford. "These people weren't passive victims, they adapted quickly."

Scientists have already studied how the 8.2 ka event affected people across the northern hemisphere, but most of this research has been regional. To take a broader view, Schulting and his colleagues compared archaeological and environmental records between north-western Europe and southern Siberia.

The archaeological records included large hunter-gatherer cemeteries and nearly 300 radiocarbon-dated human and animal remains from the Baikal region in south-east Siberia alone. They combined this with high-resolution environmental records, such as pollen and charcoal preserved in lake sediments, which reveal past shifts in vegetation, climate and fire activity with decade-level precision.

> "In the same way as 8200 years ago, humans today will need to find ways to adapt"

The results show that people adapted to the 8.2 ka cold snap in markedly different ways. In Norway's Oslo fjord, for example, the number of settlements increased. This suggests that coastal communities may have thrived by eating fish, seals and shellfish, which remained stable as the climate turned.

Likewise, at Lake Baikal, similar aquatic resources may have buffered local populations – so well, in fact, that archaeologists have found almost no trace of a human response to the 8.2 ka event.

But around Lake Onega in north-west Russia, there was a surge in cemetery use that wasn't linked to premature deaths or mass mortality, which suggests that local hunter-gatherers clustered here during the chill, probably drawn by reliable supplies of fish and elk. Meanwhile, on the west coast of Scotland, people appeared to step away from their coastal fishing lifestyle, possibly retreating inland to ride out the cold (*Quaternary Environments and Humans*, doi.org/pmg8).

The 8.2 ka event offers an important "worst-case scenario" model for understanding abrupt climate shifts and demonstrating how global warming can change ocean currents and lead to major cold snaps, says Mikael Manninen at the University of Helsinki in Finland.

A collapse of the Gulf Stream today could lead to a similar outcome, he says. "In the same way as 8200 years ago, humans today will also need to find ways to adapt to the resulting crisis."

Philippe Crombé at Ghent University in Belgium finds the team's region-to-region comparisons "especially valuable", both historically and for today. "We know from modern climate change that environmental impacts vary dramatically from one region to another," he says. "This study makes it clear the same was true in the past." ▮

Health

China sees a drastic rise in dementia cases

Grace Wade

CREDIT

People with dementia often need help from healthcare workers

DEMENTIA rates have been found to be increasing more rapidly in China than almost anywhere in the world.

Daoying Geng at Fudan University in China and her colleagues analysed dementia rates in 204 countries and regions around the world between 1990 and 2021. They used a World Health Organization database to collect information on dementia deaths and cases in people aged 40 and older, focusing on Alzheimer's disease and some other forms of dementia, such as vascular dementia and frontotemporal lobe dementia.

The researchers found that the number of people with dementia worldwide more than doubled during this period, from almost 22 million in 1990 to close to 57 million in 2021. The increase was even more drastic in China, where cases more than quadrupled, rising from roughly 4 million to nearly 17 million over the same time frame (*PLoS One*, doi.org/pk8b).

Further analysis revealed that population growth was the main culprit. Birth rates in China spiked in the 1950s. "So those people are getting older today – they are now in their 70s, which is the highest risk group for dementia," says Xi Chen at Yale University, who wasn't involved with the study.

The team identified three other major factors. The first, smoking, almost exclusively affects men, as only 2 per cent of women in China smoke cigarettes while roughly half of men do. This is in sharp contrast to wealthier countries such as the US and the UK, where smoking rates have steadily declined, says Chen.

One Western trend that China has echoed is a jump in rates of diabetes and obesity, particularly in the past few decades, both of which are risk factors for dementia. This is probably because people in China are adopting a more Western diet high in fats and calories, says Chen.

He predicts dementia rates in China will eventually resemble those in the US or UK, as younger generations tend to smoke less than older ones. But it will have a huge impact in the meantime.

"Dementia is one of the most expensive diseases in the world. It requires a lot of caregiving and treatment," says Chen. ▮

Geology

Hydrogen may be hiding in mountains

Michael Le Page

MOUNTAIN ranges could be a potential source of clean energy in the form of as-yet untapped hydrogen. While previous research has suggested this "geologic" hydrogen could be found underground, researchers have only recently turned to mountains as a possible store.

"Certain minerals react with water and can generate hydrogen like a free green energy source," says Frank Zwaan at the Helmholtz Centre for Geosciences in Germany.

There are vast amounts of such minerals on Earth, but they are mainly found deep below the surface in a layer known as the mantle, where they don't come into contact with water. But during the formation and uplift of mountain ranges, some mantle rock can be brought close to the surface, where it can react with water in a process called serpentinisation.

To get an idea of the potential for hydrogen formation, Zwaan and his colleagues modelled the uplift process, looking at how much mantle material reaches areas where there are optimum temperatures and enough circulating water for this to occur. Their results support the idea that large quantities of hydrogen could be generated under mountain ranges (EGU General Assembly 2025, doi.org/pk75).

"Certain minerals react with water and can generate hydrogen like a free green energy source"

Serpentinisation also occurs at mid-ocean ridges – some think it drove the origin of life – but hydrogen formed there is unlikely to be trapped, says Zwaan. That is because the temperature is lower than 122°C (252°F), and any trapped hydrogen will be "eaten" by bacteria, but under mountains it is possible to drill down to where the temperature is higher.

"Nothing wants to live there, so it's perfect for the hydrogen to be preserved," Zwaan told a meeting of the European Geosciences Union in Vienna last month. "And there might even be another option, to drill into what you can call the hydrogen kitchen – the area where the hydrogen is generated."

The model results are supported by early findings from studies of some mountain ranges. For instance, Gianreto Manatschal at the University of Strasbourg, France, has confirmed there is hydrogen production under the Grisons area of the Alps in Switzerland. But how much there is remains to be seen, he told the meeting. "Our research is just at the very beginning," he said.

There is also hydrogen seeping up from below the northern Pyrenees, reported Alexandra Robert at the University of Toulouse, France. This research, too, is at an early stage. ▮

The Grisons, in Switzerland, could be a source of hydrogen

WESTEND61 GMBH/ALAMY

Zoology

Tiny frog, big discovery

Beautiful poison dart frog is a species new to science

Chris Simms

RESPLENDENT with its blue stripes and golden legs, this newly described poison dart frog is about the size of a thumbnail, measuring 14 to 17 millimetres from the tip of its snout to its derrière, or cloaca.

Esteban Koch at the National Institute of Amazonian Research in Manaus, Brazil, and his colleagues found the frog in the forests of the Juruá river basin in Brazil in 2023 and went back to look for further specimens in 2024. The team has now officially described it and named the species *Ranitomeya aetherea* (*PLOS One*, DOI: 10.1371/journal.pone.0321748).

The researchers don't know how big the population of the frogs is, so can't tell if it is endangered, but in the year between the two surveys, there had been deforestation in the area. "As the frog is really specific to [one] plant in this area, any small disturbance could be dangerous to the species," says Koch.

ALEXANDER TAMANINI MÔNICO

Climate change

Europe under threat from giant hailstones

HAILSTONES the size of golfballs are increasingly raining down on Europe as the climate warms, causing expensive damage to cars and buildings.

Very large hail, which is classified as hailstones that measure 5 centimetres or more in diameter, is one of the most costly forms of extreme weather. "Some of the largest loss events, in excess of $1 billion, have been associated with hailstorms that have this type of very large hail," says Brian Tang at the University of Albany in New York state.

Such hail is triggered by severe thunderstorms and is most commonly experienced in the Great Plains of the US and in South America. But as the climate warms, new parts of the world are becoming vulnerable.

To investigate, Francesco Battaglioli at the European Severe Storms Laboratory (ESSL) in Germany and his colleagues used a statistical model to generate a global database of very large hail events from 1950 to 2023.

They found that the frequency of such events has generally decreased in the southern hemisphere and increased in the northern hemisphere. Mendoza in Argentina, for example, which has previously been a very large hail hotspot, has experienced below-average numbers of these events since 2006, with the exception of 2015 and 2016.

In Europe, by contrast, the frequency of very large hail events has increased significantly in recent years (*Research Square*, doi.org/pk77). Northern Italy has endured the largest global increase, with a record number of hail reports in Italy between 2021 and 2023. In July 2023, a hailstone with a diameter of 19 cm was recorded in the town of Azzano Decimo in northern Italy, close to the global world record for the largest hailstone diameter of 20.3 cm, which was recorded in South Dakota in 2010.

19 cm

The diameter of a hailstone that fell on Italy in July 2023

Tang, who wasn't involved in the ESSL's work, warns that changes to Europe's climate, including more severe storms that hold more water, are likely to be driving the increasing trend for very large hail across the continent.

Even a small increase could cause a sharp uptick in damages, without the introduction of protective measures such as parking cars in garages or using more resilient building materials. Such measures can "make a massive difference" to how vulnerable a city is to large hailstones, says Tang.

Madeleine Cuff

Health

A mindful approach to chronic pain

People have reported less pain after taking part in a therapy focused on emotional regulation

Stephani Sutherland

LEARNING how to regulate negative emotions like anxiety could ease chronic pain. Scientists have found that a form of therapy that partly focuses on tolerating distress relieved ongoing discomfort more effectively than existing treatments.

"Chronic pain is more than a sensory experience; it's incredibly emotional," says Nell Norman-Nott at the University of New South Wales, Australia. "We see increased levels of anxiety and depression in up to about 80 per cent of people with chronic pain."

"At any given pain intensity, if you had better emotional regulation, people's overall lives would be better"

This leads to a "vicious cycle", where pre-existing pain amplifies negative emotions, which then worsen pain, she says.

To see if they could break the cycle, Norman-Nott and her colleagues used a programme based on dialectical behavioural therapy, a form of cognitive behavioural therapy that has been adapted for people who feel emotions very intensely. The programme focused on mindfulness, emotion regulation and distress tolerance.

Eighty-nine people with chronic pain, lasting 16 years on average, were randomised to receive either the programme, delivered by a therapist via an eight-week online course, while continuing with any treatments they were already receiving, such as medication or physiotherapy, or to just continue with their usual treatment.

Nine weeks later, those in the therapy group experienced an improvement in emotional regulation of about 5 points more, on a scale of 18 to 90, than those in the control group.

IAN STAUFFER/UNSPLASH

Mindfulness could help those experiencing chronic pain

The intensity of their pain also started to lessen at week 9, and by 21 weeks they experienced significantly less pain than those in the control group (*JAMA Network Open*, doi.org/g9hmvs).

"I think that's interesting and promising," says Benedict Alter at the University of Pittsburgh, Pennsylvania. It could also help people with limited access to in-person care, he says.

"It's great that they did this as internet-based. It's a huge problem that there are small numbers of providers who do therapy, and they tend to be in urban areas."

Exactly how the therapy reduces pain is unclear, says Alter, but "at any given pain intensity, if you had better emotional regulation, people's overall lives would be better: less suffering, less functional impairment. I think pain intensity decreases as everything gets better."

The mechanism could be teased out in larger studies, he says. ▮

Zoology

Chimps and humans share a sense of rhythm

MUSICALITY may have emerged in a common ancestor of chimps and humans, as both species share similarities in how they drum.

Catherine Hobaiter at the University of St Andrews, UK, and her colleagues examined 371 examples of drumming from two of Africa's four chimpanzee subspecies: the western chimpanzee (*Pan troglodytes verus*) and the eastern chimpanzee (*Pan troglodytes schweinfurthii*).

They use their hands and feet to produce rapid-fire drumming, often on buttress roots, when resting, travelling or making threat displays.

The researchers found that chimps drum much faster than most humans (*Current Biology*, DOI: 10.1016/j.cub.2025.04.019). "The longest drum we recorded was over 5 seconds, while the shortest was less than 0.1 seconds," says Hobaiter.

CYRIL RUOSO/NATUREPL.COM

The way chimpanzees drum could tell us where our musicality came from

Despite these differences, chimps show some of the "core building blocks of human musical rhythm", says team member Vesta Eleuteri at the University of Vienna, Austria. "They drum with rhythm, as opposed to randomly, and they use a typical rhythm observed across musical cultures called isochrony, consisting of hits that are regularly spaced, like the ticking of a clock," she says. The team also found the two subspecies drummed with different rhythms.

Miguel Llorente at the University of Girona in Spain says the idea that different subspecies show distinct drumming styles is fascinating. "It opens the door to thinking about these patterns not just as individual quirks, but potentially as cultural differences in how groups use drumming as a communicative tool."

"We don't mean that chimpanzee drumming shows the sophistication of modern human musical rhythms," says Hobaiter. "But this is the first time that we've been able to show that they share the same rhythmic building blocks, making it likely that rhythm was a part of our social world long before we became human."

"Until recently, it was argued that rhythmicity was unique to humans," says Gisela Kaplan at the University of New England, Australia. "We now have plenty of evidence that this is not the case." ▮

James Woodford

Geology

Major cities across the US are sinking at a rapid rate

James Woodford

SEAN PAVONE/ALAMY

Dallas has one of the highest subsidence rates of major US cities

MORE than two dozen of the biggest cities in the US are subsiding, which could affect millions of people.

The problem has been reported before, particularly in coastal areas. But by using satellite technology, which sends radar signals towards Earth's surface and measures the time it takes for them to bounce back, scientists have found it affects 25 of the country's 28 biggest cities.

"By comparing multiple images taken over time from the same area, we can detect tiny vertical movements of the ground, down to a few millimetres per year," says team member Manoochehr Shirzaei at Virginia Tech.

Fort Worth, Houston and Dallas, all in Texas, exhibited the highest subsidence rates, exceeding 4 millimetres per year on average. For New York, Chicago, Columbus, Seattle and Denver, the average subsidence was greater than 2 millimetres per year (*Nature Cities*, doi.org/pk5p).

The researchers say that most of the subsidence is caused by groundwater extraction, however, in some cities, such as New York and Washington DC, the sinking is primarily caused by "glacial isostatic adjustment".

"During the last ice age, these areas were covered by massive ice sheets. The sheer weight of the ice pushed down on Earth's crust, like sitting on a memory foam mattress," says Shirzaei. When the ice melted thousands of years ago, the pressure lifted, and the ground began to slowly rebound, he says.

"But this rebound isn't uniform," says Shirzaei. "In some areas, like the US East Coast and Midwest, the land is still sinking rather than rising, because they're near the forebulge, a zone that had been pushed up by the weight of the ice nearby and is now collapsing."

In Seattle, Portland and San Francisco, plate tectonics is probably to blame.

Jesse Kearse at Kyoto University, Japan, has used similar satellite data to show that many New Zealand cities are also subsiding. "A key challenge that remains for the geophysics community is how to attribute the observed trends to specific causes," he says. ▮

Quantum computing

Fighting quantum with quantum

Matthew Sparkes

A "USELESS" algorithm that serves as a benchmark for demonstrating the power of quantum computers over ordinary devices could potentially be repurposed as a way to keep data secure from, ironically, quantum computers.

Quantum computers have long threatened to crack existing encryption algorithms, which rely on problems that are difficult for classical computers to solve, such as finding the prime factors of a large number.

A sufficiently big quantum computer could do this, but Bill Fefferman at the University of Chicago, and his colleagues say the devices could also offer a solution.

Their idea is based on determining the output of a random quantum circuit executed on a quantum computer. Such an output is easy to check if you know what the circuit looks like, but figuring out the shape of the circuit from the output alone is very difficult.

This random circuit sampling (RCS) algorithm is already used as a kind of benchmark for quantum computers, to identify the point at which they achieve quantum advantage – where a quantum computer becomes able to do something that no classical computer can.

"Quantum computers have long threatened to crack existing encryption algorithms"

Because it was thought that this algorithm had no particularly useful purpose, such efforts have been criticised as somewhat pointless, so finding an application in encryption would be rather handy.

There is just one problem: claims of quantum advantage have often been rebuffed at a later date when it turned out classical computers could solve RCS after all, meaning the problem may not be hard enough to be used in cryptography.

The first claim of quantum advantage came from Google in 2019, when the company said its Sycamore quantum computer could perform calculations that would take even the world's most powerful classical supercomputer 10,000 years to complete. This was swiftly refuted, twice, by different groups working on classical machines.

Back and forth

Fefferman says the jury is still out on whether RCS is a genuinely hard problem, but this is also true of current encryption methods. Cryptography builds confidence over time by showing that despite the large incentives – being able to siphon off secrets and money on a grand scale – nobody has yet found a way to crack encryption schemes, he says.

"I totally expect that there will be some back and forth in the community about new quantum algorithms that can learn some class of quantum circuits," says Fefferman.

Those classes would then be excluded from the possible circuits chosen by the algorithm, he says.

"As soon as we have some ensemble that is difficult to learn, we can use that for cryptography."

Dustin Moody at the US National Institute of Standards and Technology (NIST) says the proposed encryption method "looks like a very cool application", but it isn't necessarily practical today given the current computational capabilities of quantum computers. ▮

Health

Shingles vaccine could also boost your heart health

Christa Lesté-Lasserre

VACCINATION against herpes zoster, which is better known as shingles, not only helps to prevent this painful infection; it also curbs the risk of cardiovascular problems.

A new observational study of more than a million people shows that those who had one dose of the shingles vaccine Zostavax were 26 per cent less likely to die from heart disease or have a stroke, heart attack or heart failure compared with those who were unvaccinated, says Sooji Lee at Kyung Hee University in South Korea.

Shingles occurs when the varicella-zoster virus, which causes chickenpox and then stays in the body after symptoms clear up, becomes reactivated. This can happen when the immune system is weakened, such as during chemotherapy or periods of stress. Shingles causes a painful rash, which can sometimes get infected or leave a scar.

Although cardiovascular events aren't typically listed as complications of shingles, scientists now know that it is linked to a roughly 30 per cent greater risk of stroke and a 10 per cent greater risk of heart attack, especially within a year of having it.

Lee and her colleagues gathered data on 1,271,922 people aged 50 or over, collected between 2012 and 2024 by national health registries in South Korea. The researchers determined whether each person had Zostavax and checked for later development of any of 18 types of cardiovascular disease, such as heart failure, stroke, thrombosis, arrhythmias and ischaemia. The team also investigated other health-related factors like age, sex, socioeconomic status, exercise levels and social habits.

AMY KATZ/ZUMA PRESS WIRE/ALAMY

Shingles is caused by the same virus as chickenpox

Over an average follow-up period of six years, the risk of cardiovascular events after vaccination was 23 per cent lower compared with that for unvaccinated people, says Lee.

Risk reduction was even greater in men – with a 27 per cent drop compared with 20 per cent for women. The same was true in people younger than 60, who had a 27 per cent decreased risk compared with 16 per cent in older people.

26%

How much less likely vaccinated people were to have heart failure

For specific cardiovascular events, vaccinated people were 26 per cent less likely to have a stroke, heart attack or heart failure, and they were also 26 per cent less likely to die from heart disease. The risk of coronary artery disease, meanwhile, dropped 22 per cent (*European Heart Journal*, doi.org/g9hhgq).

Benefits were most notable two to three years after vaccination, then gradually fell over the next five years.

The study "strengthens our confidence" that shingles vaccinations cut cardiovascular risks, probably by curbing the vascular inflammation caused by the zoster virus, says Galen Foulke at the Pennsylvania State University.

"Zoster itself has high morbidity from pain and post-herpetic neuralgia – a painful condition that can last years after shingles eruption," he says. "But health systems around the world could find enormous healthcare savings through reduction of cardiovascular morbidity by investing in the relatively inexpensive zoster vaccine."

Although more research is needed, the scientists suspect that the vaccine helps reduce cardiovascular risks indirectly because it prevents shingles, which can damage blood vessels and provoke clot formation and inflammation, says Lee. ▮

Environment

Almost all of the deep seabed remains unexplored

Madeleine Cuff

THE first comprehensive analysis of deep-sea dives has revealed that humans have only directly observed a tiny fraction – less than 0.001 per cent – of the global deep seabed, leaving the vast majority of our planet unexplored.

Oceans make up 71 per cent of Earth's total surface area, and around 93 per cent of that region is deep seabed – more than 200 metres deep. While much of this ocean area has been mapped using satellites and ship-mounted sonar, very little has been directly observed.

Katherine Bell at US non-profit group Ocean Discovery League and her colleagues have analysed 43,681 records of deep-submergence activities since the 1950s to assess how much of the deep seabed has been directly studied.

The team estimates that between 2130 and 3823 square kilometres of seabed have been directly observed, an area roughly the same size as Rhode Island. That leaves 99.999 per cent of it unobserved (*Science Advances*, doi.org/pk39). "It really shows how little we know and how much there is still to understand," says Bell.

The team also found that in 67 years of deep-sea dives, less than 20 per cent occurred in the high seas, otherwise known as international waters. Instead, deep-sea observations are dominated by exploration within the waters of the US, Japan and New Zealand, accounting for 71 per cent of all dives. Bell says this is the equivalent of entire continents being left unexplored.

"If you have only explored the land of, say, North America, Japan and New Zealand, how can you really know what is in the savannahs of Africa or the forests of South-East Asia," says Bell. ▮

Quantum physics

How deep are quantum relationships?

Measuring the strength of links between quantum objects places limits on reality

Karmela Padavic-Callaghan

THE strange connections between quantum objects are the strongest relationships physicists can detect, and the mathematics of graphs may help explain why that is.

"We are touching the question of, in some way, why quantum theory is as it is," says Carlos Vieira at the State University of Campinas in Brazil. Together with José Nogueira and Marcelo Terra Cunha, also at the State University of Campinas, he has now offered one mathematically compelling answer to that question.

Quantum objects can be connected, or correlated, so strongly that measuring the properties of one can reveal those of another – even when the objects are incredibly far apart. The most famous example of this is quantum entanglement. Classical objects can also be correlated, but the connection is never as strong as in the quantum realm.

Although quantum correlations sound mysterious, they operate within set limits. For example, when the connection between objects becomes weak enough, the correlation crosses into classical behaviour. And though the connection between quantum objects can also be much stronger, even that strength reaches a maximum value.

> "We are touching the question of, in some way, why quantum theory is as it is"

The researchers wanted to understand whether there is a physical law or principle that could account for this. Answering this question would also explain why correlations stronger than quantum ones have never been recorded in the lab, says Nogueira.

He and his colleagues found that answer in the exclusivity principle, an idea that explores how to measure the properties of a collection of quantum objects. The exclusivity principle shows that, if it isn't possible to simultaneously measure the properties of a pair of quantum objects within that larger collection, then it will also be impossible to measure those same properties of the whole collection all at once.

The team combined this principle with the mathematics of "exclusive graphs", which show the relationships between different measurements of a set of quantum objects. Analysing the similarities between many such graphs led them to a rigorous proof showing that the exclusivity principle can explain why quantum correlations behave the way they do. The results will be published in *Physical Review A*.

"If the statistical observations predicted by quantum mechanics are all realised – and assuming one additional physical axiom, the exclusivity principle – then all statistical observations occurring in nature are explained by quantum mechanics," says Andreas Winter at the Autonomous University of Barcelona in Spain. The finding builds on work from 2014, which Winter says was a breakthrough.

"This is really a brutal result," says Adán Cabello at the University of Seville in Spain, who was part of the 2014 research team along with Terra Cunha. "Quantum mechanics produces a very specific, detailed set of signatures. If you find a way to reproduce that, you are touching the bones of the theory, you are understanding how nature works to produce that."

Cabello and his colleagues have done some preliminary experiments related to the exclusivity principle in the past, but he says that future experiments may make this explanation more mainstream. ▮

Ornithology

The birds upending our idea of shared parenting

THEY say it takes a village to raise a child; for some birds, it is no different. Superb starlings not only help raise other starlings' chicks, but they also switch between the roles of "parent" and "nanny" multiple times throughout their lives.

Scientists have long debated whether animals other than humans are capable of reciprocity – the tendency to help individuals in the hope they will help you down the road in turn.

Recent research has uncovered that animals such as elephants, orcas and some primates care for the young of others.

By analysing 20 years of data from a breeding site of African superb starlings (*Lamprotornis superbus*) in Kenya, researchers found the birds also display this complex social behaviour.

Up to 16 "helper" birds would assist a given set of parents in rearing their chicks. While the birds showed some preference for helping those they were genetically related to, they would readily give aid to – and accept help from – non-kin group members (*Nature*, doi.org/pk3h).

This finding undercuts the assumption that only closely related individuals act altruistically towards one another when rearing young.

What was especially unusual was that the breeding pair would often switch to a helper role during the next reproductive season. In species where animals act as "nannies" to others, they are typically younger individuals that stand to benefit from the experience before graduating to parenthood.

ALBERT SCHWEITZER/ALAMY

Superb starlings care for other birds' chicks as well as their own

Here, even seasoned bird parents take turns as helpers.

"These benefits are likely to combine and interact in fascinating ways that we don't yet fully understand," says Gerry Carter at Princeton University.

The authors say the discovery wouldn't have been possible with a short-term study, because the pattern emerged only over many years of observation.

Around 10 per cent of all bird species breed cooperatively, and long-term studies may reveal reciprocal relationships in these groups as well, says Carter. ▮

Joanna Thompson

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Views

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Comment

Spotting a murderer

There are serious issues with new proposals to use artificial intelligence to predict future crimes, says **Yu Xiong**

THE UK government's proposed AI-powered crime prediction tool, designed to flag individuals deemed "high risk" for future violence based on personal data like mental health history and addiction, marks a provocative new frontier.

Elsewhere, Argentina's new Artifical Intelligence Unit for Security intends to use machine learning for crime prediction and real-time surveillance. In Canada, police forces in cities like Toronto and Vancouver use predictive policing and tools like Clearview AI facial recognition. And in some US cities, AI facial recognition is paired with street surveillance to track suspects.

The promise of anticipating violence *Minority Report*-style is compelling. But any apparent utopia comes with substantial risks. Such technologies can easily be misapplied, especially when human complexity is reduced to data points. This shift towards prediction echoes the logic behind Prevent, a pillar of the UK's counterterrorism strategy, which drew criticism for promoting Islamophobia, turning teachers, doctors and social workers into de facto informants, and eroding public trust in public institutions.

We now risk repeating those failures – this time with machine learning's illusion of neutrality. Algorithms are only as fair as the data they are built on. In UK policing, structural racism, misogyny and homophobia are well documented. Embedding those biases into code doesn't fix the problem; it hardwires injustice into decision-making.

SIMONE ROTELLA

Religious and civil society leaders have warned that AI could revive and scale the same kind of profiling that made Prevent so controversial. Mohammad Al-Issa, secretary-general of the Muslim World League, has cautioned that unregulated AI could generate fake religious content and manipulate belief systems to fuel division and extremism.

His concerns, grounded in efforts to counter religious hate crimes and the digital recruitment tactics of groups like the Islamic State, reflect a growing consensus: AI is not neutral in its impact on belief. If misused, it can deepen mistrust and undermine the social fabric that prevention policies are meant to protect.

The idea of early intervention isn't inherently wrong. AI could support a more humane, proactive approach to justice. Tools to analyse behaviour patterns might help identify people before they resort to violence, connecting them with mental health support.

Police and probation officers could more efficiently allocate resources to the most urgent cases. Algorithms might also help reduce some forms of subjective bias, offering greater consistency in how cases are assessed.

But we must be honest about the dangers of "black box" algorithms and the need for these systems to have rigorous oversight. False positives remain a critical risk. An individual could face stigma, scrutiny or police intervention without ever having committed a crime.

The danger of mission creep is also real. Just as with Prevent, an AI tool built for serious crime prevention could gradually expand to monitor a wider range of people or beliefs – especially those already over-policed and low on trust in the justice system.

As chair of the advisory board to the UK's All-Party Parliamentary Group on the Metaverse and Web 3.0, I've seen how quickly technology outpaces ethics. Yet I remain hopeful that AI can reduce harm – not just respond to it – if we get the design, deployment and oversight right. If we have learned anything from past missteps, it's that true security begins with trust – not surveillance. Prevention means investing in people: in mental health, education and communities. AI can help scale those solutions. But we must always ask not just what it can do, but whether it should. ▮

Professor Yu Xiong is associate vice president of the University of Surrey, UK

Field notes from space-time

Conflict resolution

The discovery of the cosmic acceleration problem inspired me as a teenage physics nerd. News about dark energy is just as incredible, says **Chanda Prescod-Weinstein**

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

Chanda's week

What I'm reading
I am getting into Sex is a Spectrum: The biological limits of the binary *by Agustin Fuentes.*

What I'm watching
I have seen the film Sinners *three times now – one of the greatest movies ever made.*

What I'm working on
Trying to save US science while onboarding a new PhD student, to ensure she has a future in it.

This column appears monthly. Up next week: Graham Lawton

IN 1998, astronomers made a startling announcement. Space-time, the unified phenomenon that comprises our universe and that was previously understood to be expanding, was actually not just growing, but growing faster and faster as time went on. In other words, its expansion was accelerating. This was the birth of the cosmic acceleration problem: what was causing this acceleration? It seemed to be literally coming from nowhere – from the vacuum.

From the point of view of general relativity, cosmic acceleration could be explained by saying that empty space-time has energy that drives this expansion, that it isn't completely empty. This energy is called the cosmological constant. Happily, from the point of view of quantum mechanics, empty space-time always has an energy associated with it, which seems to offer a source for the cosmological constant. Quantum vacuum energy can be calculated.

But there is a mismatch: the number we get when quantum physics is taken into account is astronomical compared with the number that explains things from the astrophysics point of view of relativity. In other words, cosmic acceleration suggests there is a vacuum energy, but the value for this that we get from astrophysical observation doesn't match the figure from quantum theory.

Cosmic acceleration was such an exciting discovery that I wrote about it in my university applications, including one to the California Institute of Technology. For this, I cut out part of a *Scientific American* article about the discovery and glued it into my submission. Below it I wrote: "I'm going to solve this problem."

Twenty-seven years later, the problem isn't solved, but I don't even work on cosmic acceleration! Not anymore, anyway. In 2010, I defended my PhD dissertation, *Cosmic Acceleration as Quantum Gravity Phenomenology*. My premise was that the mismatch between the apparent observed value of the cosmological constant and our calculations was our first experimental hint about the nature of quantum gravity.

You might recall that quantum gravity is a hypothetical theory that merges quantum physics with general relativity. These two very different frameworks for reality are our most fundamental theories. But they don't work well together.

"My younger self is vindicated. Cosmic acceleration may indeed be a quantum gravity phenomenon!"

In general relativity, space-time is a smooth, continuous phenomenon. In quantum physics, almost nothing is smooth and continuous, but involves individual units that we call quanta. It is like the difference between your favourite quilt and an object made of individual Lego bricks.

There are other differences: in general relativity, given certain information about a system, we can definitively calculate its past and future. In quantum physics, we can only speak of probabilities for the system. This is one reason the quantum vacuum is expected to have an energy – probability means particles are constantly appearing and disappearing, so it is never really empty.

My PhD research proposed that the reason for conflict between the astrophysically observed vacuum energy and the one predicted by quantum theory is that we were getting a first hint about the need to modify how we calculate the quantum vacuum energy. I believed in this deeply, but at the time we weren't getting much data to help test the model. I was also interested in the idea the energy was dynamic and changing in time (in this form, it is called dark energy), but it would be a long time before this could really be tested.

Just months ago, the Dark Energy Spectroscopic Instrument (DESI) collaboration announced evidence that, in the past, the value of the cosmological constant was different than it is now. If so, it would mean cosmic acceleration truly is caused by something like a dark energy, a phenomenon changing in time.

I hope that for today's 16-year-old physics nerds, this news is as exciting as cosmic acceleration was for me. If it holds true, it will be just as significant. Because the US leadership is proposing to devastate the funding that is needed to follow up on this result, researchers here may not be able to investigate further. But I hope the rest of the world will – and maybe create opportunities for US scientists to join them.

Even as I worry about ensuring the next generation of stargazers has the opportunities that I did, I am heartened to see that my colleagues keep writing papers full of interesting ideas. After the DESI announcement, I started seeing researchers asking how the results could be explained using quantum gravity theories. Though I have moved on to other questions, my younger self is vindicated. Cosmic acceleration may indeed be a quantum gravity phenomenon! What a lesson in how science is multi-generational, requiring patience from those who work in it and the public that funds us. ▮

Discovery Tours
NewScientist

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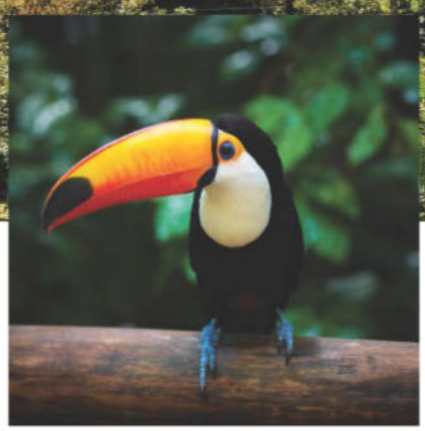

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Sleeping giants

Paul Nicklen
Photo London

WITH a full belly – look closely and you can see the tentacles of the deep-sea squid she has just feasted on, dangling from her mouth – this mother sperm whale sleeps, her calf nearby.

This photograph, named *Suspended Grace*, was taken by photographer Paul Nicklen and is one of a host of images on display this week at the photography fair Photo London. It exudes peace, but Nicklen was feeling a mix of emotions when he took it off the coast of Dominica in 2019.

"Even as my lungs burned and my brain tried to induce panic to take a breath from the surface that was 15 metres away, I had to stay calm," he says. Nicklen took a moment to settle his mind and frame the shot: "I wasn't disconnected from fear, but I was focused."

As he centred himself, a sense of "awe mixed with something quieter" came over him.

"There was a kind of joy to it – being accepted into their rhythm for even a few moments," says Nicklen. "Over time, that joy has deepened into something heavier. I think about the risks [whales] face now – the rising noise levels in the ocean, plastic, ship strikes, nets, warming seas. When I revisit these images, I see a lineage that may not survive unless we change. And still, I feel lucky. Lucky to have been let in. Lucky to carry their story."

Photo London is taking place at Somerset House until 18 May. Nicklen's work is being shown by the gallery Hilton Contemporary.

Alison Flood

Whose final frontier?

In highly politicised times, is living off-world something we should entertain, let alone do? **Christie Taylor** aims a tough lens at this futurist dream

MOVIESTORE COLLECTION LTD/ALAMY

The Martian's Mark Watney (Matt Damon): on Mars, but not by choice

Book

Out of this World and into the Next

Adriana Marais

Profile Books (UK); Pegasus Books (US)

DO YOU yearn to leave dusty footprints on the moon or prowl the rocks of Mars? Could a new life await you on future off-world colonies? Theoretical physicist Adriana Marais is convinced we are on "the brink of a new era" of humanity, where we will spread across the worlds of our solar system – and perhaps farther.

Out of this World and into the Next is Marais's attempt to share her wonder at this vision, and to sell you her dream. "Just decades since we first went to space, it won't be much longer before we're building new worlds beyond home," she writes, earnestly.

As proof, she offers the success of SpaceX's reusable rockets, nearly 25 years of human habitation on the International Space Station and the proliferation of missions to the moon and Mars in the past decade, culminating in NASA's upcoming Artemis missions to the moon and plans for the Lunar Gateway space station. She sees these as stepping stones towards tech we need for life off Earth – radiation shields, faster propulsion, long-term life support, off-world fuel production and so on.

Marais writes as a devoted would-be Martian: she applied to the Mars One contest for colonists and reached the top 100 before the organisation's bankruptcy. She reports "a sense of belonging" when considering the stars, and throughout the book romanticises exploration, stellar and earthly, as an apolitical frontier. The pages she sets aside for European colonialism and similar histories are noticeably sanitised, with references to genocide smoothed over by the passive voice. She writes that we must inhabit the stars because migration is innate to our thriving – that and the sun's eventual wrathful death make it wise to get our butts to Mars.

To drive the point home, Marais envisions an imaginary day on Mars, 10 years from now, complete with abundant, humid greenhouses, lava-tube sleeping quarters and intricate resource management systems drawn from technology she claims we are close to. She describes efficient, lower-waste fission reactors using thorium and sets out how we might terraform Mars and the moons of outer worlds using greenhouse gases. If we just apply ourselves, she says, the tech road will rise to meet us.

"Marais opines about migration as innate to our species as the US ramps up its anti-immigrant stance"

For all its rapture, I found her vision quite bleak: it's a future reliant on billionaires, with a big focus on SpaceX's Elon Musk. She posits the incentive for space investment as coming from new demands on resources caused by "international conflict, sanctions, [and] extreme weather" – that plus tourism. Meanwhile, billionaires use data centres, private jets and more to de-terraform ("pollute", to you and me) this planet. Yet Marais still hopes interplanetary societies can build on such foundations to develop altruistic economies and other utopian concepts.

It is hard to read this book as an American in 2025, as Musk's DOGE undermines grants for cancer research and hollows out state programmes my parents rely on. Meanwhile, rich musician Katy Perry gets to dip her toes above the Kármán line (the border between our atmosphere and outer space).

While Marais opines about migration as innate to our species, the US continues to ramp up its anti-immigrant stance. Space is inherently political – not just because allocation of resources is political, but because the universe's hostility puts into stark relief what is irreplaceable and endangered about Earth. A book that lauds space exploration without serious reflection on who benefits feels wholly inadequate for the zeitgeist.

If, like me, you prefer work that balances the contradictions inherent in extraterrestrial quests, I have suggestions. For the enchantment of other worlds and our effort to comprehend them, try *The Sirens of Mars* by Sarah Stewart Johnson, or Jaime Green's *The Possibility of Life*. To discover more about the origin and fate of our universe in a way that is about us, *New Scientist* columnist Chanda Prescod-Weinstein's *The Disordered Cosmos* is wonderful. And if well-researched speculation about our someday interplanetary society is more your thing, try *The Expanse* or *For All Mankind*. They're popular for good reason. ▮

Christie Taylor is a science journalist based in New York

How to make a zombie

A grisly, compelling read takes us deep into the world of parasites that hijack the minds of their hosts, finds **Sophie Bushwick**

Book

Rise of the Zombie Bugs
Mindy Weisberger
Johns Hopkins University Press

A SNAIL, eyestalks pulsing with coloured stripes, leaves the safety of the shade and oozes its way onto an exposed leaf, where it catches the beady eye of a bird. The larger animal mistakes those eyestalks for delicious caterpillars and pounces; in the process, it accidentally gobbles up the parasitic worms infesting the *Succinea putris* snail.

This poor mollusc is far from alone: worms, wasps and other creatures that manipulate their hosts' behaviour are common in the invertebrate world. In *Rise of the Zombie Bugs: The surprising science of parasitic mind-control*, science writer Mindy Weisberger examines the ways these tiny monsters hijack the bodies and brains of their victims – and how they have captured our imaginations.

Zombies are a major trope in fiction, recognised throughout Weisberger's engaging book, which is full of nods to their many guises and features quotes from zombie stories, films and TV shows to start each chapter. We can even learn a bit about real parasites from these yarns: take *The Last of Us* and its zombifying fungus; or *Alien*, whose chest-bursting "xenomorph" has a counterpart in zombifying wasps.

But real zombie species have something their fictional counterparts lack: sex appeal. Many fungus-infected insects attract mates, who inevitably leave the tryst with their own burgeoning infestation. In fact, the zombifying fungus *Entomophthora muscae* makes its victims more attractive – to the point where some experiments showed male fruit flies mating with fungus-stuffed corpses rather than living females.

In that case, writes Weisberger, the fungus releases compounds that attract would-be mates, using these signals to control not only its host, but the other insects around it. That isn't the only mechanism such parasites use, however. They also manipulate the muscles of victims, modify the hormonal signals that regulate their development and flood their brains with behaviour-modifying chemicals.

A *Succinea* snail that has been infected by a zombifying parasite

SHUTTERSTOCK/JOOSTP

Weisberger explores in great detail the experiments attempting to unravel these mechanisms. Her attention to the scientific aspects of zombification can be a positive – as a horror wimp, I was reassured when she explored if humans could ever fall victim to these zombifying mechanisms. But her narrative can be overly technical and repetitive.

Part of that is beyond her control. Despite the fact that zombie insects are everywhere – some are so common researchers can collect and study specimens from their own backyards – many of the parasites that infect them use similar tricks. Zombified insects, for example, commonly climb to unusual heights before releasing infectious material on their brethren below.

Fungus-laden ants reach the high ground by clambering up and using their jaws to grip a leaf, while infected cicadas soar overhead like "flying salt shakers of death", according to a researcher quoted by Weisberger. And while even healthy caterpillars ascend trees to eat, some virus-infected ones fail to go back down, instead melting into dripping, infectious goo. Sure, those are all grisly ways to go – but each time I read about deadly material raining out of yet another insect's corpse, it felt a little less horrible and a little more, well, normal.

For me, the real pulse-pounding action comes when Weisberger offers a glimpse of the organisms that manipulate mammals, from the rare but terrifying rabies virus to the surprisingly common *Toxoplasma gondii* protozoan, which infects at least 30 per cent of pet cats. And she touches on the ways that zombie species offer a genuinely useful window into the spread of infectious diseases.

Rise of the Zombie Bugs is a great read, but it didn't get under my skin quite as much as its author might have hoped.

New Scientist *recommends*

Alison George
Features editor
London

"Take three or four weasel testicles and half a handful of young mouse-ear [a plant] and burn it all equally in an earthenware pot..." This is no witch's potion, but a 15th-century attempt to

cure infertility, and one of many delights in **Curious Cures: Medicine in the medieval world**, an exhibition at Cambridge University Library.

It's a treasure trove of rare manuscripts, some never on show before. The well-thumbed and sometimes illustrated tomes (hand-written in middle English, Latin, French and Arabic) conjure images of a harried physician trying to cure lice or fistulas, or just dishing out advice.

Medieval medicine has a terrible reputation for bizarre remedies and wrong-headed theories, but these manuscripts show real attempts to understand disease, building on Greek and Arabic knowledge.

Even if you can't visit the exhibition (on until 6 December), the manuscripts are online as part of the library's digitisation of medieval medical recipes.

CAMBRIDGE UNIVERSITY LIBRARY

The film column

Going down singing

In a luxury survival bunker, a rich family lie to each other as Earth's surface becomes unviable. But things change when a young woman stumbles on them in *The End*, a wonderful, end-of-the-world musical drama, says **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on X @simonings

NEON

Michael Shannon, George MacKay and Tilda Swinton in *The End*

LIFE on the planet's surface has become nigh-on unbearable, but with money and resources enough, the finest feelings and highest aspirations of our culture can be perpetuated underground, albeit only for a chosen few.

In Joshua Oppenheimer's unearthly drama *The End*, Michael Shannon plays the father, an oil magnate who, years ago, brought his family to safety in an old mine. Here, he rewrites his history and that of his company in a self-serving memoir dictated to his grown-up but inexperienced son (George MacKay, whom I last encountered in sci-fi drama *The Beast*). His wife, the son's mother, played by Tilda Swinton, curates an art collection purloined from the world's great collections.

The mine (a real working salt mine in Petralia Soprana, Italy) is simultaneously a place of wonder and constriction. The family can walk out of the bunker and wander around its galleries, singing as they go (did I mention this was a musical?), but were they to hike outside the mine, I wouldn't fancy their chances.

It is a premise familiar from *Return to the Planet of the Apes* and last year's streaming hit *Fallout*. And when a rare surface-dweller (Moses Ingram) stumbles on their home, it looks as though she will be expelled – more likely killed – to keep this Shangri-La a secret. But, at the last moment, the son cries: "I don't want to do this!"

> **"Lies stand between us and despair. They create bubbles in which kindness, generosity and love can be grown"**

It turns out nobody else wants to either, not even the mother, who is the most terrified of the bunch.

Clumsily, over 2.5 hours, the family draws this young stranger into their bubble of comforting lies. Lies – this is the film's shocking premise – are necessary. Lies stand between us and despair. They create the bubbles in which kindness, generosity and love can be grown. Like the golden-age musicals of the 1950s to which it pays homage, *The End* tells an optimistic tale (details of which follow – you have been warned).

The visitor resists assimilation at first – she can't forgive herself for abandoning her family on the surface. Living as if she belonged to this new family would be to let herself off the hook.

Worn down by her honesty, the family reveals its complicity in the end of the world. The father's industry set fire to the sky. The mother finally admits she wants Earth's surface to be uninhabitable. If it isn't, the family she abandoned might be alive and suffering. Her best friend, the son's confidante (Bronagh Gallagher), who also lives in the mine, in fact sacrificed her child to ensure her own survival.

But then, bit by bit, this wounded and reconfigured family sews itself a new cocoon of lies and silences, taboos and songs (and those songs are accomplished and astonishing), all to make life not just bearable, but possible. Of course, the stranger ends up absorbed in this effort. Of course, she ends up singing along. Wouldn't you, in time?

Whoever these people used to be, and however much you point accusing fingers at their past, the fact is that they are all good people, singing their way back into the delusion that they must carry on, day after subterranean day.

True, the lies we tell today tell us tomorrow. But this unlikely, left-field musical (my early pick for the sci-fi movie of 2025) is prepared to forgive its characters. We can only get through life by lying, so is it any wonder we make mistakes? Should the worst happen, we might at least be permitted to go down singing. ▮

Film
The End
Joshua Oppenheimer
Streaming on MUBI

Simon also recommends...

Film
Aniara
Pella Kågerman and Hugo Lilja
On demand
Adapted from the epic sci-fi poem by Harry Martinson, Aniara *follows doomed starliner passengers into the void.*

Book
Slaughterhouse-Five
Kurt Vonnegut
Penguin Books
Billy Pilgrim turns injury into elegy as he relives war's horrors for a host of puzzled aliens.

Editor's pick

Getting to the bottom of the quantum world

19 April, p 28

From Bernd-Juergen Fischer, Berlin, Germany

You say there is no clear reason why the behaviour of subatomic particles can't be governed by deterministic laws, and the fact that they aren't demands an explanation.

Well, here is one: we are working our way down the chain of causality. This will either end or it won't. If it doesn't, then either the search keeps going on and on or causality becomes cyclic and causes may cause themselves. If, on the other hand, the chain of causality comes to an end, then what? The last part can't have been caused, so it must have been brought about without rhyme or reason, which is a non-scientific way to say randomly. The fact we find only probabilities in quantum theory shows that, with quantum theory, we have come to the end of the chain.

From Nick Rowden, Liverpool, UK

Could the ancient Greeks have invented quantum theory? While a full-blown version probably couldn't have been formulated much earlier than it was, all you would need to postulate a sort of quantum theory would be to assume that nothing in the real world can be infinite. This probably isn't an unreasonable assumption. After all, if infinity crops up in modern physics, it is normally taken as a sign that a theory is incorrect.

Once this assumption has been made, it is clear nothing can be known with infinite precision and some form of quantum theory is required. Perhaps the ancient Greeks could have thought of this?

From Larry Stoter, The Narth, Monmouthshire, UK

In discussing quantum computing, the comparison always made is with digital computer efficiency. Numbers between 0 and 1023 can all be encoded at once with 10 qubits, while digital computers need 10 bits just to be able to encode any one of those numbers at a time. But what about analogue computing? Just one capacitor, for example, could encode any of the numbers 0 to 1023, depending on its state of charge, arguably more efficiently than its digital counterparts.

Analogue computers have a long history and have made many important contributions in various fields. I wonder what might have been achieved if the same money and effort put into digital and quantum computing had been invested in analogue computing.

Troublesome moon dust could be tamed

26 April, p 38

From Geoff Harding, Sydney, Australia

Levitation of moon dust at lunar sunrise and sunset is surely partly down to the pyroelectric effect, which induces an electrostatic charge on particles when warmed or cooled that then causes repulsive forces and floating dust. This can potentially coat scientific instruments. A possible means of suppression may be to seed the local area with electrically conducting aluminium particles.

The power of forests in the face of climate change

22 March, p 17

From Bill Wilkinson, Burnt Ranch, California, US

Even if there is doubt about how much carbon dioxide trees will soak up in a warmer future, they can still help us deal with climate change. Forest management strategies can help buffer (if not prevent) droughts, floods and heatwaves, and milled wood incorporated into structures provides a carbon sink capable of storage over decades or centuries.

Techniques such as single-tree selection can sustainably produce periodic harvests while retaining forest cover and all the benefits it provides. Forestry ensures that younger trees replace older, harvested ones via seeding, sprouting or, if necessary, planting. Even after a catastrophe, most forests quickly reoccupy disturbed sites, and new forest, if managed, can still provide habitat, recreation and soil protection

For me, reconstructions trump simulations

26 April, p 9

From Richard Ellam, Bristol, UK

You report on suggestions that the Antikythera mechanism didn't function. Over the past 70 years or so, a number of distinguished and skilful historians and museum curators have conclusively established, by making physical replicas of the mechanism, that it did function. Thanks to their work, we now have a pretty good idea of what it was designed to do. All the study in your article establishes, I think, is that computer simulations are a poor substitute for reconstructions using authentic tools and materials.

Reaction to a new take on life's chemical origin

26 April, p 34

From Andrew Hawkins, Peaslake, Surrey, UK

Your feature explained a concept that was new to me, a form of evolution in chemistry as a potential origin of life on Earth. The idea dates back to at least 1944 and Erwin Schrödinger's book *What is Life?*. I want to thank your contributor Elise Cutts for her brilliant prose, allowing one of your many lay readers with no scientific background to grasp the idea and its significance in the mystery of how life on Earth got started.

For real life, look away from your screens

19 April, p 19

From Richard Bradford, Chesterfield, Derbyshire, UK

The younger generation may or may not be as intelligent as their elders, but their lives are markedly different. Entwined with digital devices, can they fully appreciate the real world? If not, how will they be able to cope with the realities and uncertainties of life?

I take pains to remind my students in their early 20s that the real world isn't on a screen, but "out there", where they feel hot and cold and hungry, and may fall in love. It is also the world where they will look for work. But their attention lasts for about 5 seconds before their eyes start twitching and they look back at a screen.

Hoping to get that fuzzy feeling one day

12 April, p 8

From Ravi Sankuratri, Epsom, Surrey, UK

It is brilliant to know that quantum Darwinism, which seeks to bridge the divide from the quantum realm to classical reality, is proven mathematically. I hope one day we, the "classical" beings, will somehow experience the fuzziness of the quantum realm and see all its states at once. The crumbs are there for us to follow deep into this beautiful quantum world. Exciting times are ahead!

Want to get in touch?

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

For the record

The northern hemisphere is thought to store around 1.5 trillion tonnes of carbon in permafrost (5 April, p 17).

Defying gravity

It has long seemed completely impossible to test one of the most important questions in physics: is gravity a quantum force? But new experiments might just pull it off, says **Jon Cartwright**

PHYSICS is tough. Want to spot a ripple in space-time? You just need a detector capable of seeing a length change less than one-millionth the size of an atom. Want to find a Higgs boson? No problem – so long as you have $7 billion, 14 years and 6000 scientists to hand. Still, one experiment is so hard as to make even the cheeriest physicist gulp: testing the idea that gravity is quantum.

A theory of quantum gravity is the outstanding goal of modern physics. It would reconcile two currently incompatible pillars of our description of the universe: general relativity, our large-scale theory of gravity; and quantum mechanics, our microcopic account of nature's other fundamental forces. Individually, these have been thoroughly tested, always passing with flying colours. Yet try to combine them, and things fall apart. If we could show that gravity is quantum in nature, perhaps by finding a quantum particle of it, the problem would be all but solved. However, even our most powerful detectors don't come close to the extraordinarily high energies thought to be needed to find these so-called gravitons.

Not long ago, the late theorist Freeman Dyson echoed the mood among many physicists when he argued that quantum gravity might simply be untestable. But recently, some have begun to claim that it may not be so. If true, we could soon see the first hints of how the two most fundamental theories of nature relate to each other. "It seems to me that, technologically speaking, the time is opportune," says Vlatko Vedral, a theorist at the University of Oxford.

Uniting physics

The two pillars of modern physics have never been likely bedfellows. On one side, general relativity says that the universe is made of a continuous and predictable space-time, which results in a particular force – gravity – when it flexes around massive objects. On the other side, quantum mechanics says that all of the universe's matter and forces should be made of indivisible particles with an odd property – they can't decide exactly where they are.

For decades, physicists have muddled along with both theories. Broadly speaking, general relativity excels for everything that is very big, when gravity dominates, while quantum mechanics rules over everything very small, when nature's other forces take over. But, ultimately, both can't be true: nature cannot be simultaneously continuous and made of indivisible chunks; it cannot be both predictable and random. Nowhere is this more evident than at the big bang, when everything in the universe was compacted into an infinitesimally small point with infinite gravity. Anyone hoping to understand that extreme event has no choice but to attempt a reconciliation.

Bringing gravity under the framework of quantum mechanics – "quantising" gravity – has been the biggest project in fundamental physics for more than half a century. There are several ideas that claim the capability to resolve it, the most promising being string theory, which replaces fundamental particles with vibrating strings. Because strings are naturally spread out over multiple higher dimensions, the big bang would no longer be a pure singularity, so the tension that arises between general relativity and quantum mechanics at infinitesimal scales is diluted. An alternative means of reconciliation is loop quantum gravity, which attempts to build space-time itself out of indivisible quantum units. Both amount to a quantum version of gravity – and both are immensely hard projects mathematically – but what makes them harder still is the lack of any way to check them empirically. As far back as 1957, the theorist Richard Feynman said that the "one serious difficulty" is the lack of experiments testing for signatures of quantum gravity. "Furthermore," he stated, "we are not going to get any experiments."

Behind his assertion was some fairly basic logic. We know that all the other forces governed by quantum mechanics are transmitted by indivisible particles: photons for the electromagnetic force, which governs light and the basic chemistry of matter; gluons for the strong force, which sticks together protons and neutrons inside atoms; and W and Z bosons for the weak force, which enables certain particles to radioactively decay. If gravity has the same underlying theory as these forces, it should also be carried by its own particle: a graviton. True, the graviton might be a front for something more fundamental – the hum of a string in string theory, for example, or the excitation of space-time in loop quantum gravity. But whatever the theory, something like a graviton should almost certainly appear.

The trouble is, the weaker the force, the more rarely its particle interacts with other ›

SEBASTIEN PLASSARD

particles. And gravity is a very weak force – 10 trillion trillion times weaker than the force actually known as the weak force. We might think gravity is strong, seeing it pull an apple from its branch to Earth's surface, but the gravitational attraction between a pair of apples is scarcely perceptible. That is why the prospect of spotting a graviton in an experiment has always been unimaginably slim. According to conventional theory, the effects of quantum gravity can be felt only at unthinkably high energies. Even the Large Hadron Collider – the hugely powerful particle accelerator that detected the Higgs boson – is one thousand million million times too weak to see quantum gravity in action. In the early 2000s, Dyson said you might need detectors so big that they would collapse in on themselves, forming a black hole.

SHUTTERSTOCK/USAMA AFZAL GULBANA

The ping of a graviton

No wonder it came as a shock last year, when a group led by Igor Pikovski at Stockholm University in Sweden suggested that it could be possible to detect a graviton in the lab. The experimental blueprint involved a microscopic metal bar, like a tiny tuning fork. First the bar is cooled close to absolute zero, so that its atoms all adopt the same behavioural state. Next it is illuminated by a laser, ever so slightly nudging this collective state into one that is – in hazy quantum fashion – both resonating and not resonating. Set up like this, the researchers claimed, the bar will fully resonate upon even the tiniest of disturbances – even the ping of a single graviton.

It sounds too good to be true – and for some other physicists, it is. Several months before the Pikovski group published its paper, theorist Daniel Carney at the Lawrence Berkeley National Laboratory in California and his colleagues revisited the question of whether gravitons are detectable using the technology designed to capture gravitational waves.

These waves are ripples in space-time that are occasionally produced in distant cataclysmic events, such as the merging of black holes, but, like gravitons, were considered undetectable for most of the past century. It was only in 2015 that one was spotted for the first time, when the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the US measured a minuscule disturbance in space-time equal to less than one millionth of an atom's width.

If gravitational waves can be detected, asked Carney and colleagues, why not gravitons? In principle a gravitational wave is just a bunch of gravitons, and the researchers calculated that technology developed in the past decade has already become sensitive to waves small enough to constitute a single graviton. But here is the catch: any signal would be identical to that from a classical, non-quantum gravitational wave that just happens to be very small. Carney argues that the same ambiguity would bedevil any click recorded in a bar-resonator experiment, as proposed by Pikovski's group. "You hit it with some energy, and it starts moving," he says. "That doesn't tell you if the gravitational field is quantised."

"Even the Large Hadron Collider is far too weak to see quantum gravity in action"

There is disagreement as to what a bar-resonator experiment could actually show. Some, including Carney, believe it cannot say anything useful about the quantum nature of gravity. Others, such as Pikovski and Vedral, argue it could strongly suggest that gravity is quantised, just not in a foolproof manner. Either way, most agree that a clear-cut signal of a graviton is, alas, an impossible dream. "For an unambiguous proof of quantisation we'll probably have to wait another 100 years or more," says Pikovski.

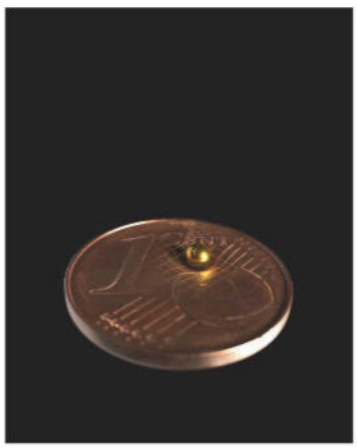
So were the cynics right in the end? Not quite. After all, there are other hallmarks of quantum mechanics besides quantisation itself. One is entanglement: whenever two quantum objects interact, some of their properties should

become instantaneously correlated. In 2017, Vedral and his collaborator Chiara Marletto at Oxford, and, independently, a team led by Sougato Bose at University College London, outlined a way to exploit this phenomenon. Their proposal is to prepare two masses in a quantum state such that their positions are uncertain, then isolate them from all other forces – and wait. If, after a time, the positions of the masses begin to correlate with one another, they must have become entangled by gravity. Ergo, gravity must be quantum.

It isn't quite as simple as it sounds. In fact, Feynman once considered a more primitive version of this experiment, only to dismiss it as "phenomenally difficult". Bigger masses are harder to put in quantum states, but you can't go too small, or else the gravity between the objects becomes too weak to measure. Worse, our everyday world is saturated with photons in the form of light, heat and radio waves, which all risk drowning out any subtle correlations. Yet technology has come a long way since Feynman's day, when quantum experiments consisted of a few atoms at best. In 2019, a team led by Markus Arndt at the University of Vienna in Austria put some 2000 atoms at once in a quantum state – a milestone on the way to gravitational entanglement. "There are three or four experimental groups who are racing to do it," says Vedral.

We are a way off, though – these masses are at least a million times too small for gravity to have a measurable effect. Markus Aspelmeyer, who leads a different group at the University of Vienna, hopes to perform a viable experiment in 15 years, but he admits that this is a self-imposed deadline. ("I'm forced to retire in 20," he says.) He also points out that, strictly speaking, a foolproof setup would demand the masses be prepared far apart from one another in an effort to prevent meddling by any external effects, such as light passing between the two masses. Unless they are far enough apart, we can't say that only a quantum theory of gravity could explain their entanglement without violating relativity. But gravity is so weak as to be practically zero between masses that are well-separated. "That sort of experiment is impossible in any realistic time frame," says Aspelmeyer. "Let's say before the next catastrophic meteor hits the Earth."

So gravitons can't be directly detected, and any sign of gravitational entanglement will take 15 years or more – and might still then be uncertain. It certainly seems anticlimactic. But all is not lost. For there is a third way – one that turns the question around. What if gravity isn't quantum?



ARKITEK SCIENTIFIC

Quantum gravity's effects would have been clearest at the big bang (left) but physicists are now hunting for them using tiny gold beads (above)

There are good reasons to think gravity is categorically different from the other forces. For starters, it is the only force that affects everything. In general relativity, this is because gravity is equivalent to the very curvature of space-time, not attracting objects to one another but rather creating a slope in the fabric of space-time that they simply slide down. In this sense, gravity is not really a force like the others – it is more like a geometrical mirage.

Inevitable noise

Not wanting to mess with this neat description, some theorists have tried to find ways to preserve classical space-time, setting gravity apart as the only fundamental force that isn't quantum. In some hypotheses, it would even break down the quantum nature of objects above a certain mass, explaining why our everyday world appears classical. The ideas within this so-called "semi-classical" approach are various, but as a group led by Jonathan Oppenheim at University College London showed in 2023, they must all have one thing in common: some kind of gravitational randomness, or noise.

To understand why, imagine a mass that, according to standard quantum mechanics, is in two positions at the same time. Does the mass's gravity originate from one position, or the other? If gravity isn't a quantum force, but an innate feature of space-time, it cannot originate from both – there can be only one space-time, after all. If the mass's position is indefinite, but space-time is definite, the best space-time can ever do is guess where to bend.

The point isn't how gravity does this, Oppenheim says, only that if it is a fundamental feature of space-time, it has to do it somehow. And that means that if gravity itself isn't quantised, any precise experiment involving mass ought to be fundamentally limited in its possible accuracy – some noise will always be present. "It holds for any theory in which space-time is fundamentally classical, so it's very broad," says Oppenheim.

Crucially, unlike the graviton and the entanglement experiments, tests of this idea can begin right now. In fact, they already have. In 2021, Aspelmeyer's group made a few gold beads, each just a couple of millimetres across. They attached a bead to each end of a toothpick-sized rod, so as to look like a miniature dumbbell, and suspended the rod horizontally on a spring. Next, they oscillated a third bead close by, to see if its gravity would make the others shift. They detected an acceleration equal to about one hundred-billionth of that due to Earth's gravity – the smallest source of gravity yet recorded.

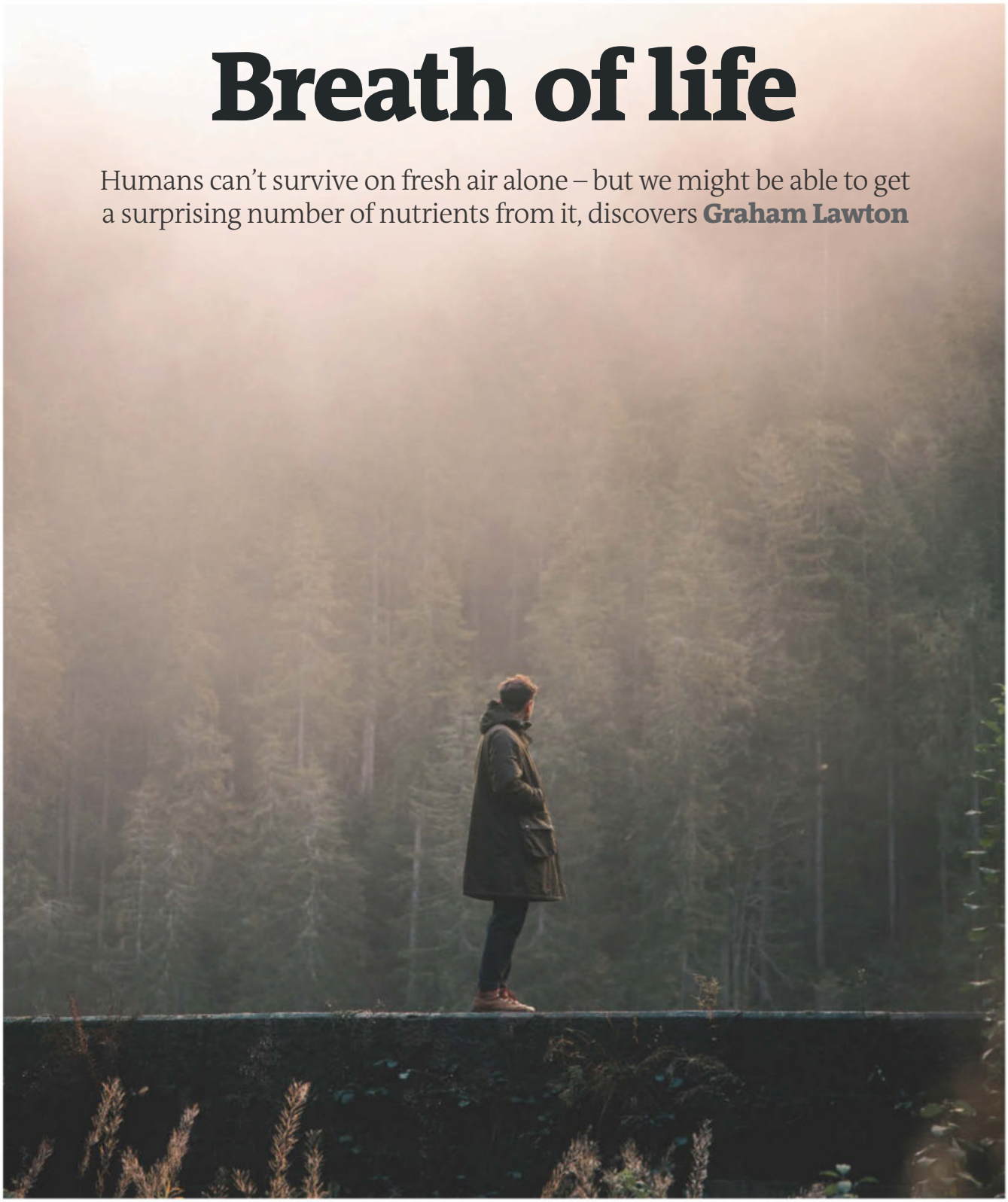
This measurement is not precise enough yet – Oppenheim reckons it needs to be about a thousand times better to tell us anything useful about the nature of gravity. But we are closing in fast. Aspelmeyer's group is already finalising an upgraded experiment based on masses 10,000 times smaller, using computer-chip manufacturing techniques. Results from this type of test can be combined with data from the ongoing experiments on gravitational entanglement, to "squeeze" the noise parameter and see if gravity really does butt up against a classical limit.

How long will this take? No one knows for sure. But what was once thought impossible – actually testing whether gravity is quantum, rather than just pondering it – looks to be finally within sight. "This is now a question for experimenters," says Oppenheim. "Nature doesn't care what theorists think." ▮

Jon Cartwright is a freelance science writer based in Bristol, UK

Breath of life

Humans can't survive on fresh air alone – but we might be able to get a surprising number of nutrients from it, discovers **Graham Lawton**



DANIEL ERNST/STILLS

AROUND 10 years ago, British tabloid newspaper *The Sun* ran a memorable article about a couple who claimed to be "breatharians", able to survive on a little water and even less food. Instead, they said, they derived sustenance from air, sunlight and the energy of the universe. The story was picked up by media outlets across the world and propelled the couple and their unusual lifestyle to fame – and no small amount of ridicule.

Needless to say, humans – even self-described breatharians – can't live primarily on air and sunlight, as some practitioners tragically discovered when they died trying. But weirdly, the concept turns out to be more substantial than it first seems. According to a duo of Australian scientists, we can and do derive nutrients from the air – nowhere near enough to live on, but perhaps enough to benefit our health. Is it possible that a source of nutrition has been under our noses all along?

"The evidence shows very clearly that we can absorb nutrients from the air we breathe," says Flávia Fayet-Moore, a nutrition scientist at the University of Newcastle in Australia. Whether or not these "aeronutrients", as the pair have dubbed them, make a significant contribution to our health isn't yet clear, she says – but they could in the future.

Every day, we breathe around 7000 to 8000 litres of air, a mixture of nitrogen, oxygen, argon, water vapour and whiffs of other gases. Our lungs extract oxygen and replace it with waste carbon dioxide. But air can also contain trace amounts of compounds not normally thought of as airborne, many of which have nutritional value when we ingest them. Fayet-Moore and her colleague Stephen Robinson at RMIT University in Bundoora, Australia, are investigating what happens when we inhale them.

Their starting point was a 2019 article by Paul Trayhurn, a nutritional biologist at the University of Liverpool, UK, who argued that oxygen should be reclassified as a nutrient. Trayhurn pointed out that despite being absorbed through the airways rather than the gastrointestinal tract, oxygen meets the definition of a nutrient as "a substance that provides nourishment for the maintenance of life and for growth".

The idea didn't catch on, but it did catch the eye of Robinson. Over dinner one evening, he and Fayet-Moore got talking about the oxygen-as-nutrient concept and wondered whether air might contain other beneficial compounds that we absorb into our bodies. Curious, they trawled through the literature and uncovered ample evidence that it does, and we do.

"We were trying to disprove it, but the more we read into it, the more the evidence started piecing together and we were like, 'How is this possible? How has no one ever noticed this until now?'" says Fayet-Moore.

To determine whether aeronutrients really were possible, the pair first needed to figure out the mechanisms by which inhaled compounds can be absorbed by the body. Inhaled air's first port of call is the nasal cavity, where the nasal microvasculature, a dense bed of tiny blood vessels separated from the airway by a thin layer of cells, heats and humidifies it. Airborne molecules readily diffuse into this layer of cells, which is primarily how snortable drugs of misuse, such as cocaine, enter the bloodstream. Intranasal drug delivery – which, owing to the area's permeability, is rapid – is also increasingly being explored for other uses, including analgesics, sedatives and migraine treatments.

The nasal cavity also provides direct access to the central nervous system via the olfactory epithelium, a patch of nerve endings linking

> "We can absorb nutrients from the air we breathe"

the airspace to the brain's smell centre, the olfactory bulb. This is the only part of the brain in direct contact with the environment and so offers an opportunity for the administration of drugs targeting the brain. Current research is exploring a "nose-to-brain" route for giving medication, such as intranasal insulin to treat dementia and post-traumatic stress disorder, and oxytocin to manage anxiety disorders.

The final destination for inhaled air is the lungs and these, too, are capable of transferring molecules from the air into the bloodstream. The terminal ends of the airways – tiny, densely capillaried sacs called alveoli – are principally involved in gas exchange, but can also facilitate the rapid absorption of other molecules, such as anaesthetics, nicotine, cannabinoids and opioids. In addition, therapeutic molecules, such as insulin, vitamin B12 and a form of vitamin A called all-trans retinoic acid, can enter the bloodstream via the lungs.

All of this suggests that, if there are nutrients in the air, they will be taken into ›

Could aeronutrients explain the benefits of being in nature?

the bloodstream, the brain, or both, says Fayet-Moore (see "How aeronutrients could work", below). But are there nutrients in the air? Again, the existing literature says there are.

The most compelling evidence is for iodine, a trace element micronutrient required to synthesise thyroid hormones. We usually obtain it from food – seafood is an abundant source, as are dairy products and crops grown in naturally iodine-rich soil – however, access to those foods can vary. In 1960, around 60 per cent of the world's population was iodine deficient, which can cause an enlarged or underactive thyroid. That situation has largely been rectified with iodised table salt, but significant pockets of deficiency remain.

In 1964, iodine expert Robert Vought at what was then the US National Institute of Arthritis and Metabolic Disease had a thought: maybe air was an important source of iodine? He and his colleagues found that the concentration of gaseous iodine in outdoor air ranged from zero to 7.4 micrograms per cubic metre and estimated that inhaling iodine-rich air could supply around 7.3 per cent of the US recommended adult intake of 150 micrograms per day. They also studied a group of laundry employees who were exposed to elevated atmospheric iodine at work, finding that their blood and urine contained higher amounts of the element compared with a matched group who worked outside. Vought speculated that they were absorbing iodine through their airways, but couldn't rule out other routes.

A few years later, in 1968, a team led by D. J. Morgan at the UK Atomic Energy Authority asked volunteers to inhale radioactive iodine gas – an isotope with a short half-life that is typically used in thyroid function tests and tracer studies – to determine the radiological hazard of an accidental release of the gas. The research found that iodine could indeed be absorbed by the airways and could be carried by saliva into the small intestine.

But research into inhaled iodine lay fallow until 2011, when a team led by Peter Smyth at the National University of Ireland in Galway took a look at airborne iodine absorption in the wild. The researchers compared three groups of people: some living near beaches where there was a lot of seaweed, a rich source of iodine gas; some living near beaches with little seaweed; and others living inland. The first group had the highest levels of iodine in their bodies and the lowest incidence of iodine deficiency, which Smyth surmised was because they were inhaling the stuff into their

DANIEL SLIM/AFP VIA GETTY IMAGES

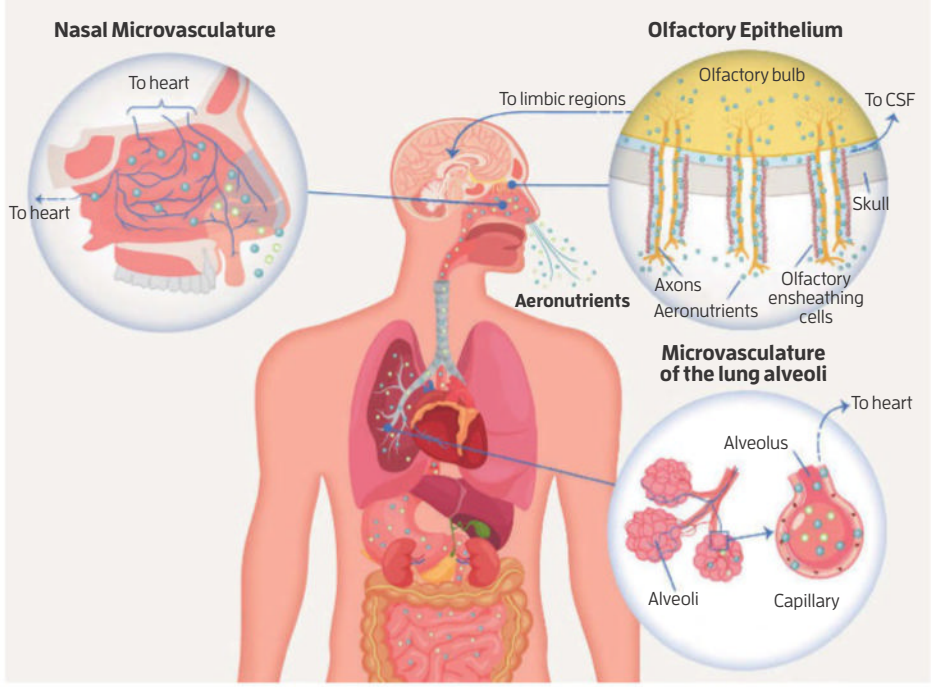
LARRY LEE PHOTOGRAPHY/GETTY IMAGES

Seaweed can be a source of airborne iodine that we inhale and then absorb

Welders are sometimes exposed to toxic levels of manganese in the air

How aeronutrients could work

According to research, aeronutrients could have three distinct routes into the body: through tiny blood vessels in the nasal cavity; via the olfactory epithelium, which would transport them to the brain; and through the lung alveoli.



FLÁVIA FAYET-MOORE AND STEPHEN ROBINSON

bloodstreams. "The eureka moment for me was these iodine studies," says Fayet-Moore.

The evidence for other aeronutrients may be weaker, but it isn't non-existent. We know, for example, that the micronutrient manganese, a component of the detoxifying enzyme glutamine synthetase in the central nervous system, can enter the brain via the olfactory epithelium. Manganese – in the right amounts – is a trace metal element essential for certain metabolic brain functions. Present in soil, it can be dispersed into the air as tiny particles through soil erosion or human industrial processes, such as fossil fuel combustion. Concentration depends on location – higher near industrial areas, lowest in rural areas. However, says Fayet-Moore, it is plausible that we acquire much of what we need by breathing it in .

At first glance, that appears unlikely: breathing in 7000 litres of air a day could deliver about 100 nanograms of manganese, which is a fraction of the US recommended dietary intakes of 2.3 milligrams for men and 1.8 milligrams for women. But manganese acquired through diet is largely excluded by the blood-brain barrier, the semi-permeable membrane that protects the central nervous system from potentially harmful substances in the blood, says Fayet-Moore. As a result, we have to eat considerably more than we require to see a benefit.

Nose-to-brain

The nose-to-brain route, on the other hand, delivers it directly to where it is needed, so its effect could be potent. "Not only can we absorb nutrients from the air, but we can absorb them more efficiently than we can from our guts," she says. "The amounts of nutrients in air are minute, yes, but our respiratory airways are way more efficient at absorbing molecules than our gut." In fact, it can be too efficient: welders exposed to high levels of airborne manganese are at risk of accumulating neurotoxic amounts via the nose-to-brain route, sometimes resulting in cognitive impairment and Parkinson's-like symptoms.

Two other micronutrients, zinc and iron, may also enter the brain via the olfactory epithelium, says Fayet-Moore, but the evidence for these being present in air in significant amounts is lacking.

Another promising candidate is all-trans retinoic acid, which is typically acquired by eating carrots, sweet potatoes and other foods containing beta-carotene. It is essential to embryonic development, as well as cellular regeneration and immune function. All-trans retinoic acid has been shown to occur naturally at the air-water interface of rivers, lakes and oceans, suggesting that it could be in the air in significant amounts.

There could be other, yet-to-be-discovered nutrients in the air that we only acquire by breathing, says Fayet-Moore. But even if aeronutrients currently contribute little or nothing to our natural intake of micronutrients, there is an opportunity to exploit the fact that they could supply more. It is surprisingly common for people to lack micronutrients – a recent global analysis found significant deficits for 15 of them, including iodine, vitamin E and calcium – and supplementation by inhalation might be an effective way to address this, says Fayet-Moore. "One in two people globally are deficient in vitamin D. The prescription might be: 'Sit here and inhale vitamin D for a few minutes and you're sorted for the next month.'"

Fayet-Moore, who is also a space nutritionist, suggests that aeronutrients could be useful in artificial environments, where the air is filtered. "They are potentially going to play a big role in closed loop ecosystems like submarines and space stations."

Aeronutrients may partially explain the mysterious health benefits of spending time in nature, too. "All the evidence that exists on nature therapy, like 'forest bathing', shows quite conclusively the health impact: if you spend more time in nature, you're healthier," says Fayet-Moore. "But no one really knows why. There are lots of hypotheses. We think that one of the reasons might be aeronutrients."

When she and Robinson published their idea, also suggesting that inhaled bacteria, "aeromicrobes", could similarly contribute to human health, in the journal *Advances in Nutrition*, they expected pushback from nutrition scientists. But the reception has been surprisingly positive, she says. "Typically, academics approach the concept of aeronutrients cautiously – until they read the evidence," she says.

According to Jean Debédat at the University of California, Davis, the article has been shared among several nutrition working groups and many experts found it intriguing. He came across the idea when the journal invited him to write an accompanying editorial. "I have to admit I was initially really sceptical," he says.

"One in two people are deficient in vitamin D. The prescription might be: 'Sit here and inhale it'"

"However, after digging deeper, I found the idea fascinating. It does make sense: we are breathing thousands, maybe millions, of small molecules with every breath. Like all molecules, some get absorbed, and likely have different bioactivities, some good, some bad. It's clear to me that there is a lot of potential here."

Trayhurn – the oxygen-as-nutrient scientist – is also impressed. "The concept that they develop is compelling, and the arguments and the evidence that they marshal are strong," he says. "The data on manganese and iodine is particularly intriguing. There is, of course, a question of how large a contribution aeronutrients make – or could make – to intake, but the iodine studies suggest that, for some nutrients, it is considerable."

Having tested the waters, Fayet-Moore and Robinson now want to test the air. "We need more research to understand the amount of nutrients that are naturally occurring in nature," she says. They also want to test whether delivering micronutrients in inhalable form would work, although the existing literature on vitamin B12 and other therapeutic treatments suggests that it will.

After that, who knows? "We're only at the very beginning of this field," says Debédat. "It reminds me a bit of how the microbiome field looked 25 years ago: people knew it was there and probably important, but most researchers really didn't pay too much attention to it. It wasn't until new methodologies emerged that the field really exploded. I believe that the field of aeronutrients might follow the same path in the coming years."

For a fusty old area like nutrition science, that would be a breath of fresh air. ▮

Graham Lawton is a staff writer at *New Scientist*

ULA ŠVEIKAUSKAITĖ

Cycle of despair

Many women deal with premenstrual symptoms, but for some, their effects are unbearable. **Helen Thomson** discovers why – and what can be done

STORIES about medical problems often start with an explosive quote from someone experiencing the condition. After dipping into an online forum of people diagnosed with premenstrual dysphoric disorder (PMDD), however, I found that a single comment didn't seem to suffice.

"One week before my period, like clockwork, I want a divorce, I don't want to be a mom, I hate my job and I rage," said one member. "Who can relate with the awful feeling of waking up the next day after an episode and being so embarrassed with what they said or did?" said another. "I wound up convincing myself that I was not a real member of my family, and I was done with life. I drove to a gun dealer very sure and relieved that I was ready to die... This isn't me," said a third. "PMDD is ruining my life," was a common refrain.

PMDD is sometimes referred to as "bad PMS", but these statements reveal how inaccurate that label is. PMDD is a chronic hormonal condition that causes interpersonal conflict, depression, lethargy, anxiety, thoughts of self-harm and suicide. Yet, so marginalised has it been that it was only officially recognised by the World Health Organization in 2019. Recently, though, there has been a surge in interest, helped by media personalities like Dixie D'Amelio and Vicky Pattison talking publicly about their struggles with PMDD. Meanwhile, a flurry of research is also bringing the condition out from the shadows. What's more, new ideas about PMDD aren't just promising better treatments, they are also part of an emerging picture that is revealing sex hormones to have a far greater impact than anyone imagined.

At least since the time of Plato and Hippocrates, women's emotions have been attributed to their menstrual cycle. "Hysteria" comes from the Greek word for uterus, and the ancient Greeks believed the uterus travelled around the body causing all sorts of ailments – sex and pregnancy were the suggested cures. Fast-forward to the Victorian era, and a "wandering womb" was one reason given for marital disobedience. Thankfully, we now live in more enlightened times. Yet menstruation, even in the most progressive countries, is still something of a taboo.

That's a problem, given that up to 90 per cent of women who have periods experience at least one symptom of premenstrual syndrome (PMS). For the estimated 31 million people – roughly 1.6 per cent of women and girls globally – with diagnosed PMDD, this taboo is catastrophic. Research from last November of 3600 women with the condition revealed that just under half had deliberately harmed themselves during a PMDD crisis, 82 per cent had experienced suicidal thoughts and 26 per cent had attempted to end their own life.

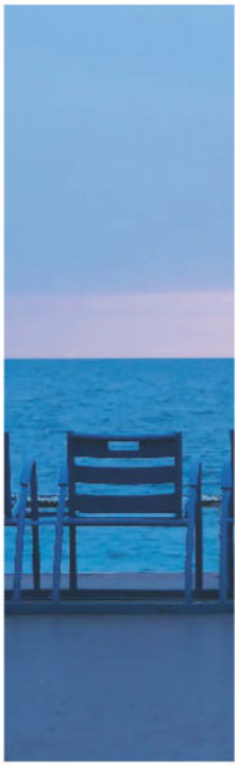
Although the recent celebrity-driven media spotlight is changing things, it can lead to confusion. "I see a lot of social media influencers talk about moon cycles and their effect on PMDD, which does not have valid scientific evidence. Another media hype is the use of antihistamine as a treatment for PMDD, which we also do not have evidence for," says Sneha Chenji at the University of Regina in Canada, who also does work for the non-profit International Association for Premenstrual Disorders. "It's fantastic how much conversation is going on about PMDD in Instagram and TikTok," says Chloe Apsey, who studies the condition at Cardiff University in the UK. "But personally, I'm concerned about misinformation – with people thinking they have PMDD when they don't and getting misdirected with treatments they don't need. I think social media can also undersell how severe PMDD can be."

Not just bad PMS

On the positive side, increasing awareness is getting people more interested in participating in research, says Apsey. But one of the initial problems with understanding PMDD is figuring out exactly who has the condition. It is defined by symptoms including headache, cramping, and extreme anxiety and depression in the week or so leading up to a period. It can start at any point from the very first period and is sometimes triggered by a big reproductive milestone, such as stopping breastfeeding. It usually ends at menopause, but perimenopause can worsen symptoms.

The best way to diagnose PMDD is to keep a daily diary for at least two cycles, says Apsey. "Often people think they have PMDD, but once they keep a diary over a few months, they realise their symptoms are more persistent or at different times of each month, which may point towards something like bipolar disorder or depression." Some pre-existing conditions other than PMS can also get worse just ›

"Hormones are not the noise in the data, they are the data. Yet research often ignores them"



More than 80 per cent of people with PMDD have suicidal thoughts

before a period, which is called premenstrual exacerbation. Without keeping a diary, it is hard to identify who actually has the condition, says Apsey, and many previous studies haven't ensured that all participants really do. "It's made the data we have so far very blurry."

Nevertheless, when it comes to understanding what causes PMDD, things are getting a little clearer. Two hormones are certainly involved – progesterone and oestrogen, which naturally fluctuate throughout the menstrual cycle. Oestrogen affects various brain functions, including learning, memory and mood. Progesterone also plays a significant role in mood and is linked with stress because it can be converted into the stress hormone cortisol. Both oestrogen and progesterone are known to contribute to susceptibility to mental health conditions such as depression.

Hormonal imbalance?

Pioneering work in the late 1990s showed that if you completely suppress these hormones – inducing an artificial menopause – this can also reduce symptoms of PMDD. The finding seemed to indicate that people with the condition have an overabundance or erratic fluctuation of progesterone and oestrogen. However, later work showed that hormone levels in people with PMDD tend not to differ from those without the condition. "That points towards it not being a hormonal imbalance, but having an abnormal response to normal hormone changes," says Thomas Reilly, who studies PMDD at the University of Oxford. Apsey and her supervisor at Cardiff University, Arianna Di Florio, are now searching for genetic clues that might help them discover why some people are more susceptible to natural hormone fluctuations, and whether it runs in families, as it seems to anecdotally.

Meanwhile, other researchers have turned their attention to allopregnanolone (ALLO), a breakdown product of progesterone. ALLO has a key role in helping people deal with stress and anxiety because it modulates receptors of a neurotransmitter called GABA in the brain. When these receptors are active, they help control our mood and turn off our fight-or-flight systems after a period of stress. It may be that in PMDD the brain has become desensitised to ALLO, says Reilly, resulting in it failing to lower stress and anxiety. "There's an idea that the way these people's GABA receptors react to hormones might be the cause of their symptoms, but it hasn't been shown conclusively yet."

There also seems to be a link between serotonin and PMDD. Serotonin is a key neurotransmitter that carries messages between brain cells and is involved in regulating mood. At normal levels, it helps us feel happy, emotionally stable and focused, while low levels are generally associated with symptoms of depression and anxiety, although some dispute this. Brain imaging studies of people with and without PMDD show that those with the condition experience an increase in the number of serotonin transporters in their brain just before their period. These transporters suck up serotonin into nerve cells, meaning there is less washing around the brain. That might help explain some of the negative emotions associated with PMDD.

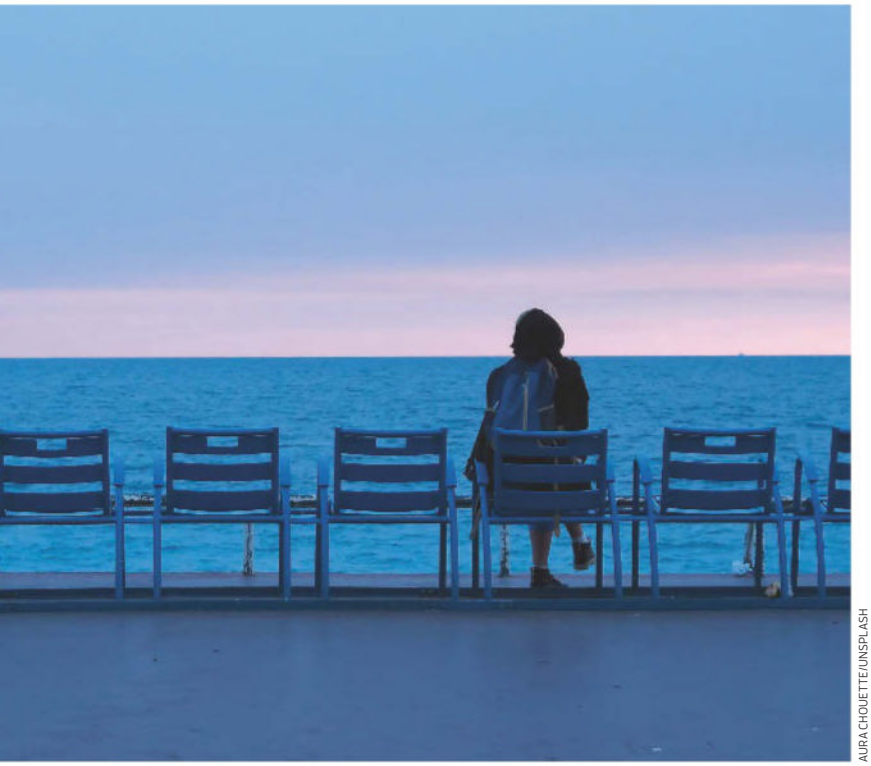
Given an increased understanding of what causes PMDD, along with a new appreciation of its seriousness, you might think that finding treatments would be a top research priority; sadly, that hasn't been the case. "Even with growing interest, the condition is very much under-researched and overlooked," says Reilly. This is reflected in the paucity of treatments on offer, which primarily entail cognitive behavioural therapy – to help people regain some control over their thoughts and mood – hormonal contraceptive pills, which maintain more stable levels of oestrogen and progesterone throughout the month,

Dixie D'Amelio is one celebrity shining a spotlight on PMDD

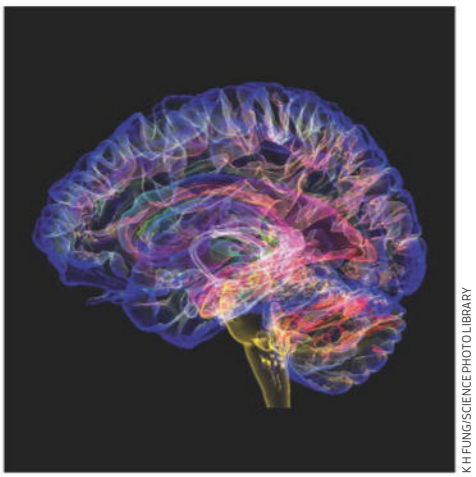
DARREN AGBOH/SHUTTERSTOCK

and antidepressants, specifically selective serotonin reuptake inhibitors (SSRIs), which prevent nerve endings from sweeping up serotonin too quickly and may also help increase ALLO availability.

Not only are there few treatment options, those that are available also don't work for everyone. For example, 30 to 40 per cent of people don't respond to SSRIs. Lisa, whose name has been changed to protect her privacy, is one of them. Having battled PMDD since she was 12, she found that antidepressants took the edge off, but her symptoms were still terrible. "Sometimes I just felt like I didn't want to be here," she says. "I was calling up the doctors constantly, telling them 'I'm really suffering'." Eventually, she was offered a more drastic treatment called a gonadotropin releasing hormone (GnRH) agonist to shut down her ovaries. It worked. "My emotions were so much more balanced," she says. But because using the drug over the long term can increase risk of osteoporosis, Lisa was only allowed to take it for six months. "Now I've stopped it and I've just felt – it sounds dramatic – but I've just wanted to die," she says. "It's been awful. For half of every single month, it ruins my life. I have three children; it's been so hard." Others who opt for GnRH drugs don't even have a temporary reprieve. Unfortunately, for around half of people who take them, they don't work either. This isn't just a problem, it's a puzzle. "I think there is a lot of work that needs to be done to understand why treatments are effective in some but not others with PMDD," says Chenji.



AURA CHOUETTE/UNSPLASH



K H FUNG/SCIENCE PHOTO LIBRARY

Research on a potential treatment called Sepranolone suggests one reason. This synthetic version of ALLO showed promise in preliminary trials, but then a large randomised control trial found no meaningful differences between the group that received it and those who took a placebo. However, diving deeper into the Sepranolone trial data showed it was effective for a sub-group of people with PMDD whose symptoms are confined to the luteal phase, which follows ovulation, and disappear completely when their period starts. This could point to PMDD manifesting differently in different people. Indeed, in 2020, researchers found some of the first evidence that there may be at least three subtypes of the condition. People with one form experience moderate symptoms only in the week before their period, those with a second type have severe symptoms across the full two weeks of the luteal phase and a third group have severe symptoms in the premenstrual week that are slow to resolve in the following weeks.

Expensive challenge

If PMDD does come in distinct forms, this offers new hope for treatments. "I believe that future research looking at different temporal subtypes of PMDD, including severity and timing of symptoms, would be helpful," says Chenji. But she also notes that planning any study that involves analysing the effects of the menstrual cycle is challenging and expensive. Historically, in both early-stage animal studies and human clinical trials, females have been excluded from biomedical research specifically because their menstrual cycles could affect the data. "Hormones are not the noise in the data, they are the data," says Chenji. "Research on these differences must become the norm if we are to achieve equity and, most important, to improve the health and well-being of women and men," state the authors of a report on the subject by Brigham and Women's Hospital in Boston, Massachusetts.

The fact that change is needed is becoming increasingly apparent. Back in the 1970s, the first review of the menstrual cycle's impact on cognition and perception found no conclusive evidence of cycle-related differences. But the review also pointed out that numerous papers on the subject had methodological problems such as a lack of hormonal measures and incorrect dating of menstrual cycle stages.

In more recent times, there is growing evidence that hormones affect women's health and well-being in all kinds of ways. In 2011, for instance, several studies found that people have stronger emotional memories during their luteal phase, with implications for how to treat trauma. In the past decade, we have learned that women's brains undergo a dramatic remodelling during pregnancy, which could impact behaviour and risk of conditions such as postpartum anxiety and depression. And last year, researchers found that menstrual cycle phase can influence the effectiveness of chemotherapy for breast cancer. These scientists, as well as many others, are calling for more women-specific drug research. That can't come soon enough for the millions of people whose hormones are presenting them with so much adversity during the years they are menstruating – not to mention the countless family members and friends who are also affected.

PMDD isn't a hormonal imbalance. Instead, it lies in the brain's response to normal hormone changes

For now, though, we have so few treatments that some people with PMDD choose to have surgery to remove their ovaries and uterus. This concerns Apsey. "Taking out your ovaries when we don't know exactly what causes the condition seems premature," she says. "We need to take a step back and really understand what is causing it and what will help."

Unfortunately for people like Lisa, surgery can feel like the only option. She is on a waiting list to have her ovaries removed. "I will be able to live a normal life again," she says. "I just hope it happens soon." ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org). US 988 Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries. Consult with your doctor before taking any medical decisions

Helen Thomson is a science writer based in London

New Scientist

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Picturing the lighter side of life p48

Stargazing at home

Dipping deeper

Most of us can spot the group of stars known as the Plough or the Big Dipper. But there's more to explore here, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy*. Follow her @abbybeall

SOME of my earliest stargazing memories involve the same seven stars. Whether you call it the Plough or the Big Dipper – or even the saucepan, the panhandle or the wagon – the stars that form this asterism are ones I think many people learn to recognise from an early age. But just because most people can recognise the Plough, and, by extension, Ursa Major, the constellation in which it lies, doesn't mean we have explored everything in this patch of the sky. And May is as good a time as any to get to know the Great Bear.

Ursa Major is a circumpolar constellation in the northern hemisphere, which means it never sets and is visible to stargazers year-round in northern-enough latitudes.

Parts of Ursa Major, including the bear's legs, can be seen from some locations in the southern hemisphere. But the Plough is not visible from Australia.

Somewhat confusingly, there is another "saucepan" star pattern, or asterism, visible in Australia, sometimes referred to as the little dipper, comprising stars within the constellation Orion. Its handle is the three stars of Orion's belt.

Finding the Plough (pictured) starts with looking north to find the four stars that make up the "pan" part of the asterism, and the three bright stars that extend behind it, which are the "handle" of the pan. This handle is the tail of the bear, and it extends from a star in the upper corner of the pan, called Megrez.

Once you have the Plough, identify the rest of the bear by looking out from the other three corners of the pan. Look for the star in the lower corner closest to where the tail comes out, called Phecda, from which the back legs extend. Follow the stars in an anticlockwise direction and you will reach the star from which the front legs extend, called Merak, followed by Dubhe in the upper corner, from which the bear's face and its long torso appear. You might know this pair already, as Merak and Dubhe point towards the north star, Polaris.

VCG/VCG VIA GETTY IMAGES

One challenge, once you know your way around Ursa Major, is to find the Owl Nebula. This is a planetary nebula. These have nothing to do with planets, but they were named that way because they look like a ring around a planet. They are created by the death of a large star, which released gases that ended up as a cocoon around it. The Owl Nebula, also known as NGC 3587, sits just to the south-east of Merak. To see its owl-eye shape you will need a large telescope, but it can also be spotted with binoculars, looking like a fuzzy dot.

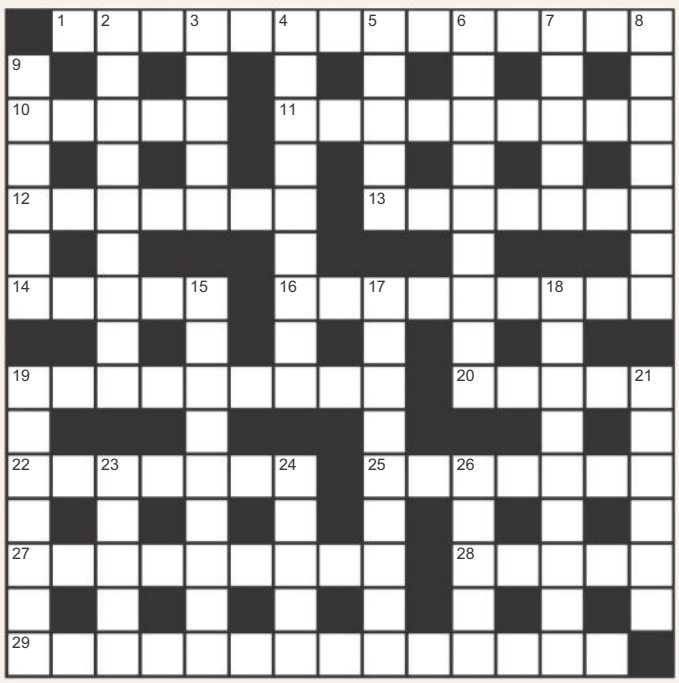
The Owl Nebula isn't visible from the southern hemisphere, but stargazers in the south this time of year could instead look for planetary nebula NGC 3132, also known as the Eight Burst Nebula, in the constellation Vela. It sits between the bright star Canopus and the long constellation Hydra. ▮

Stargazing at home appears monthly

Next week
Mathematics of life

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

Quick crossword #183 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Not working properly (14)
10 Ar (5)
11 High level of incandescence (5,4)
12 1×10^6 (7)
13 Timber-cutting tool (4,3)
14 Concerning the nervous system (prefix) (5)
16 State of autoxidation in fats and oils (9)
19 Not precisely aligned (3-2-4)
20 Microsoft spreadsheet software (5)
22 Printmaking technique (7)
25 Radical; very great (7)
27 Gas-filled cavity (3,6)
28 Ω (5)
29 Part of the sphenoid bone (9,5)

DOWN

2 Phencyclidine or PCP, colloquially (5,4)
3 Mushrooms, for example (5)
4 Renewable power (3,6)
5 Item (5)
6 20 per cent (3,2,4)
7 Intestinal disruption (5)
8 Connective technology used in telecoms (7)
9 Nickname for US plutonium bomb (3,3)
15 Concerning the sense of smell (9)
17 Having undergone the first phase of a transition between states (9)
18 Degree of increase or change (9)
19 Archaic lighting device (3,4)
21 Relating to the spleen (6)
23 Healthcare professional (5)
24 City that is home to the Japan Academy (5)
26 Online provocateur (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #302
set by Corryn Wetzel

1 What is the name of the first interstellar probe, launched in 1977?

2 There is a 9-centimetre-tall sculpture of what on the moon?

3 What is the term for the silk-producing organs in a spider's abdomen?

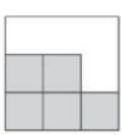
4 What is the primary neurotransmitter involved in muscle contraction?

5 In what year did Erwin Schrödinger publish his wave equation?

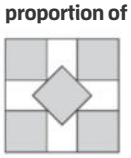
Answers on page 47

BrainTwister
set by Sam Hartburn
#73 Square dance

If you arrange five square tiles, each with side length 1, in a bigger square as shown, what proportion of the area of the square do the tiles use (to three decimal places)?



One of the tiles is rotated by 45 degrees and all five are arranged inside a smaller square as shown. What is this square's area? What proportion of that area do the tiles use?



Ten tiles in a 4-by-4 square use up 10/16 = 0.625 of the area. But with four of them rotated by 45 degrees, they fit in a smaller square. What is this square's area? What proportion of that area do the tiles use?

Solution next week

Double negative

If I were somehow able to create two negatively charged black holes, could they repel each other? Or does gravity always win?

Ron Dippold
San Diego, California, US
Gravity wins. Which is strange, because gravity is by far the weakest major force – the gravitational force between an electron and positron is 10^{43} weaker than the electromagnetic force between them. But while charged black holes are certainly theoretically possible, a negatively charged black hole will preferentially attract positively charged particles and repel negatively charged ones. This then increases its mass and lowers its negative charge. The takeaway is that it is quite hard to keep a black hole too positively or negatively charged for long.

What if you could somehow create two 1-kilogram black holes in a perfect vacuum with zero other forces? The particle physics laboratory CERN in Switzerland would like to talk to you. But there is another limit – the extremal charge for a black hole is the amount of charge it can

"Two negatively charged black holes attracting or repelling depends on the distance between them"

have before the electromagnetic forces trying to tear it apart balance the gravitational forces holding it together, creating an event horizon. If it had more charge than that, the interior of the black hole would be pushed beyond the event horizon, and as far as we know, that's impossible.

This also holds for the forces between two black holes. Neither can exceed the extremal charge, and if they are both at the extremal charge, the best you can do is have the electromagnetic repulsion between them balance their gravitational attraction. It doesn't matter how big they are; even if they were each 1 trillion kilograms, this would still be a limit.

And, as noted, it is very hard to keep a black hole from losing charge and gaining mass. It is possible that the extremal charge limit is incorrect, because black holes are weird. But barring that, eventually, gravity wins. That, or else both black holes disintegrate from Hawking radiation.

Philip Lillies
Ottawa, Canada
This is a very interesting question, and amazingly, I think I know the answer. At some specific distance, the black holes would neither repel nor attract. But if they just got a little closer together, they would attract each other (gravity would win). If they got a little farther apart, they would repel each other (negative charge would win).

The reason why is that gravity, unlike electrical force, is nonlinear. Gravity works by bending space-time, which adds energy, which causes more bending. In other words, gravity gravitates. Near massive bodies like the sun – or black holes – this effect becomes more noticeable, which is why Mercury's orbit slowly shifts over time. So, whether two negatively charged black holes would attract or repel depends on the distance between them.

Eric Kvaalen
Les Essarts-le-Roi, France
Certainly, if they have enough charge, two black holes will repel each other. Specifically, if they both have a ratio of charge to mass greater than 86.2 nanocoulombs per tonne or, more generally, if the geometric mean of this ratio for the two black holes is greater than that value. That's equivalent to 538,000 electrons per gram.

But the question is whether it is possible to create such black holes. If a non-conducting ball has a constant ratio of charge density to mass density throughout that is greater than 86.2 nanocoulombs per tonne, then it won't collapse into a black hole – it will expand. If a ball that does conduct charge, such as a star, has such a high charge, the charge will migrate to the surface, and the outer shell will be accelerated away from the rest of the star.

STEVE KYDD/ALAMY

Do all languages have the equivalent of please and thank you, as per this fierce sign?

This week's new questions

Only polite **Do all languages have the equivalent of "please" and "thank you"? Why are these words so important to us?**
***Adrian Moore**, Maidenhead, Berkshire, UK*

Blank sky **How would human civilisation differ if the sun, moon, stars and planets were always obscured by clouds?**
***Simon Rockett**, Debenham, Suffolk, UK*

Cosmic sprint

How long would it take to accelerate a spacecraft to 99 per cent light speed without major injury to astronauts within it? (continued)

Bryn Glover
Kirkby Malzeard, North Yorkshire, UK
Reading between the lines of the question about humans travelling at near-light speed, one might assume that the possibilities for human interstellar flight were on the questioner's mind. As if the three published answers were not depressing enough for that ambition, may I point out that each of them omitted a vital component for star travel: presumably, once the 99-per-centers approached their destination, they would need to stop to land and explore.

If deceleration is to be as non-traumatic as acceleration, then it will require the same amount of time and fuel as was consumed for the start of the journey, and the monstrous extra mass of that to be carried will clearly affect the calculations for acceleration.

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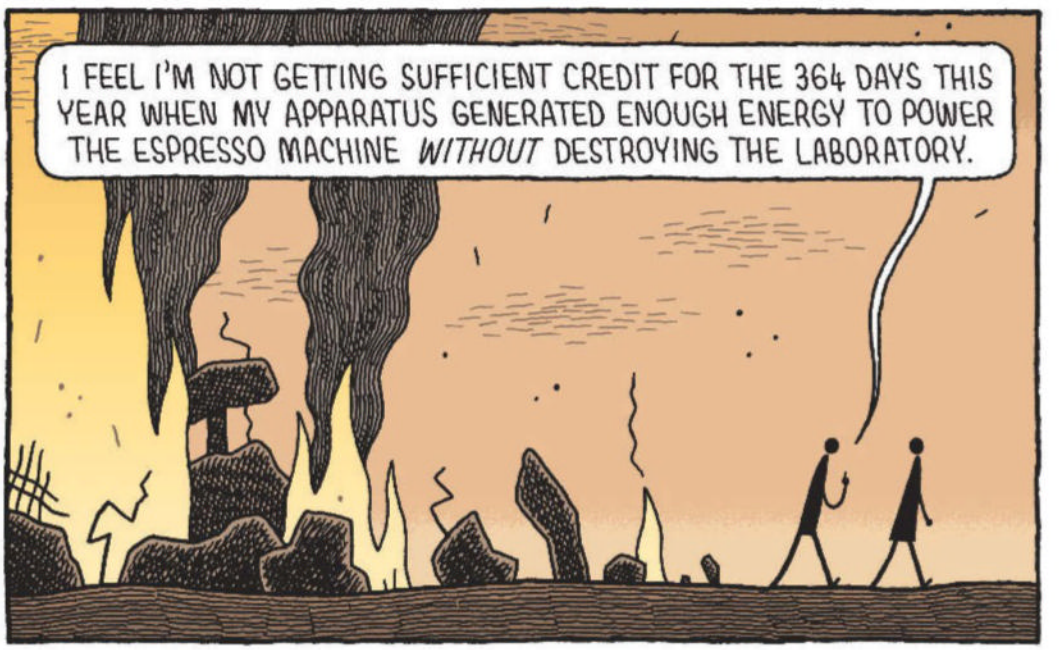
Tom Gauld
for New Scientist



I haven't done any careful calculations; when the message is so blunt, accuracy is immaterial. In an earlier issue, *New Scientist* reported on the discovery of a planet that may support life, and at 125 light years away, may well be the nearest such planet. To travel such a distance using sensible and possible technology would, I reckon, take rather longer than the existence of the *Homo* genus on Earth. It seems as though the dreams of Earth billionaires to colonise space will need to wait until *Star Trek*'s James T. Kirk comes along after all.

Mel Earp
Macclesfield, Cheshire, UK
The key number in many relativistic calculations is the Lorentz factor. It is often thought that this number becomes extremely large extremely quickly as you approach the speed of light. But this doesn't happen as fast as you might imagine; it certainly doesn't need to invoke the words "infinite" to stress the point.

In the question, the suggested final speed is 99 per cent the speed of light, or 99c. At this speed, the Lorentz factor is only slightly over 7. This would certainly be noticeable to a stationary observer in terms of length contraction and time dilation. What is also affected is the amount of energy needed to get that next bit of acceleration, seven-fold at this speed. Hence the need to carry lots of fuel, which merely adds to the problem. The added energy requirement makes the spacecraft look more massive to the observer and is known as the Lorentz mass, in this case, seven times the spacecraft's rest mass.

"Presumably, once the 99-per-centers approached their destination, they would need to stop to land and explore"

By way of comparison, the Large Hadron Collider (LHC) accelerates protons to about 99.999999 per cent the speed of light, or 0.99999999c. At this speed, the Lorentz factor is about 7000. Again, this isn't indescribably big. It does affect the energy required and is why the LHC consumes so much – along with its magnets, of course. The LHC does this in a time frame measured in tens of minutes, but at this acceleration rate, it wouldn't be comfortable for a passenger on one of the protons!

In both cases, there are no black holes and no fatal drawing-in of neighbouring masses to create one.

Guy Cox
Sydney, Australia
Some years ago, I was writing a science fiction story about a team colonising a planet 10 light years away. To keep the colonists healthy, they would accelerate at *1g* for half the journey and decelerate at *1g* for the second half, as to experience Earth's gravity the whole way. Their maximum speed would be 98 per cent of the speed of light. So, it would take 20 years to an outside observer, or six years from the passengers' perspective, to reach 98 per cent light speed at *1g* acceleration.

Answers

Quick quiz #302 *Answers*

1 Voyager 1

2 An astronaut in a spacesuit

3 Spinnerets

4 Acetylcholine

5 1926

Cryptic crossword #161 *Answers*

ACROSS 1 Nectar, **5** Caster, **8** Manatees, **9** Rate, **10** Alas, **11** Flogging, **12** Tattoo, **14** Anchor, **16** Quackery, **18** Each, **20** Bill, **21** Buckland, **23** Rancid, **24** Debunk

DOWN 2 Email, **3** Transit, **4** Rye, **5** Cassowary, **6** Shrug, **7** Eat into, **11** Flower bed, **13** Alumina, **15** Chem lab, **17** Colic, **19** Canon, **22** Cud

#72 Match up *Solution*

After two rounds, player A has a (2/3) × (2/3) = 4/9 probability of winning the game.

Player B has a (1/3) × (1/3) = 1/9 probability of winning after two rounds. In other words, player A wins 4 times as often as player B, or 4/5 of the time. This applies regardless of the number of rounds, as if neither wins after two rounds, they return to level.

If player B is one point up, the next point will either be won by player A (2/3 of the time) – taking them back to level, where player B wins 1/5 of the time – or it will be won by player B (1/3 of the time), who then wins the game. So the overall chance of player B going on to win is (2/3) × (1/5) + (1/3) = 7/15.

Hot! Hot! Hot!

Saturday 17 May will see the final of this year's Eurovision Song Contest, which will be the most over-the-top evening of television since, well, the previous Eurovision. Feedback is deeply relieved that Feedback Jr appears not to be interested this year, so we might escape having to sit up and watch the entire thing. While we are deeply supportive of the contest's kind and welcoming vibe, most of the songs make our ears bleed.

Anyway, who needs it when we have the winners of this year's Dance Your PhD contest? For readers who may not be familiar, Dance Your PhD encourages researchers to explain their postgraduate research findings through the medium of interpretive dance. It's been running since 2008, and Feedback thinks that countries struggling to find suitable entrants for Eurovision should take a look.

This year's winning routine is by Sulo Roukka at the University of Helsinki in Finland. Roukka studies chemesthesis: the sense, distinct from taste and smell, that detects the heat of chillies and the coolness of menthol. The video is set to a walloping song that Feedback didn't recognise but would describe as "Lady Gaga-adjacent" (there are shouts of "Hot! Hot! Hot!" at key points). It starts with Roukka and his team dancing while seated around a table with lab equipment, before unleashing a cavalcade of costume changes, stunts (at one point Roukka is lifted up, Kylie Minogue-style) and lurid red and green colour schemes to signify the different chemesthetic sensations.

To quote the UK's Eurovision entry, what the hell just happened?

Truly, the most shocking thing about the routine is that it isn't already on Eurovision. The only possible snag is that the song was "prompted by Dr Sulo Roukka, Sampo Marjomaa, and AI-Shaman Jami Pietilä". If that is a reference to using AI, it might run afoul of Eurovision's organisers.

If Eurovision isn't an option, Dance Your PhD at least ought to get onto TikTok. *Science* did post a sample of Roukka's video to its TikTok account, but the contest is otherwise absent – from the one app that's basically famous for the song and dance trends it spawns.

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

Watts going on?

An email arrives from John Harper at Victoria University of Wellington in New Zealand, alerting us to that rare unicorn: a "double dose of nominative determinism". The country's minister for energy is one Simon Watts. In this position, Watts naturally spends a lot of his time dealing with the Electricity Retailers' Association of New Zealand, an industry organisation whose independent chair is one Simon Watt.

"They both know it needs more than 2 watts to keep our lights on," points out John.

Imagine if their kids got married.

World's top polymath

Feedback likes to think we have a broad range of interests. Science, sure, but also history, music, cinema, books, video games, ASMR videos as long as they don't involve chewing noises; it's a broad mix of stuff in our brain. Of course, this does mean that Feedback isn't really an expert in anything, apart from dragging out a simple point to fill an entire paragraph without regard for concision or readability.

Nevertheless, Bruce Durie has us outclassed. "I've recently discovered that I'm internationally regarded as quite the polymath," he writes. This was based on him having been invited, in rapid succession, to speak at conferences on subjects as diverse as chemistry, social studies, education, cell biology, cancer research, and two successive events on arts, humanities, social sciences and education.

To be clear, Bruce is rather an accomplished person: he's a genealogist and heraldist who lectures, writes books and presents on BBC Radio. But quite what he would be doing at conferences on chemistry or cancer research is beyond both him and us.

Yet it doesn't stop there. His "encyclopaedic eminence" has also led him to be invited to submit papers to a host of journals, which "aspire to disseminate supreme publications from prominent people like you" and describe him as "one of the leading experts in the field" and "similar hyperbolic emollients".

Bruce actually listed these journals in full. We thought it might be funny to reproduce his entire list, but when we tried there were so many long words it took up most of a column. (Also, the lawyers said we shouldn't.) Suffice it to say, they ran the gamut from archaeology and family medicine to infrastructure and posthumanism.

Finally, Bruce has been offered yet another academic accolade: "I am 'highly invited' to become the editor-in-chief of a new but unnamed journal from the Euro-Asia Academic Alliance. I can even start my own journal – last month alone, 58 scholars successfully did so, we're told."

Also spare a thought for molecular biologist Richard Sever, at Cold Spring Harbor Laboratory in New York state. He was sent a "request to accept for the position of 'editorial board' for the journal *Advances in Behavioral Neuroscience*". As he put it on Bluesky: "Can't think of anyone less qualified for this than I am – except perhaps the people who run the journal..."

We truly do live in a brave new world, where scientific journals and conferences are promoted in the same way as Nigerian princes and cryptocurrencies.

As Bruce says: "Predatory publishing is one thing, but aren't predators supposed to be stealthy at the very least?"

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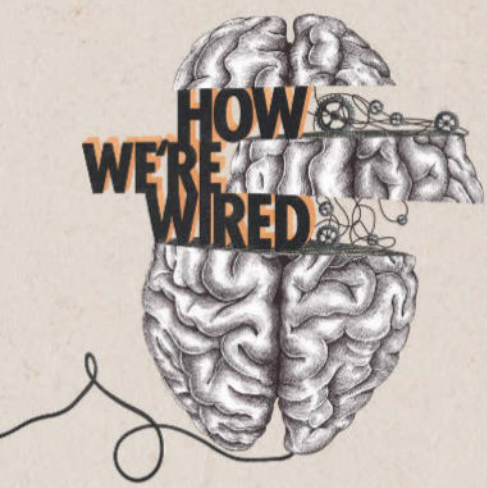

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