New Scientist

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HOW REMOVING AIR POLLUTION HAS WARPED THE WEATHER

THE SURPRISING POWER OF ONE MINUTE OF EXERCISE

SECRET LANDSCAPE OF THE QUANTUM REALM

We've caught our first glimpse of the strange world where particles roam

SNOT TRANSPLANTS

Can a radical new treatment relieve chronic sinus infections?

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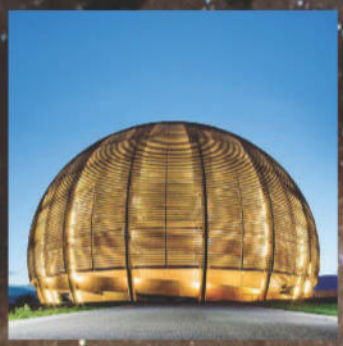

CERN and Mont Blanc, dark and frozen matter: Switzerland and France

7 October 2025 | 6 days

Prepare to have your mind blown as you explore the world's greatest physics laboratory, CERN.

- Walk the grounds of the famous Large Hadron Collider and witness firsthand where groundbreaking discoveries are shaping the future of science
- Take a trip on Europe's highest vertical ascent cable car to the Aiguille du Midi
- Joined by CERN physicist Darren Price to gain rare insider access through private lectures and a guided tour of the facility's groundbreaking experiments.

Land of fire and ice: Iceland

18 October 2025 | 8 days
2 August 2026 | 6 days

Discover Iceland like never before on this immersive tour accompanied by a volcanologist who will reveal the hidden stories and powerful forces shaping the landscape.

- Visit a spectacular ice cave, located underneath Europe's biggest ice cap, Vatnajökull, with around 30 glaciers flowing out from it
- Explore Thingvellir National Park, Gullfoss and Skógafoss waterfalls and the Jökulsárlón glacier lagoon
- See where two tectonic plates meet and walk on lava from recent fissure eruptions at the Reykjanes peninsula

Science of astronomy and the northern lights: Sweden

18 March 2026 | 5 days

Journey with astronomy expert Jamie Carter to the Arctic to discover the wonders of astronomy and the northern lights under some of the clearest skies on Earth.

- Learn about the science of the northern lights from experts at the Aurora Sky Station, where you'll uncover the fascinating physics behind this natural wonder
- Accompanied throughout by astronomy expert Jamie Carter, guiding you through stargazing sessions for a better understanding of the night sky
- Sleep on ice at the world's coolest hotel, where you'll stay in artfully crafted rooms sculpted entirely from ice and snow

Astronomy and radio telescopes in New South Wales: Australia

29 April 2026 | 8 days

Experience an unforgettable journey through eastern Australia alongside renowned astrophysicist Jonathan Bland-Hawthorn.

- Visit iconic observatories, including the Parkes Observatory, which received the first television images of Neil Armstrong's Moon landing
- Enjoy guided nighttime observing sessions in Australia's first International Dark Sky Park, one of the best places on Earth to see the southern constellation
- Travel alongside Professor Jonathan Bland-Hawthorn, a world authority on galactic structure and evolution

Find out more and explore other fascinating voyages of discovery online

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A note from the magazine editor

Dear reader,

Here at *New Scientist*, we love hearing from you, and so I have an ask of you.

Over the next two weeks, we are running a survey to get your feedback about the print magazine so that we can make it even better.

Whether this is the first time you've picked up a copy or you are a seasoned subscriber, we want to know what you love and what you would rather do without. Do you have a favourite section? Are you a culture vulture or a news hound? Do you prefer in-depth articles or solving our puzzles? What are we missing or what could we do better?

The survey should take no more than 10 minutes to fill in. Please do be honest! To take part, please scan the QR code below with your smartphone or go to: newscientist.com/magazinesurvey.

Thanks so much for taking the time to share your valued opinions. I look forward to finding out what you think.

Eleanor Parsons
New Scientist magazine editor

Our material world

As our lives play out in the digital realm, materials are undergoing a quiet revolution

THESE days, our lives revolve around the digital world. Money, culture, news, gossip – all of it lives there. Generative artificial intelligence is the biggest story in the world, but could you point to where that technology is physically located? The material world just isn't where the action is.

And yet, despite appearances, we still live in a material world. We need steel for building, lithium and cobalt for batteries, and (despite our best efforts) oil to power our vehicles. Materials might not be sexy, but they still undergird our way of life and shape world events.

We may now be on the cusp of something radical: a completely new way to understand materials. History teaches us that the consequences could be huge. The last time we had such a groundbreaking idea in materials science, it was the late 1920s, with discoveries about the way electrons occupy particular energy levels – or bands – and the gaps between them. This presaged the development of the transistor, the basic unit of all computer hardware, including the chips that power modern AI.

"Materials may have a subtle, undulating quantum topography"

But researchers have long suspected that the innards of materials contain more than those simple energy bands. They may also have a subtle, undulating quantum topography that could determine their properties. And as we report in our cover feature (see page 30), we are now charting this quantum landscape for the first time.

This deeper exploration could lead to discoveries as revolutionary as the transistor. One hope, for example, is a material that conducts electricity with zero resistance at room temperature.

Finding one of these superconductors would mean we could transmit electricity with no loss in power, a serious boon to green energy and our fight against climate change, among other things.

Even better, this probing could lead us to some new kind of material that we haven't foreseen at all. Far from retreating from the material world, we might be on the brink of expanding its horizons. ▮

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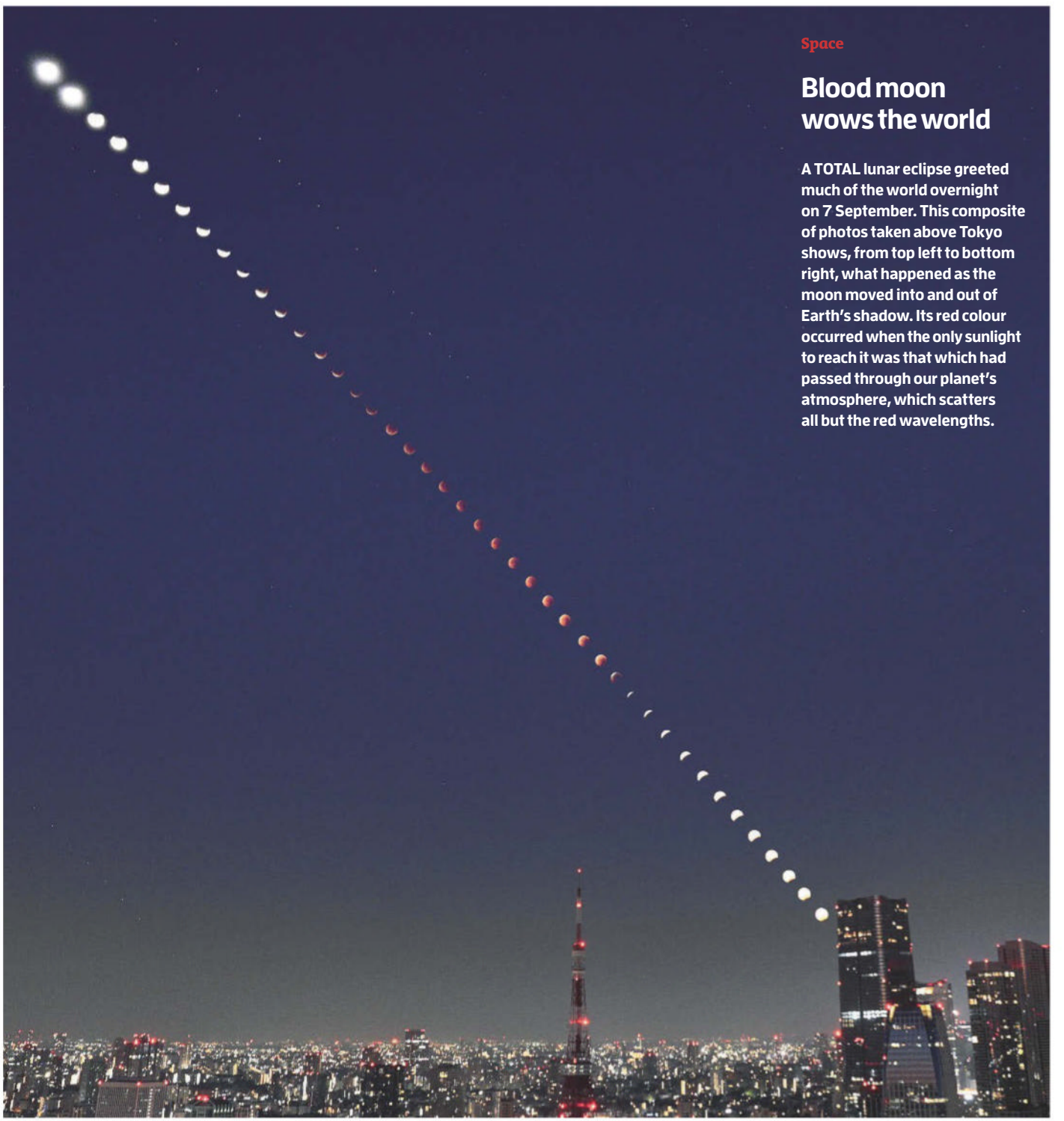


KYODO NEWS VIA GETTY IMAGES

Space

Blood moon wows the world

A TOTAL lunar eclipse greeted much of the world overnight on 7 September. This composite of photos taken above Tokyo shows, from top left to bottom right, what happened as the moon moved into and out of Earth's shadow. Its red colour occurred when the only sunlight to reach it was that which had passed through our planet's atmosphere, which scatters all but the red wavelengths.

Neuroscience

Brain map may explain intuition

Scientists have mapped the activity that takes place across a mouse's entire brain and observed how it changes based on prior experience, finds **Helen Thomson**

THE first complete activity map of a mammalian brain has revealed unprecedented insights into how decisions are made – and may even hint at the roots of that mysterious feeling we call intuition.

For decades, neuroscientists have wanted to capture activity across the whole brain at the level of individual neurons – but there is a limit to how many neurons an electrode can record from, how many electrodes can be implanted in a single brain and how many animals a single lab can test.

To overcome this, researchers across 12 labs have joined forces, each running the same experiment but recording activity from different areas of the brain, with some overlap to ensure the data they collected was consistent. The combined data from more than 650,000 neurons has produced the first brain-wide activity map of a complex behaviour.

"This work demonstrates a completely new way of tackling complex questions in modern neuroscience," says Benedetto De Martino at University College London, who wasn't involved in the research. "Just as CERN [the European Organization for Nuclear Research] brought physicists together to confront the deepest problems in particle physics, this project unites labs worldwide to take on challenges too great for any single group."

At each lab, mice were trained to move a stripy target towards the middle of a screen using a tiny Lego steering wheel. When the stripes were high contrast, the target stood out clearly. When the contrast diminished, the target all but disappeared, and the animals relied on prior knowledge to answer correctly in order to receive a reward.

Biases were built into the experiment to influence the mice's prior expectations of where the target might be – it might appear on the left side of the screen 80 per cent of the time and on the right side 20 per cent of the time, for instance. When the bias was flipped, the mice updated their expectations accordingly.

"The map shows activity associated with decision-making is distributed across the brain"

The resulting map reveals that activity associated with decision-making isn't confined to a single region, but is distributed across the brain (*Nature*, doi.org/p4vq). "There have been lots of claims about 'this area does this'. If there's one thing we've discovered from this work, it's that no one brain area 'decides'," says team member Alexandre Pouget at the University of Geneva in Switzerland. "Decision-making involves tens of areas that decide through a kind of consensus."

The results also support previous work showing that decision-related signals build long before action is taken. Pouget says that even before each individual experiment began, while the mouse was still, signals associated with the next decision were apparent. These built up as the target appeared, until they reached a threshold, at which point the mouse moved the wheel.

A second paper shows how prior expectations, in this case the belief about where the target might be, are encoded in brain activity remarkably early. The researchers found that even as signals left the eye and began their journey to the thalamus, the brain's relay centre, prior expectation of whether the target would be on the left or right had already had an effect (*Nature*, doi.org/p4vr).

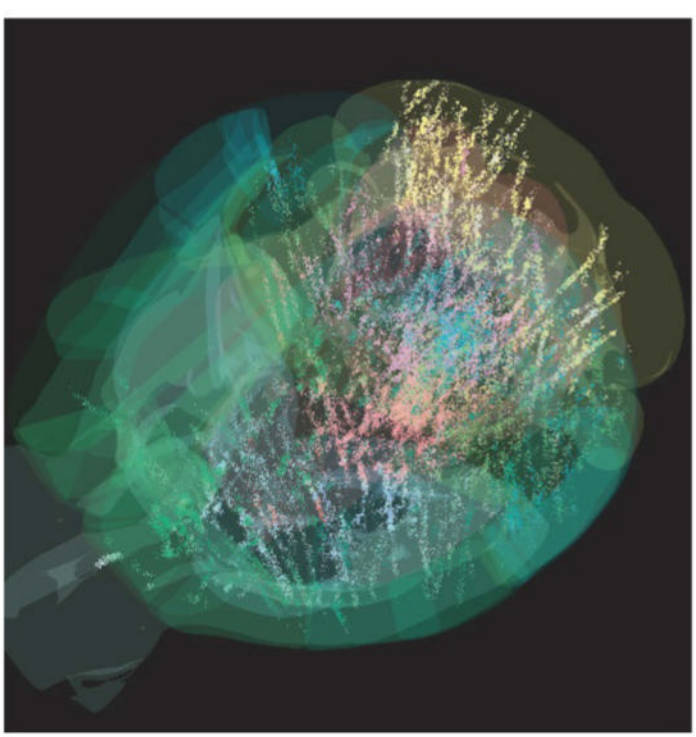
This suggests that from the moment sensory data enters our brain, it is already encoded in a way that is influenced by prior knowledge, swaying our conscious decision-making process without our awareness, says Pouget. It is speculation, but this might correspond with what we perceive as intuition, he says.

Managing expectations

What is particularly intriguing is that the encoding appears not only to be tracking recent sensory experiences, but also the recent history of choices taken, says Laurence Hunt at the University of Oxford. "This suggests that it is our own behaviour and subjective experience that shapes what we expect to see next, rather than the true, objective state of the world."

Does this imply our decisions are predetermined? "The brain plus the world around it forms a deterministic system. People hate that, but it's true," says Pouget. "It means that I can predict, to some extent, what you're going to do before you actually decide." However, when we acquire new data, we modulate that prior expectation, and because we don't know how the world around us will evolve, it creates uncertainties, he says.

In the future, the researchers hope their results and approach will advance understanding of conditions such as autism. Mouse models of autism suggest these animals have difficulties updating their prior expectations when new information comes along, which fits with what we see behaviourally in people, says Pouget. ▮



DAN BIRMAN, INTERNATIONAL BRAIN LABORATORY

This map of a mouse's brain shows 75,000 neurons

Space

Blip detected in space could be the earliest galaxy we've ever seen

Jonathan O'Callaghan

ASTRONOMERS might have discovered a galaxy that formed extremely early in the universe, nearly 200 million years before its closest competitor, but there could be other explanations too.

Giovanni Gandolfi at the University of Padua in Italy and his colleagues probed data from the James Webb Space Telescope (JWST) to look for distant objects that formed early in our universe's 13.8-billion-year history.

The further away a galaxy is from Earth, the longer its light will have taken to reach us and the more it will be shifted to the red end of the spectrum by the expansion of space, a property known as redshift.

To date, the earliest confirmed galaxy – which was spotted by JWST and is called MoM-z14 – has a redshift of 14.4, meaning the light now reaching us from it began travelling towards us when the universe was 280 million years old. Gandolfi and his team, however, have reported an object with a redshift of 32, implying that we are viewing it as it was when the universe was just 90 million years old (arXiv, doi.org/p4vp). They named it Capotauro, after a mountain in Italy.

"Capotauro could be the farthest galaxy ever seen," says Gandolfi, at a "timescale that is compatible with the first stars and black holes to form in the universe".

The researchers arrived at this conclusion by noticing a small blip that appeared to be a distant galaxy in a deep JWST survey of the sky. Using different filters on the telescope, they could calculate how much the light from the galaxy would have been redshifted, arriving at a figure of 32.

If correct, the object might be an extremely young galaxy in the process of formation, or something more unusual like a primordial black hole surrounded by a dense atmosphere – a hypothesised object known as a black hole star.

However, the supposed galaxy appears unusually bright, similar to galaxies seen at later redshifts like MoM-z14, giving it a suspected mass of around a billion times that of the sun – beyond what models suggest should be possible at this age of the universe.

To achieve such a mass, the efficiency at which the galaxy turned gas into stars would have to be close to 100 per cent, says Nicha Leethochawalit at the National Astronomical Research Institute of Thailand: "It means no stars can explode." But modelling suggests no more than 10 to 20 per cent is possible. "I think there's something wrong," she says.

If it isn't a galaxy, Gandolfi and his team say the object could instead be explained by a brown dwarf – a failed star – or a rogue planet in our galaxy drifting through JWST's field of view, appearing similar to the distant blob of a galaxy. Those explanations are interesting too, says Gandolfi, because it would be a particularly remote and cold brown dwarf or planet, up to 6000 light years away and at room temperature.

"It could be one of the first substellar objects ever formed in our galaxy," says Gandolfi. ▮

The possible galaxy was detected using the James Webb Space Telescope

BEST-BACKGROUNDS/SHUTTERSTOCK

Quantum computing

Quantum router might speed up quantum computers

QUANTUM computers may be able to run useful algorithms more quickly, thanks to a new quantum router that helps data get to the right place faster.

Traditional computers avoid becoming slow when faced with a complicated program in part by using random access memory (RAM) to temporarily store some information. The component key to building RAM's quantum counterpart, QRAM, is a router. This isn't the router that directs your internet queries to the right IP address, but rather an internal router that directs informational traffic inside a computer.

Connie Miao at Stanford University in California and her colleagues have now built such a device. The router consists of qubits, the basic building blocks of quantum computers and quantum memories, made from tiny superconducting circuits and controlled by electromagnetic pulses.

Similar to a traditional router, this quantum one sent quantum information to quantum addresses. What distinguishes the device as being fully quantum is that it allows the address to be encoded not just in one place, but in a "superposition" of two. The team tested this with three qubits and found the routing to have about 95 per cent fidelity. The work will appear in *PRX Quantum*.

This means that if it were incorporated into a QRAM, the device could push information into a quantum state where it is impossible to say which of the two locations it is stored in – exactly the kind of phenomenon believed to make quantum computers powerful.

"The device allowed the address to be encoded not just in one place, but in a 'superposition' of two"

Luming Duan at Tsinghua University in China, whose team previously built a quantum router that only worked during some runs, says the new device is an important step towards building practical QRAMs, which may enable quantum machine learning algorithms to run. ▮

Karmela Padavic-Callaghan

Mental health

A single dose of LSD could be enough to reduce anxiety

Carissa Wong

JUST one dose of the psychedelic drug LSD seems to reduce anxiety without lasting side effects.

Generalised anxiety disorder is characterised by excessive worry about a broad range of things, such as work and relationships. First-line treatment includes mood-enhancing drugs, like selective serotonin reuptake inhibitors (SSRIs) and other antidepressants, and talking therapies. But about half of people don't respond to such treatments.

Previous studies have suggested LSD may be an alternative. The psychedelic is used recreationally for its hallucinogenic effects. Dan Karlin at biotech company MindMed in New York says it is thought to act by increasing levels of the mood-boosting chemical serotonin in the brain.

Until now, no trial comparing those taking LSD with others taking placebo pills has explored whether the substance can benefit people with generalised anxiety disorder.

To fill this gap, Karlin and his colleagues recruited 198 adults with the condition. The participants slowly tapered off any anxiety medications they had been using, but those who were receiving psychotherapy continued with their sessions.

In a survey commonly used in clinics, the participants then rated the severity of each of 14 symptoms, such as feeling worried, tense or struggling to focus, on a scale of 0 to 4. Out of a maximum total score of 56, the participants scored 30, on average, above the threshold of 24 for severe anxiety.

Next, the team randomly split the participants into five groups that took either LSD – at various doses of 25, 50, 100 or 200 micrograms – or placebo pills, without being told which they were given. A day later, those who had received 100 and 200 microgram doses, but not the other groups, already reported an improvement in symptoms, says Karlin.

A month later, those who had received the 100 and 200 microgram doses experienced an average 21- and 19-point reduction in anxiety, respectively, with the improvement sustained until the end of the study, three months after the dosing day. About 46 per cent of these participants went into remission, which is a score of 7 or below (*JAMA*, doi.org/p4v4).

> "It's a promising finding that you can get a very rapid effect in symptom reduction"

Meanwhile, those taking the placebo and the two lower doses saw between a 14- and 17-point reduction in anxiety over the same period, with about 20 per cent going into remission.

The benefit seen by the two highest dose groups is a substantial improvement above the placebo, says Sunjeev Kamboj at University College London.

Those on lower doses of LSD and on the placebo experienced changes in visual perception like hallucinations at far lower rates than those on the higher doses. This makes it hard to tell whether the LSD-related benefits were due to a person's expectations based on the effects they felt or the direct effects of the drug on the brain, says Kamboj.

However, he says, "It's a very promising finding that you can get a very rapid effect in symptom reduction, that would be extremely meaningful to patients." ▮

Chemistry

Sun-powered device extracts lithium more sustainably

THE mining of lithium for batteries – the key to the electric vehicle revolution and levelling out the power supplied by renewables – is environmentally damaging. But an experimental sun-powered method could make it more sustainable.

Today, most lithium is obtained from underground brine reservoirs in the Andes. The brine is concentrated by letting it evaporate in open-air ponds for months, and the subsequent extraction of lithium carbonate from the concentrated brine requires large quantities of fresh water. What's more, as the brine is pumped out of the reservoirs, fresh water in the rocks above may flow down to replace it, causing the water table to fall.

PHILIPPE PSAILA/SCIENCE PHOTO LIBRARY

Most lithium is obtained from brine that's been evaporated in open-air ponds

Yu Tang at Lanzhou University in China and her colleagues have developed a direct litihium extraction method that doesn't require open-air evaporation. It would also produce fresh water that could be used or pumped back underground.

The researchers based their technique on a form of manganese oxide with two key properties. Firstly, it converts a lot of the light falling on it into heat. Secondly, it can selectively bind to lithium ions.

In their design, a thin layer of brine or seawater flows down a sun-facing layer of manganese oxide. As the sun warms the material, the water evaporates and the lithium ions bind to the oxide. Once the layer is saturated, the ions can be removed using an acidic solution, and the material can be reused (*Advanced Functional Materials*, doi.org/p4v8).

Because the process takes place inside a sealed system, the water that evaporates condenses out and can be harvested. The team has tested a small prototype over five cycles of lithium adsorption and release, and the harvested water met the drinking standards of the World Health Organization. ▮

Michael Le Page

Entomology

Queen ant can make two species

Iberian harvester ant queens lay eggs that turn into males of another species. This trick helps the colony survive, but it may not work forever, finds **Tim Vernimmen**

JONATHAN ROMIGUIER

These *Messor ibericus* (left) and *Messor structor* (right) ants share the same mother

SOME of the eggs laid by Iberian harvester ant queens contain males of another species, the builder harvester ant – and these males father all of the workers in the colony.

"This statement sounds really, really crazy, like impossible," says Jonathan Romiguier at the University of Montpellier in France. And yet, it is true.

Romiguier became intrigued by Iberian harvester ants (*Messor ibericus*) when he discovered that all the workers in *M. ibericus* nests were hybrids, with about half of their DNA matching that of the builder harvester ant (*Messor structor*).

The most likely explanation, it seemed, was that *M. ibericus* queens were mating with *M. structor* males. This kind of thing happens in some other ant species. No one knows why, but there are two competing explanations that appear to be most likely. One is that hybrids of closely related species benefit when the genes of each species compensate for some of the other's flaws, a concept known as hybrid vigour.

Another possibility is that it might resolve a peculiar problem that *M. ibericus* shares with some other harvester ant species: whenever *M. ibericus* queens mate with *M. ibericus* males, all of their offspring become queens. This might be due to a genetic quirk that ensures its own inheritance but is devastating for the colony, which needs workers in order to survive. Breeding with another species may be a way to circumvent this.

However, *M. ibericus* colonies occur in many areas across the Mediterranean region where there are no *M. structor* colonies, including on the island of Sicily. Yet Romiguier and his colleagues

"The queen ensures her daughters that become queens can mate with males of both species"

did find some odd-looking, hairless *M. structor* males in *M. ibericus* nests. So where were they coming from?

Genetic analysis of the strange males provided a confusing clue. A tiny bit of DNA that is inherited only from the mother, the mitochondrial DNA, in these M. *structor* males was the only bit that clearly belonged to *M. ibericus*, revealing that their mother was an *M. ibericus* queen.

This suggested that an egg of an *M. ibericus* queen can contain a male from another species. To test this idea, Romiguier brought dozens of *M. ibericus* colonies into his lab. "It was very difficult, because in lab conditions, it's nearly impossible to have males," he says. "We had something like 50 colonies, and monitored them for two years without a single male being born. Then we got lucky."

With three *M. structor* males born in the lab, the evidence was unmistakable: *M. ibericus* queens were producing males of both species (*Nature*, doi.org/g92j8t). The only possible explanation for this appears to be that the queen ants are cloning the *M. structor* males from sperm stored in a specialised organ called a spermatheca. The resulting eggs are almost entirely devoid of *M. ibericus* DNA, except for their mitochondrial DNA, which is absent from sperm.

This also explains where that *M. structor* sperm is coming from: by producing two species of males, the queen ensures that her daughters that become queens themselves can mate with males of both species. They use *M. ibericus* sperm to make new queens, while *M. structor* sperm is used to produce hybrid workers and new *M. structor* males.

There are a few examples from other animals – including some ants, clams and stick insects – where a female's eggs are hijacked by the sperm of a male from another species, which eliminates the DNA from the egg and forces her to produce an individual she is unrelated to. Yet this benefits only the males. This is the only known case of males and females from different species that depend on each other to reproduce.

Not made to last?

"The *M. ibericus* queens absolutely need their clonal males. Otherwise, they can't have workers," says Romiguier. And the clonal *M. structor* males need *M. ibericus* queens to reproduce and hybrid workers to survive – there is no evidence they are ever mating with their own kind.

The findings have convinced other experts. "The authors have done a very rigorous study of the ants in question," says Nathan Lo at the University of Sydney.

He suspects that because the clonal males never mix genes with other lineages, they are gradually accumulating bad genetic mutations they cannot get rid of. "So, at some point, the lineage may start to deteriorate, especially as environments change."

Romiguier agrees that this peculiar situation might eventually collapse. But as much as it looks as if these *M. ibericus* females and *M. structor* males may have painted themselves into an evolutionary corner with their dangerous liaison, for now, their tryst appears to be a success. ▮

Climate change

Earth's capacity to store CO_2 could be less than we thought

Madeleine Cuff

SIGRG/CARBFIX

Power plants may only be able to inject so much CO_2 underground

THE world may run out of storage space for captured carbon dioxide within the next two centuries, according to new research that suggests the planet's practical capacity for holding CO_2 underground is far less than we thought.

Storing captured CO_2 in subterranean reservoirs has been touted by governments and industry as a way to reach net zero without eradicating fossil fuel use.

The planet's capacity for storing this CO_2 was thought to be vast, with industry estimates putting global geological storage capacity at around 14,000 gigatonnes of the gas.

But together with his colleagues, Joeri Rogelj at Imperial College London has conducted further analysis of storage reserves and found the usable volume of storage space may be far smaller. The team analysed stable geological formations, excluding areas affected by risk factors such as proximity to large cities, environmentally sensitive landscapes or regions vulnerable to earthquakes. Once those factors are taken into account, they conclude that just 1460 gigatonnes of geological storage capacity is available globally (*Nature*, doi.org/p4vg).

"We have reduced the practical potential that we think one should assume for CO_2 storage by a factor of 10," says Rogelj.

"We have reduced the practical potential one should assume for CO_2 storage by a factor of 10"

Most climate projections assume some level of underground carbon storage will be needed to enable the world to reach net-zero emissions.

How much storage will be used depends largely on how far the world manages to reduce fossil fuel use. If we continue to use geological storage to sequester large volumes of emissions from fossil fuel plants once net zero has been reached, the world's carbon storage is likely to run out by 2200, the researchers warn.

Rogelj argues that his findings mean we should treat underground carbon storage sparingly, when all other options to decarbonise have been exhausted. For example, rather than capturing emissions from coal or gas power plants and storing them underground, economies should rely on zero-emission power sources where possible, he says.

That would free up underground storage capacity for CO_2 trapped using technologies such as direct air capture (DAC), which draws excess CO_2 straight from the atmosphere. DAC, as well as other so-called "negative emissions" technologies, could offer the world a route to going beyond net zero and delivering net-negative emissions, effectively reversing climate change.

If the 1460 gigatonnes of feasible underground CO_2 storage capacity were reserved for this CO_2 drawdown, the world could reverse up to 0.7°C of warming, Rogelj and his colleagues calculate.

However, Stuart Haszeldine at the University of Edinburgh in the UK warns that while the usable capacity of geological storage is likely to be less than industry estimates, he suspects the new figure is too low.

The team's approach to risk factors is "extremely cautious", he argues, pointing out that some earthquake-prone areas, such as the North Sea, are effectively excluded by their approach, but can still be safe places to sequester carbon. ▮

Health

Smartphone use on the toilet may raise risk of haemorrhoids

Michael Le Page

DO YOU use your smartphone while you sit on the toilet? If so, you could be increasing your risk of haemorrhoids by nearly 50 per cent.

Trisha Pasricha at Beth Israel Deaconess Medical Center in Boston, Massachusetts, and her colleagues asked 125 people who were scheduled for colonoscopies to fill out questionnaires about their toilet habits, general health and physical activities. Images from the colonoscopies were then reviewed to determine if they had haemorrhoids, which are lumps in the rectum or around the anus.

Two-thirds of the participants, who were all aged over 45, said they used their smartphone on the toilet. Of those participants, 37 per cent of them spent more than 5 minutes on the toilet on average, compared with just 7 per cent of those who didn't use their device there – that is, phone-users were about five times as likely to spend more than 5 minutes on the toilet.

After adjusting for factors such as age and activity levels, the team concluded that smartphone use on the toilet is associated with a 46 per cent greater risk of haemorrhoids (*PLoS One*, doi.org/g92fhp). "Obviously our study didn't prove causation," says Pasricha. To address this, the next study will be an intervention one – where some participants will be asked not to use phones on the WC, which should help gauge whether it really is a problem.

Pasricha's study suggests the main risk factor for haemorrhoids is time spent on the toilet. The team speculates this is because our pelvic floor muscles have less support in this position than when we sit on a flat surface. "You don't have pelvic floor support, so there's this increased passive pressure that's engorging those hemorrhoidal cushions," says Pasricha. ▮

Space

Black hole search gets AI assistance

Using Google DeepMind to help detect gravitational waves could lead to new discoveries

Matthew Sparkes

EFFORTS to understand the cosmos could get a boost from an AI developed by Google DeepMind. The algorithm can cut unwanted noise by up to 100 times at the Laser Interferometer Gravitational-Wave Observatory (LIGO), which might allow this experiment to spot a particular type of black hole that has so far proved elusive.

LIGO is designed to detect the gravitational waves produced when objects such as black holes spiral into each other and collide. These waves cross the universe at the speed of light, but the fluctuations they cause in space-time are extremely small – 10,000 times smaller than the nucleus of an atom. Since its first observations 10 years ago, LIGO has recorded such signals produced by nearly 100 black hole collisions.

To do so, the facility consists of two observatories in the US, each with two arms 4 kilometres long that are set perpendicular to each other. Lasers are beamed down each arm, reflected by precise mirrors at the end and then compared using an interferometer. The length of the arms is changed by a tiny amount as gravitational waves wash over them, and this is carefully recorded to build a picture of the origin of these signals.

Such demanding accuracy is required that even distant ocean waves can affect measurements. This noise can easily drown out signals, which then makes some observations impossible. Dozens of major adjustments need to be made to filter out the worst of this noise, tweaking the orientation of mirrors and other equipment.

When black holes collide they produce gravitational waves

VICTOR DE SCHWANBERG/SCIENCE PHOTO LIBRARY

DeepMind's new Deep Loop Shaping AI aims to reduce the level of noise from adjusting the mirrors at LIGO by up to 100 times (*Science*, doi.org/p4vj). The AI was trained in a simulation before testing in the real world, and is effectively tasked with achieving two goals: reducing noise and minimising the number of adjustments it makes. "Over time, by repeatedly doing it – it's like hundreds and thousands of trials that are running in simulation – the controller will sort of find what works and what doesn't work," says Jonas Buchli at DeepMind.

Alberto Vecchio at the University of Birmingham, UK, who wasn't involved in the research but works on LIGO, says the AI is exciting, although there are many hurdles yet to overcome.

Firstly, the technology has been run for only an hour in the real world on LIGO, so it needs to be shown that it can operate for weeks or even months at a time. Secondly, the technology has so far been applied to only one aspect of control, helping to stabilise the mirrors, and there are hundreds if not thousands of aspects it could conceivably be applied to.

If similar improvements could be made across the board, then he thinks we could spot so-called intermediate-size black holes – for example those with masses around 1000 times that of our sun – a class of objects without any confirmed observations. The improvements would tend to occur on lower-frequency gravitational waves, where the length of wave is more susceptible to noise, and which are created by larger objects.

"We know black holes up to 100 solar masses. We know the black holes in our galaxy that are a million solar masses and above. What's in between?" says Vecchio. "People think there will be black holes at all these different mass ranges, but nobody has got uncontroversial experimental observational evidence." ▮

Technology

A modified hot glue gun can mend broken bones

WITH a few tweaks, hot glue guns commonly used in arts and crafts can repair damaged bones quickly and cheaply.

Bones can repair themselves after small injuries, but if there is a void – because of serious trauma or tumour removal, for example – then that space needs to be filled with either a graft or an artificial plug made of a material that encourages bone cells to spread.

One solution is to use 3D printers to create perfectly fitting scaffolds to fill such voids, but this requires scanning and remote fabrication – a process taking at least a week. That is fine for a pre-planned operation, but not emergency trauma surgery.

To solve this problem, Jung Seung Lee at Sungkyunkwan University in South Korea and his colleagues have developed a system that can be applied instantly during a single surgery.

They modified a hot glue gun by reducing the temperature at which it operates from over 100°C (212°F) to around 60°C (140°F). They also made a material that acts as a biological glue – a mixture of hydroxyapatite, which makes up 50 per cent of the volume of normal human bones, and a biodegradable thermoplastic called polycaprolactone (*Device*, DOI: 10.1016/j.device.2025.100873).

Surgeons can use the hot glue gun to fill bone voids in a matter of minutes during surgery, and bone cells are then able to span the gap and repair the injury over time.

Lee and his colleagues tested the glue gun by repairing centimetre-long gaps in rabbits' femur bones.

"Surgeons can use the hot glue gun to fill bone voids in a matter of minutes during surgery"

In samples taken after 12 weeks, there were no signs of medical problems or separation between the glue and the bone. The bone volume was more than twice as high in the animals treated with the glue gun than in control animals where the repair was made with traditional bone cement.

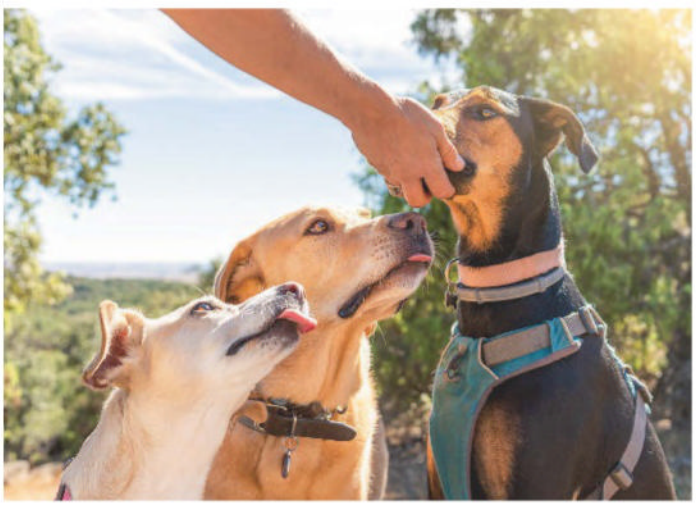
The researchers also found they could incorporate vancomycin and gentamicin, two antibacterial compounds, into the filament to reduce the potential for infection. The drugs are released slowly and diffuse directly onto the surgical site over several weeks. ▮

MS

Nutrition

Meat-free dog foods meet most dietary needs

Christa Lesté-Lasserre



SHUTTERSTOCK/IVAN MORENO SL

Some dog owners struggle with the ethics of feeding their pets meat

VEGETARIAN and vegan dog foods just need a few tweaks to make them nutritionally complete diets. Analyses reveal that meat-free dry kibbles are lacking only in iodine and B vitamins.

Many vegan and vegetarian dog owners struggle with the ethics of feeding meat to their omnivore pets, says David Gardner at the University of Nottingham, UK. So pet food manufacturers have started offering plant-based kibble.

Government organisations like the European Pet Food Industry Federation and the Association of American Feed Control Officials require standardised testing of commercial pet foods and additives to ensure they meet nutritional standards. Even so, most pet foods worldwide don't go through robust nutritional testing by independent research teams, says Gardner.

He and his colleagues analysed 25 commercial dry foods for healthy adult dogs – 19 containing meat and six based exclusively on plants. Among the latter, two were labelled as vegetarian and four were vegan.

None of the foods met all the official nutritional guidelines for dogs, despite being packaged as nutritionally complete, the researchers say. Even so, all the foods had acceptable concentrations of protein, fatty acids and essential amino acids (*PLoS One*, doi.org/g92fhr).

Most – including five of the six plant-based foods – didn't have enough iodine, but seaweed could easily make up for that deficiency.

Vitamins in general were sufficient across the board, except for vitamin B, which came up particularly short in plant-based foods. Dogs low in vitamin B can have issues with their skin, nerves and digestive systems, so manufacturers should supplement those foods, the researchers say.

"I believe a vegetarian diet can be adequate if carefully supplemented with nutrients lacking in plants – as is the case for humans who choose a vegetarian diet," says Lucia Casini at the University of Pisa in Italy. Owners should avoid making their own plant-based foods for their pets, she adds. ▮

Health

Hepatitis B shot might lower diabetes risk

Carissa Wong

THE hepatitis B vaccine seems to reduce the risk of developing diabetes, and not just by preventing the infection.

Scientists have previously found the vaccine appears to cut the risk of diabetes. This may be due to the hepatitis B virus, which infects the liver and spreads through blood, semen and vaginal fluids, disrupting the organ's ability to store sugar from the blood. This could raise the risk of diabetes, where blood sugar levels go awry.

But prior studies haven't looked at whether the vaccine might reduce diabetes risk among a group of both immunised and non-immunised people who haven't contracted hepatitis B, which would suggest the effect acts independently of just preventing the infection.

To explore this, Nhu-Quynh Phan at Taipei Medical University in Taiwan and her colleagues analysed the health records of more than 580,000 people living across the US, Europe, Africa, Latin America, the Middle East and the Asia-Pacific. None of the participants, who were aged between 18 and 90, had any kind of diabetes or had been infected with the hepatitis B virus, according to their records and the absence of infection-specific blood markers. About half of them had received a hepatitis B vaccine, gauged according to levels of virus-specific antibodies in their blood.

15%

How much lower the diabetes rate was among participants vaccinated against hepatitis B

The team found the vaccinated participants went on to have an overall 15 per cent lower rate of diabetes – defined as them either receiving a diagnosis, having a persistently high blood sugar level or being prescribed diabetes drugs – than their unvaccinated counterparts. The average follow-up period was four years; the maximum, 15. The vast majority of cases were type 2 diabetes, the most common form of the condition. The results will be presented at the European Association for the Study of Diabetes Annual Meeting in Vienna, Austria.

The researchers also found that vaccinated participants with higher levels of hepatitis B-specific antibodies were less likely to develop diabetes than those with lower levels. Differences in antibody levels may be a reflection of how many vaccine doses the individual received, how recently they were immunised or general variation in immune responses.

The fact that none of the participants had knowingly been infected with hepatitis suggests being immunised reduces diabetes risk independent of just preventing infection, says Phan. One potential explanation is it somehow reduces chronic inflammation that damages the liver and pancreas, which release hormones that regulate blood sugar levels, like insulin, she says.

However, Phan says they can't rule out that part of the vaccine's protective effect comes from preventing the infection.

The team accounted for factors such as the participants' age, sex and whether they smoked. But virologist Albert Osterhaus at the University of Veterinary Medicine Hannover in Germany maintains the influence of such factors can't be ruled out. ▮

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Environment

No more cars on the scrap heap?

Metal from old cars could be turned into a mouldable material for use in electric vehicles

Madeleine Cuff

A NEW way to recycle the metal from scrap cars could eliminate millions of tonnes of waste each year and cut the carbon emissions from producing virgin aluminium.

For decades, much of the scrap aluminium in cars has been recycled into a low-grade cast alloy for use as engine blocks in new combustion engines. But as the car industry transitions to building only electric vehicles, there is nowhere for this low-grade scrap metal to go.

Without a solution, the world risks creating mountains of unusable scrap and emitting millions of tonnes of additional carbon dioxide by producing more virgin aluminium for vehicle manufacturing, warns Stefan Pogatscher at the University of Leoben in Austria.

Together with his colleagues, Pogatscher has developed a new process to recycle the metal from scrap cars – which in Europe alone amounts to 7 million to 9 million tonnes per year – into a new high-grade aluminium alloy that can be used to make a variety of car components.

The solution lies in retaining a wide range of alloy materials from scrap cars to make the new product, he explains.

"The new material could be used to make a wide range of car parts, including chassis and frames"

Normally, when cars go to scrap, the materials are sorted, with plastics, fabrics, steels and aluminium all dealt with separately. Next, the aluminium alloys – of which there can be up to 40 in a single car – are separated as much as possible for different recycling streams. What can't be separated is then melted and cast into engine blocks for combustion engines.

The new recycling method developed by Pogatscher's team involves melting down all of the scrap aluminium from an old car in one go, thereby including a much wider range of alloys and impurities than standard.

This produces a slab of very brittle material that is "more like a ceramic than like a metal", says Pogatscher. But the team found that reheating this material to about 500°C, for a 24-hour period, helps to change the structure of the metal to make it stronger and more mouldable (*Research Square*, doi.org/p4nq).

The team claims the new material rivals typical automotive alloys with its "impressive" strength and could be used to make a wide range of car parts, including chassis and frames. It can be made using common industrial processes and therefore could be immediately scalable, says Pogatscher. He admits that it will be challenging to get the "conservative" manufacturing sector to adopt the new alloy at scale, but the research team is already in talks with industry partners about developing the process.

Geoffrey Scamans at Brunel University of London says although the idea is "very interesting", more work is needed to prove that the new alloy can pass the stringent tests necessary to allow its use in car body parts.

He also warns it may prove challenging to produce a consistent high-grade alloy, given that vehicles are scrapped "at random and not as individual vehicle types". "It's difficult to see how the individual alloy compositions could be collected in a practical way," he says. ▮

Palaeontology

Pterosaur hatchlings flew straight into the eye of a storm

BABY pterodactyls apparently flew within days of hatching – but some broke their wings in rough storms that sent them crashing into a lagoon, where they drowned.

Very young pterodactyls had wing structures similar to adults, with the power and aerodynamic features that would enable flight. Even so, palaeontologists have long debated whether such hatchlings could actually fly.

At the Solnhofen site in southern Germany, hundreds of pterosaur fossils lie encased in limestone. While inspecting some of them under ultraviolet light at the Museum Bergér in Harthof, David Unwin and Robert Smyth, both at the University of Leicester, UK, discovered a broken wing in a *Pterodactylus antiquus* hatchling. Later, they came across another tiny hatchling with the exact same break in the other wing (*Current Biology*, DOI: 10.1016/j.cub.2025.08.006).

"It just sort of leapt out of the rock when we put the UV light on it," says Unwin. "We both kind of went, 'Bloody hell! Look at this!'"

Unwin and his colleagues estimated that the two animals, which had wingspans of only 20 centimetres and bones still in early growth stages, lived about 2 million years apart, roughly 150 million years ago. At the time, the site was part of an archipelago with islands and seawater lagoons, where occasional, severe tropical cyclones would lead to rapid underwater mudslides that trapped and preserved fallen animals.

UNIVERSITY OF LEICESTER

This young pterosaur had a broken wing, probably due to flying in bad weather

The hatchlings had healthy skeletons except for a clean, angled break in the humerus – the upper arm bone that anchors the wing – with rotation of the bone and no healing, meaning the animals died just after the fracture. The breaks resemble typical wing overload injuries that occur in adult birds and bats flying through sea storms.

"The best explanation we have for these two poor, unfortunate pterosaurs with broken arms is that they were in the air when they had their accident," says Unwin.

The findings help close the long-standing debate by providing direct evidence of flight in these pterosaur hatchlings, the researchers say.

"I don't think they just hatched out and leapt into the air," says Unwin. "But they were probably in the air very shortly after they were born, and that's one of the reasons we have these very young individuals in the fossil record." ▮

Christa Lesté-Lasserre

Health

A minute of exercise could boost lifespan

Michael Le Page

GREG BALFOUR EVANS/ALAMY

Incidental exercise, like walking up a steep hill, can have huge health benefits

IF YOU don't exercise for the sake of exercising, doing five or six vigorous activities every day instead, each lasting 10 seconds or so, can make a big difference. A study in the US has found that people who did a total of just over 1 minute of vigorous activity each day were much less likely to die of any cause in the following six years than those who did none.

Only around 15 per cent of adults exercise regularly, says Emmanuel Stamatakis at the University of Sydney.

So he and his colleagues have been exploring the health benefits of the incidental exercise people get, such as walking up a steep hill or carrying heavy loads. They did this by getting people who are already taking part in large health studies to wear monitors for one week to assess their normal activity levels, and then looking at their risk of dying in the following years.

In 2023, the researchers reported results from tens of thousands of people taking part in the UK Biobank study. They found that those who did around 4.4 minutes of vigorous activities a day were 38 per cent less likely to die from any cause in the following seven or eight years than those people who did none.

Now, the researchers have reported the results from 3300 people taking part in the NHANES study in the US, who were generally less fit than those in the Biobank study. In this group, just 1.1 minutes of vigorous activity a day was needed to lower the risk of dying of any cause in the following six years by 38 per cent (medRxiv, doi.org/p4nm).

This means 1.1 minutes in the US group produced the same relative improvement as 4.4 minutes in the UK group, but it doesn't mean they reached the same level of health. The US group generally had a lower level of fitness to start with, so their overall risk of dying of any cause was still higher.

"The authors suggest, and I agree, that this may reflect a more inactive, higher-risk population deriving greater benefit from small amounts of vigorous activity," says Carlos Celis-Morales at the University of Glasgow in the UK. ▮

Technology

Liquid crystal lenses may make better bifocals

Karmela Padavic-Callaghan

LENSES made with liquid crystals could lead to glasses that can easily switch between correcting near- and far-sightedness.

Bifocal glasses date back to the 18th century, and their design has not fundamentally changed since. Typically, the lower halves of their lenses are shaped for looking at objects that are close, while the upper halves are tailored for distant ones – so a person wearing them must keep shifting their gaze, which can be uncomfortable. Yi-Hsin Lin at National Yang Ming Chiao Tung University in Taiwan and her colleagues built glasses that can switch between the two modes at the tap of a button.

Instead of fashioning lenses just from glass, which must be made convex or concave depending on its function, the researchers filled them with a thin layer of liquid crystal. The crystal's molecules bend light differently depending on their arrangement within the layer, and this can be controlled with electric fields (*Physical Review Applied*, doi.org/p4tq).

Lin says the idea for switchable glasses based on this principle, where thin electrodes in the frame would create the necessary electric fields, is almost 50 years old, but technical challenges stalled their development. Her team overcame some of these and made a wearable prototype.

> "Sooner or later almost everyone needs prescription glasses, so the market is huge"

These glasses currently reach only a limited range of power, have a functional viewing region of about 10 millimetres – three to four times smaller than conventional glasses – and take about 5 seconds to adjust after you tap the button on their frame. But Lin says her team has fully characterised the physics principles that make the glasses work, and the group has a sense for how to improve them going forward, including shortening the switching time by optimising the electronics. "Sooner or later almost everyone needs prescription glasses, so the potential market is huge," says team member Victor Reshetnyak at the Taras Shevchenko National University of Kyiv in Ukraine.

Viola Kanevsky, an optometrist in New York, says people who could benefit most from switchable glasses hold technical jobs where small objects may be at the top of their field of vision. They may also be in a job that requires a wide view – for instance, architects who need to judge wide, straight lines or stockbrokers who may need to view multiple large screens, both near and far, without constantly turning their heads, she says.

But the new prototype is far from being clinically ready, in part because of the lenses' small operational area, says Mark Rosenfield at the SUNY College of Optometry in New York. Using electronic components also drives up the cost and complexity of liquid crystal glasses production, which may be an obstacle to quickly getting them to billions of potential users, says Joshua Silver at the University of Oxford. In 2004, he and his colleagues developed a different self-adjustable glasses design that uses fluids. ▮

Analysis Environment

Are farmed oysters, mussels and clams the ultimate green foods?

Some studies claim farmed bivalves can capture carbon, but not everyone is convinced, finds **Michael Le Page**

COSTFOTO/NURPHOTO VIA GETTY IMAGES

Farming shellfish, like oysters, can have environmental benefits

PICTURE an environmentally friendly food. Your mind might turn to the humble lentil, but is it possible to eat more luxuriously while still staying green? Bivalves such as oysters, mussels and clams already have green credentials, thanks to their ability to clean polluted water. Now, some researchers are arguing they can even mop up carbon dioxide. Could farmed bivalves be the ultimate green food?

Food production is to blame for around a third of greenhouse gas emissions, on top of all the other damage it does, so identifying foods that minimise that harm is essential. When it comes to seafood, farming is usually regarded as more sustainable than catching wild fish. But farmed fish need at least some wild fish in their diet and, according to a study last year, the amount of wild fish being caught to feed farmed fish has been wildly underestimated.

The huge advantage of bivalves is that they don't need active feeding. They are filter feeders that eat tiny nutrient particles in seawater, including plankton. Most coastal waters are now overloaded with nutrients due to nitrogen and phosphorus pollution, so the harvesting of farmed bivalves helps to remove some of this excess, cleaning up the water as a byproduct of food production.

Harvesting wild bivalves can be harmful – for instance, dredging for wild scallops destroys seafloor life such as sea fans, corals and sponges. But farming bivalves has relatively few downsides, especially compared with, say, razing rainforests to feed beef cattle.

> **"Bivalves, unlike farmed fish, don't require active feeding, instead eating particles like plankton"**

But wait, there's more: in the past decade, a growing number of studies have claimed that farmed bivalves capture carbon.

However, Fabrice Pernet at the University of Brest in France, whose team recently reviewed more than 50 studies of the issue, isn't convinced. Most of these studies are based on theoretical models that assume that the formation of calcium carbonate shells removes CO_2 from the oceans.

But this is true only on a geological timescale. Over mere decades or centuries – which is what matters when it comes to global warming – carbonate formation releases CO_2.

What's more, Pernet says, it is common for waste shells to be incinerated, releasing more CO_2 into the atmosphere, instead of being put back in the sea to reverse the CO_2-releasing process. As for the carbon in the flesh of the animals, that is released as CO_2 after we consume it.

Some researchers are now making a different claim, that more carbon in the form of organic matter ends up in sediments below bivalve farms, making them a net carbon sink.

The latest claim of this kind is based on a study of oysters growing in five 150 cubic-metre enclosures. But Pernet says this and similar studies have flaws, such as CO_2 measurements being made only in the daytime and summer periods, when photosynthesis is happening.

The team behind the study says this didn't affect the result, but Pernet isn't sure. "Today's evidence suggests that bivalve farming emits CO_2 overall," he says.

Don't cancel your reservation at the oyster bar just yet, though. While bivalve farming likely is a net emitter, it isn't by much – just 1.4 kilograms of CO_2 or the equivalent per kilogram of edible weight according to a 2021 study. That is less than wheat or maize, and without the high land and fresh water requirements.

"So yes, farmed bivalves are one of the greenest foods," says Pernet. Feast away. ▮

Technology

3D-printing method aims to create bigger quantum computers

Karmela Padavic-Callaghan

TO MAKE some quantum computers larger, and therefore more powerful, we may have to 3D-print them.

At the moment there is no consensus on the single best design for quantum computers, but researchers agree that to become unambiguously useful, these devices will have to be made larger. For those that use ions as quantum bits, or qubits, a key building block is called an "ion trap".

Now, Hartmut Häffner at the University of California, Berkeley, and his colleagues have come up with a 3D-printing technique for miniaturised ion traps, which could make it easier to combine many of them into one large computer.

As its name suggests, an ion trap is used to confine ions in place and help control their quantum states with electromagnetic fields, an essential condition for using ions to run calculations.

For their version, the researchers 3D-printed traps that were just a few hundred microns across. In extensive laboratory tests, these beat more conventional designs (*Nature*, doi.org/p4nx). They captured ions up to 10 times more efficiently and did so with shorter wait times from when the trap is turned on to when the ions can be used, says Häffner.

Team member Xiaoxing Xia at Lawrence Livermore National Laboratory in California says that 3D-printing is a perfect match for the problem at hand, because it can make small and complex objects with fewer restraints than methods more akin to chip manufacturing.

This means the researchers could follow the success of their tiny ion trap with more innovative and novel designs. Team member Shuqi Xu, also at the University of California, Berkeley, says some are already in the works. "3D-printing lets you reimagine things to a large degree," says Xia. ▮

Health

Rapamycin may stop DNA damage

Effect on human immune cells could explain why the drug has been linked to longer lifespans

Chris Simms

THE drug rapamycin's anti-ageing effects could at least partly be due to it preventing DNA damage in our immune cells – an understanding that might help us unleash its potential as a life extender.

Originally developed as an immune suppressant for people undergoing organ transplants, rapamycin blocks the action of the mTOR protein, which is key in cell growth and division. At low doses, it has been shown to increase the lifespan of animals such as flies and mice, possibly by interfering with processes that lead to signs of ageing, such as inflammation, cellular breakdown and reduced mitochondrial function.

Now, Lynne Cox at the University of Oxford and her colleagues have found that rapamycin also seems to stop DNA damage in a type of immune cell. DNA damage is a major driver of the ageing of our immune system, which accelerates ageing in the entire body.

The researchers uncovered this when treating human immune cells called T-cells, a type of white blood cell that fights off infections, with rapamycin while they were also exposed to the antibiotic Zeocin, which causes DNA damage.

"Blood tests showed that the T-cells of men on rapamycin had less DNA damage"

They found that rapamycin reduced DNA damage and tripled the cells' survival rate compared with those exposed only to Zeocin (bioRxiv, doi.org/p4nk).

The researchers saw no evidence this was occurring as the result of another of rapamycin's effects.

The speed of the effect also suggests it was happening directly. "The impact is so quick, it looks like it is impacting the DNA damage response and the accumulation of [DNA] lesions within about 4 hours, so I don't think it can be a downstream consequence of the other things being affected," says Cox.

Matt Kaeberlein at the University of Washington in Seattle says the study supports rapamycin having a direct protective effect on DNA, but "stops short of a definitive mechanism". The researchers hope to find this by investigating rapamycin-induced changes to RNA and proteins produced in immune cells.

In another part of the study, they assigned nine men, aged between 50 and 80, to take either 1 milligram per day of rapamycin or a placebo. After eight weeks, blood tests showed that the T-cells of the men on rapamycin had less DNA damage. There was also no drop in the overall number of white blood cells in either group, suggesting that rapamycin doesn't negatively affect immune function. "We've shown it's not harmful at low doses, and this is a critical point," says Cox.

Zahida Sultanova at the University of East Anglia, UK, notes that as the placebo-controlled experiment was done only on older men, it is important to also do trials in women and people of different ages. Studies in non-human animals suggest that rapamycin can have sex-specific and age-specific effects. ▮

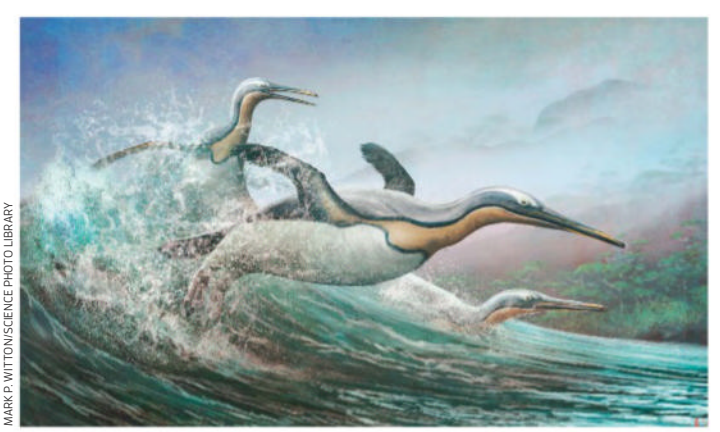
Zoology

Early penguins could have hunted with dagger-like beaks

FOUR new fossil species from New Zealand illustrate the striking diversity of the earliest penguins, which possessed long, dagger-like beaks they may have used to skewer their prey.

The new discoveries "provide a stunning glimpse into the earliest evolution of penguins", says Gerald Mayr at the Senckenberg Research Institute in Germany.

The fossils were unearthed from the Waipara Greensand formation in Canterbury, New Zealand, which contains rock dating back to between 62 million and 58 million years old. The formation is well-known for holding some of the earliest bird species that flourished and diversified after the mass extinction event that killed off all non-avian dinosaurs.



MARK P. WITTON/SCIENCE PHOTO LIBRARY

Some species of early penguin had long beaks, which may have helped them catch prey

"We think that a key feature of ancient New Zealand was the absence of terrestrial predators, which enabled the loss of flight capabilities in the earliest penguins," says Mayr. This lack of predators may also explain why some early penguins grew as large as humans, he says.

In total, Mayr and his colleagues described four new species, which illustrate a broad diversity in shape and size. Many of the fossils contain skeletal features that were hitherto unknown, including one specimen with abnormally long hind toes and another that had the most remarkably complete skull and beak of any early penguin (*Zoological Journal of the Linnean Society*, doi.org/p4qk).

"The earliest penguins seem to have speared their prey with the long beaks," says Mayr. After skewering a fish, the penguin might have resurfaced from the water to throw it into the air and catch it, he says.

Penguins lost their elongated beaks after about 20 million years, which was probably an adaptation to prolonged diving periods underwater. As they adopted a more aquatic lifestyle, their feeding strategies and beak began to change, too. ▮

Taylor Mitchell Brown

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Views

Comment

The nose knows

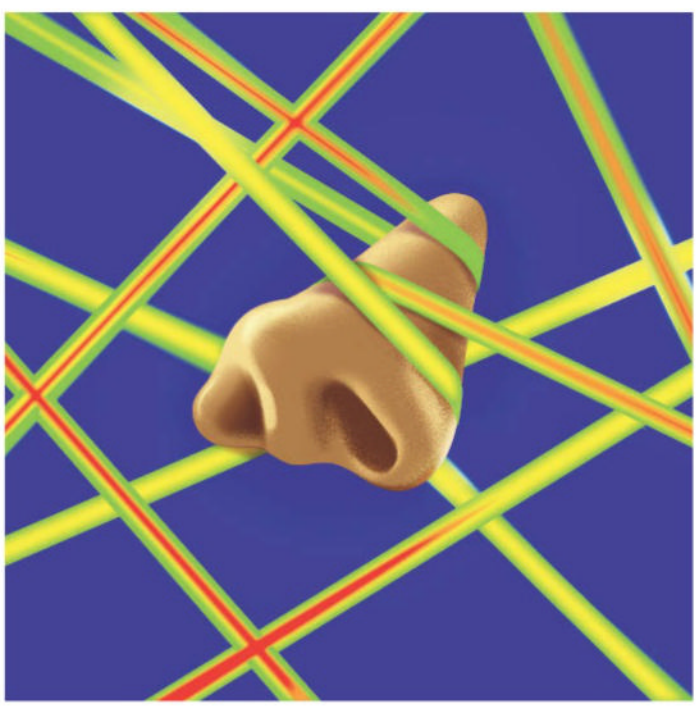
We need a better way to measure how stressed we are feeling – and our noses may offer a surprising breakthrough, says **Gillian Forrester**

IT IS probably no surprise to you that stress is a major driver of illness, including mental health conditions like anxiety and depression and physical ones such as heart disease. We urgently need simple, objective and non-invasive ways to study and measure it. The temperature of someone's nose – most prominently, on the tip – might be about to give us the answers we need.

Working out how stressed we are has been a tricky problem for scientists to tackle, because how we experience stress combines how we mentally perceive a situation and how that makes us feel physically. Our individual stress response is also influenced by our genes, the people around us and our cultures, making it different for everyone.

Traditionally, we measure stress in two ways. One approach is to use questionnaires. These are usually administered after the stress has passed, removed in time and place from the actual stress-inducing situation. Another issue with surveys is that they are subjective; not everyone is good at knowing or explaining how they feel.

The second main method is tracking physical markers like blood pressure, respiration and heart rate. These biological measures often rise in times of stress. These might seem more objective, but they come with their own limitations. They require being hooked up to machines in a lab or medical setting, which disrupts a person's routine.



ADRIÀ VOLTÀ

These tests can also be stressful in themselves, causing a rise in blood pressure, respiration and heart rate.

Sometimes scientific breakthroughs are literally flashes of light. Thermal cameras, typically used to reveal heat leaks in buildings, are proving invaluable in medicine for tracking abnormal changes in body temperature associated with conditions including infection, inflammation and even tumours. Researchers are now also using thermal cameras to read people's stress levels by mapping their temperature changes in their face.

Blood is constantly moving around our bodies through the dilation and constriction of vessels to regulate its flow. But blood flow gets rerouted when we are stressed. The nervous system pushes blood towards our eyes and ears, resulting in less blood around the nose. This decrease in blood is detected by a thermal camera as a drop in temperature. This quirky effect has been dubbed the "nasal dip", and it isn't unique to humans. It has been reported in adults and children, but also in non-human primates, suggesting there is an evolutionary story behind the stress response.

In times of stress, our nervous system redirects blood towards our other sensory organs so we can spot danger, leaving our nose just a little bit colder. Since the nose doesn't move much, that temperature change is considered a relatively clean signal of stress.

Used in combination with existing measures, thermal imaging could be a game changer for stress research. With no need for labs or machines or awkward questions, it can provide a way to continuously monitor without any physical contact with the person under evaluation.

In the very near future, we could be checking the temperature of our nose as a kind of biofeedback to help us understand and modify our stress states. We could track stress in babies before they learn to speak, and in patients who struggle to communicate. We could detect harmful levels of stress in high pressure environments like emergency rooms, trading floors or even zoos.

Research suggests that being aware of your stress response can actually help you manage it better. By making stress visible, we have a better chance of learning about how it affects our minds and our bodies before, during and after a stressful event. The future of stress research looks cooler than ever. ▮

Gillian Forrester is a professor of comparative cognition at the University of Sussex, UK. See her speak at New Scientist Live on 18 October

No planet B

All about the money? There is growing opposition to environmental policies around the world, but exciting new research shows there are ways to defuse the "green backlash", finds **Graham Lawton**

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

Graham's week

What I'm reading
The Pillars of the Earth *by Ken Follett.*

What I'm watching
I'm re-watching the BBC's adaptation of Dracula *on Netflix in anticipation of my upcoming holiday in Transylvania.*

What I'm working on
An article for the Christmas issue. Honestly.

This column appears monthly. Up next week: Annalee Newitz

I HAVE written before about the outcry in my home city of York, UK, when the council announced plans to increase parking fees to discourage people from driving on our polluted streets. In case you were wondering, the council eventually caved in to opposition and hiked fees by a lot less than it had originally wanted.

This is a good example of "green backlash" – the term given to the growing tide of opposition to pro-environmental policies in high-income countries. This often goes hand in hand with rising support for right-wing populist parties such as Reform in the UK, which cynically stoke and exploit it for electoral gain. It works: Reform leads recent polls asking UK voters which party they plan to support at the next general election.

This isn't good news for the planet. Meaningful progress against climate change is impossible without government intervention, but such policies may become counterproductive when they open the door to anti-green parties. Research has shown that where right-wing populists hold power in Europe, action on greenhouse gas emissions and the transition to renewable energy slows down.

A recent study published in *Nature Climate Change*, however, suggests that there are ways to defuse the green backlash. The researchers, led by Valentina Bosetti at Bocconi University in Milan, Italy, reviewed the literature on the green backlash in an attempt to understand why it happens – and what can be done to mitigate it.

They found that disaffection with climate policies has two root causes: economic and cultural. The former relates to the costs imposed on voters by the policies, such as having to pay more to park near the city centre. The latter reflects a general and growing mistrust of politicians and scientific elites. Both can seriously erode support for incumbent political parties that are trying to enact environmental policies and push some people into the arms of parties opposed to them, which are overwhelmingly right-wing.

One illuminating case study involving both types of grievance comes from Ontario, Canada, where in 2009 the provincial administration removed the power of communities to veto new wind power installations. More than 50 campaign groups sprung up in protest, fearful of the impact on the value of their properties. Despite the broad popularity of wind power in Ontario, this localised opposition seems to have swung the next provincial election. In October 2011, the incumbent Ontario Liberal Party lost its overall majority, with many of its defeats coming in precincts where there was an operational or proposed wind turbine. Similar backlashes against wind power have been seen in Sweden and Germany.

> "Researchers found that opposition to wind power melts away when subsidies are available"

Moves to encourage people to swap internal combustion engine vehicles for electric ones have also provoked pushback from people who stand to lose out – namely those in the conventional automotive sector. In the 2016 US election, Donald Trump gained an average of 3 percentage points in counties that were home to car part manufacturers. When researchers interviewed workers, they cited the threat of the EV transition as a motivation for deciding to back Trump.

It is a pretty depressing picture: governments that attempt to do the right thing for the environment face pushback and end up watering down their policies or losing power, usually replaced by parties that won't impose such policies or are dismissive of the need to do so.

It doesn't have be that way. There is probably no reaching those attracted to right-wing populism by cultural issues, but they will very likely never form a majority. Economic grievances, on the other hand, can be assuaged. Bosetti found that opposition to wind power, for example, melts away when government subsidies are available, when the tax revenues are ringfenced for local projects and when local jobs are created. Fear of job losses and the obsolescence of skills could be addressed by retraining people or simply compensating them fairly, she suggests. It is that simple.

On top of all that, there is broad but underestimated support for the policies that will deliver a green transition. Researchers in the US recently asked adults about their attitude to reducing food waste, eating less beef, installing home solar and heat pumps, driving an EV and buying carbon offsets, and found large majorities in favour of all of them. But when they asked the same people how much they thought other people supported them, they found a huge mismatch between perception and reality. There is another message there for politicians: don't shy away from green policies because you have fallen into the same trap.

Back in York, the next local elections are in 2027. I expect parking charges will be an issue on the doorstep and fear a green backlash at the ballot box. ▮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Parks and Landscaping

Fishing for truth

Nicole Tung
Carmignac Foundation

THESE powerful images are the work of photographer Nicole Tung, who spent nine months documenting the human and environmental cost of overfishing in South-East Asia. Since the 1950s fishing has morphed from artisanal trade to industrialised global industry. Overfishing and illegal fishing have also risen to meet rapidly increasing demand from a growing population.

Tung focused on the region because it plays a key role in the global fishing trade. Her project, funded by a €50,000 Carmignac Photojournalism Award for fieldwork, changed her stance on seafood. It isn't about consumers giving it up completely, she says. Rather, they need to be much more aware of their choices.

It was, she adds, "harrowing" to hear stories from Indonesian fishermen describing violence they had witnessed at sea and the terrible conditions they often experienced working on fishing vessels.

The large far-left image shows a fisher unloading yellowfin tuna at General Santos fish port in the Philippines after being at sea for a month. Bigeye tuna and blue marlin are also part of his catch.

Elsewhere, a dock worker from Myanmar (upper near-left) sorts the fish species being unloaded in Ranong, Thailand. Below (middle near-left), Indigenous Urak Lawoi people and Thai villagers from Koh Lipe, Thailand, gather wood from nearby islands during a festival marking the end of the fishing and tourism season. They will use the material to build a ceremonial boat as an offering to their ancestors.

And at bottom near-left, a family of Filipino fishers bait fishing lines.

Matthew Sparkes

Food for thought

Geneticist Tim Spector's meticulous guide to fermentation could supercharge your gut microbiome – and transform your health, says **Helen Thomson**

Book
Ferment
Tim Spector
Jonathan Cape (UK); US TBC

ANTHONY WALLACE/AFP VIA GETTY IMAGES

Fermented foods like kimchi can have benefits for your body and brain

THERE are two reasons why humans became interested in fermentation: preservation and pleasure. Before refrigeration, the process let us store drinks like mead for months when water could be deadly. And milk that spoiled within a day could last for weeks as yogurt or cheese. We grew to enjoy these tangy flavours, and the microbes that created such delicacies not only produced the odd impromptu aperitif, but also brought many health benefits.

Today, fermented foods like kimchi and sauerkraut are firmly on trend. Yet, as doctor and geneticist Tim Spector argues in his new book *Ferment: The life-changing power of microbes*, this isn't really something new – we evolved to consume such produce as a regular part of our diet.

He begins with the basics: fermentation is simply the transformation of food by microbes. The effects of this aren't at all simple, however, with consequences not just for the flavour and longevity of food, but also our health. Even dead microbes can influence our body and brain.

Fermentation and our microbiome are intimately linked. Fermented products give gut microbes raw materials to turn into nutrients and active molecules, such as short-chain fatty acids, which help regulate the immune system, writes Spector. These foods also assist microbes in maintaining the gut's mucus barrier, preventing inflammation.

They are probiotics, too, adding millions of microbes to our guts. A diverse microbiome, explains Spector, has been linked to better health in a wide range of studies. Improving this diversity by eating fermented foods might even play a role in how well cancer treatments work, he writes.

The most compelling parts of *Ferment* explore this "microbial pharmacy", demonstrating how, if only in small studies so far, fermented products are linked to improvements in everything from irritable bowel syndrome to anxiety and immune health.

"Improving your gut microbiome's diversity might even play a role in how well cancer treatments work"

Spector's own research suggests people who regularly ate fermented foods had around 14 per cent less severe covid-19 symptoms compared with those taking other supplements, such as vitamin C. As with many nutrition studies, it is hard to distinguish correlation from causation, but Spector draws on multiple strands of evidence to build a persuasive case for eating fermented food.

The book is peppered with interesting facts. For instance, did you know that scientists have been unable to reproduce natural kefir grain (the "starter" for any good kefir) in the lab, despite their attempts to introduce the 30 or so microbes it contains to each other?

Throughout *Ferment*, we are reminded of how vital microbes are to us, and that we are only just scratching the surface of how we interact with them. Spector's access to health data often allows him to fill in gaps where other studies fall short, and although his company's gut supplements are mentioned, he avoids straying into marketing territory.

At its best, the book balances science, medical anecdotes and Spector's own fermentation journey with practical advice. In those moments, the writing feels authentic and useful, especially when guiding readers on what foods to choose – pick kefir made from grains in whole milk, for example, as these contain yeasts as well as multiple microbes, which are likely to have greater health benefits.

At times, though, *Ferment* is a little repetitive, with knowledge occasionally prioritised over narrative. And despite Spector warning against overinterpreting animal studies, the infancy of the field means he is often forced to lean heavily on them himself. Still, this is a persuasive, meticulously researched book. Its final chapters were particularly intriguing, looking ahead to a future that may include personalised microbes – a yogurt for depression, say, or a cheese that helps with menopause.

Once hesitant to ferment at home, I was persuaded to begin experimenting by around page 40. By the end of the book, I had jars of kombucha and sauerkraut brewing in my pantry, an organic kefir grain winging its way to me and a fresh appreciation for the microbes – living and dead – that are shaping my health. ▮

Helen Thomson is a writer based in London

Coming of age

An essential new book grapples with how the modern world is changing the nature of adolescence, finds **Chris Simms**

Book

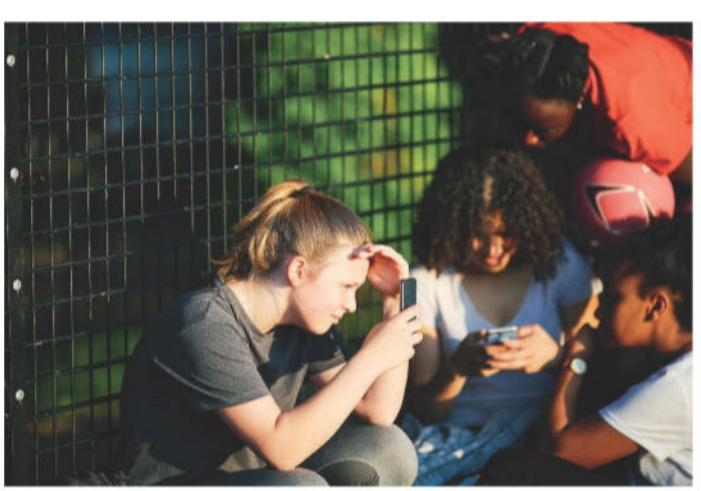
How We Grow Up
Matt Richtel
Mariner Books

THE true story at the start of *How We Grow Up*, the latest book by Pulitzer-winning journalist Matt Richtel, is chilling to read as a parent of children nearing adolescence.

Elaniv was a happy, effervescent girl. But when puberty kicked in, she began to change wildly, and for no obvious reason. She couldn't concentrate on her studies and became depressed. Medication didn't seem to help. Despite her parents' efforts, she eventually ended her own life. "It was not for a lack of personal relationship, nor for lack of treatment," her father tells Richtel. "I did the very best I could for my daughter."

In *How We Grow Up*, Richtel searches for the roots of a possible mental health crisis among young people today, combining interviews, scientific research, historical data and the voices of key researchers.

Social media can bombard adolescents with people to judge themselves harshly against



ALYS TOMLINSON/GETTY IMAGES

The book paints a vivid picture of the changes our modern world has wrought on this pivotal transition to adulthood, bringing fresh, formidable challenges.

Adolescence is linked to the onset of puberty and a shift in the balance of key brain chemicals. As young people strive to work out who they want to be, they can become rebellious, moody and impulsive. But adolescence is starting earlier and lasting longer in many nations, with serious consequences, Richtel writes. Two centuries ago, puberty arrived for children in the US some four years later than it does today, for instance. Since 1900, the average age at which girls in the US have their first period has dropped from 14 to 12. Much of that change is down to better nutrition, allowing the body to develop faster, he writes.

The world has also transformed in that time: our planet is well mapped and technology has left most people physically safer and better fed. The spaces in which adolescents can rebel have become more cerebral – our identities and ethics – and ever-more interaction happens online, where there is more information to process and more people to judge yourself against, argues Richtel.

Dramatic drops in binge drinking and drunk-driving accidents among teenagers in the US may be linked to this reduced focus on the external world, says Richtel, but there is a flip side: reduced physical activity, less sleep and an increase in loneliness. Covid-19 lockdowns also isolated some adolescents – who Richtel says need in-person interaction to develop emotional intelligence – as support networks changed and sometimes vanished.

All this means that adolescents' bodies are maturing faster while their brains remain immature, he writes, alongside which they must deal with the mentally challenging environment of modern life. For most, there will be no serious misadventures, but the online world's impact is far from uniform.

Data on the mental health effects of social media is mixed, but *How We Grow Up* contends that it works like a volume knob that amplifies an existing emotional state. Courtney, an interviewee who had their first period at age 10, sums this up well: "I feel like if I was born in 2000 BC in the Alps, I'd still be depressive, but I think it's wildly exacerbated by the climate we live in."

Scary, illuminating and hopeful by turns, *How We Grow Up* clears up some of the realities of adolescence and how to handle them better, whether you are an adolescent or a parent. For me, it helped to read that the rebellions of adolescence have a profound purpose – not just to establish independence, but to remake the future in the image of the next generation.

Chris Simms is a writer based in Somerset, UK

Need a listening ear? UK Samaritans: 116123 (samaritans.org); US Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for services in other countries.

New Scientist *recommends*

Catherine de Lange
Editor
London

Science journalists tend to approach the edges – or dare I say fringes – of science with caution, and rightly so. But former *New Scientist* staffer and acclaimed

journalist Jo Marchant boldly goes there in her new podcast series, **Where the Wild Thoughts Are**.

Each episode features a conversation with a researcher challenging the limits of conventional thinking. I particularly enjoyed the story of biologist and film-maker Tom Mustill, who was out kayaking when a humpback whale breached on top of his boat.

After that brush with death, Mustill became compelled to understand whale behaviour. He talks to Marchant about whether we can actually communicate with whales, and what this might tell us about animal consciousness.

This podcast is a mix of the personal stories that drive scientists and the types of outrageous idea that lead to creative leaps and fresh perspectives, which makes for excellent listening.

The TV column

The world before Ripley

The long-running *Alien* franchise gets a much-needed injection of genre-defying creativity, thanks to Noah Hawley's surprisingly inventive *Alien: Earth* TV show, discovers **Bethan Ackerley**

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

PATRICK BROWN/FX

Wendy (Sydney Chandler) is a hybrid, a new creation in the *Alien* universe

TV

Alien: Earth

Noah Hawley

Disney+

Bethan also recommends...

Film

Alien

Ridley Scott

The original film is still the best part of the Alien *universe. Not only did it give us the slavering xenomorph and its face-hugging, chest-bursting larval stages, it also gave us one of the great sci-fi protagonists. Ellen Ripley, I salute you.*

Aliens

James Cameron

The brawnier little brother of Alien*, many fans will tell you that this action-packed sequel is the best instalment in the franchise. They are wrong, but* Aliens *is still an absolute thrill ride.*

THE description "genre-defying" gets thrown around a lot these days – it is a convenient sticking plaster for any film or series that hasn't quite figured out what it wants to be. That said, it is an apt term for the *Alien* franchise.

Ridley Scott's 1979 movie *Alien*, in which Ellen Ripley (Sigourney Weaver) is part of a crew trapped on a spaceship with a salivating, scorpion-like "xenomorph", had such blood-curdling visuals that it made an indelible impact on both science fiction and horror films.

But while the deadly parasite and its psychosexual torment were ever present, subsequent instalments tried their hand at being everything from a blockbuster to a prison flick to a philosophical drama. Which leads to the question: after nearly 50 years of films, comic books and video games, is there any new ground to cover?

Yes, it turns out there has never been an *Alien* TV series. On paper, that might not sound like a good idea: what is frightening in a 2-hour movie may not be so potent in eight, hour-long chunks. But I am happy to say the show's first six episodes are a grim triumph – and a key reason for this is how they flit between old and new.

Alien: Earth is set in 2120, two years before *Alien*, with Earth ruled by five corporations: Weyland-Yutani, Lynch, Dynamic, Threshold and Prodigy. Alongside synths (artificially intelligent robots that have appeared in the franchise from the beginning), there are cybernetically enhanced human beings, or cyborgs, and hybrids, synthetic beings with a human consciousness.

> **"*Alien: Earth* creates new genres. It more than justifies its existence by daring to reimagine the franchise"**

Our protagonist is Wendy (Sydney Chandler), the first hybrid, dreamed up by Prodigy CEO Boy Kavalier (Samuel Blenkin). She leads the Lost Boys, fellow hybrids who, like her, were once terminally ill children, their consciousnesses uploaded to superstrong adult bodies.

While Wendy is happy with her lot, she misses her brother Joe (Alex Lawther), a Prodigy tactical officer and medic who believes she is dead. After a Weyland-Yutani ship crashes in the middle of a Prodigy-run city on Earth, Joe is among the team that must pull wealthy survivors from the wreckage and uncover the craft's cargo. When things inevitably go wrong, Wendy convinces Kavalier to send in the Lost Boys to help.

Series creator Noah Hawley takes a playful approach to what follows, one moment evoking *Alien*'s haunted-house narrative and its gruesome body horror, the next returning to the thrilling action of James Cameron's *Aliens*. Hawley nests the modalities of those early films inside each other. The shots are also layered: as Wendy recalls her life with Joe, we see the animated film they loved playing across her face. There are dreams here, amid the blood and sputum.

But *Alien: Earth* is more than a lovingly crafted homage. It is full of invention, including new monsters, such as a menacing plant pod hanging from the ceiling of the downed spaceship. And there are new mysteries to ponder, particularly when it comes to Morrow (Babou Ceesay, a standout), a cyborg and the only crew member of the spaceship to survive, and Kirsh (Timothy Olyphant), a steely-eyed synth.

Alien: Earth even creates new genres. One episode is a full-blown conspiracy thriller, as Morrow hunts a saboteur. At other times, Wendy feels like the heroine of a dark, coming-of-age fantasy, with her katana-like sword strapped to her back. At such times, the show more than justifies its existence by daring to reimagine the franchise.

Editor's pick

Ethical diamonds hold a lesson for food industry

30 August, p 19

From Sam Edge, Ringwood, Hampshire, UK

Sophie Attwood's observations made me nod in agreement. It is nonsensical to reject "artificial" foodstuffs while allowing synthetic materials to be pumped into our bodies for cosmetic ends and eating meat from animals stuffed with pharmaceuticals and industrially made cattle feed.

Touching on another of her insights, companies that now only sell lab-grown diamonds – advertising that this means they are far more ethical and environmentally benign than the "natural" ones that were often mined in horrendous conditions – are perhaps an example that the synthetic food industry might emulate. Consumers need to be disabused of rose-tinted notions about the wholesomeness of the farming industry.

Why we feel too old after three score and 10 years

16 August, p 28

From Kate Brown, Canterbury, New Zealand

Your look at ageing was another great article from Graham Lawton. Interesting and informative with a good dose of optimism.

There is an aspect of ageing that isn't generally addressed. I have witnessed a number of my female relatives age, becoming "too old" by their own reckoning. I have also listened to many patients say the same during my work in hospitals. Now, at 69, I share their perspective. This is despite being in excellent health, physically fit, mentally alert and having a great quality of life. I am objectively one of the luckiest of the luckiest generation.

Put bluntly, one just becomes tired. Tired of the endless rounds of life. Tired of coping with the small, unavoidable niggles of getting older. Overwhelmingly, one becomes tired of impotently watching the suffering caused by the folly of humanity.

Some noise pollution flies under the radar

23 August, p 27

From Robert Checchio, Dunellen, New Jersey, US

The realisation that different kinds of noises affect different people in different ways struck a chord with me. In my work with a small non-profit that advocated for small airports, it was common for a homeowner who lived close to such an airport to be extremely bothered by the sound of a small plane flying nearby, yet apparently oblivious to the sound of a neighbour's lawnmower creating noise of far higher decibels.

It seems that familiar noises (lawnmowers) don't elicit the same response that a powered leaf blower might, even if the noise profiles are largely identical. Furthermore, the familiarity of a noise (especially one that might be occasionally created by the individual) also creates some sort of "noise insensitivity".

If we want to talk to the animals, try a macaw

30 August, p 36

From Chris Eve, Dundee, UK

What a fascinating article about deciphering animal languages with AI. It is about time because, to date, a few dogs and chimpanzees seem to have learned far more of ours than we have of theirs.

I hope someone tries it with wild Brazilian macaws (which would be easy to set up). These birds mate for life and rear their single young for nine months. What takes so long to teach? And what is the medium of instruction?

I once witnessed a 10-minute conversation back and forth between two macaws perched far apart in a tall tree – mainly vocal, but through gesturing, too. One syllable in the conversation was much louder than all the rest, after which one of them flew to perch together with the other. I have wondered if what I saw was a marriage ceremony.

Perhaps dog domestication was just natural selection

9 August, p 34

From Jens Jensenius, Odense, Denmark

Your feature describes ideas about the origin of dogs, that is, how wolves were domesticated. Why, I wonder, is there no speculation on Darwinian evolution: mutations and selection of the fittest? I like to relate an example of such domestication: a cousin of mine had a small mink farm of about 200 minks. One day, so he told me, one of the minks signalled to him that it was tame and that it was safe to let her out of the cage. So, he did, and the mink followed him in his footsteps wherever he went on the farm and in the house. This was 60 years ago. This summer I learned from another former mink farmer that this isn't unique, but has occurred several times. I can only imagine it happening as the result of mutations followed by selection. Certainly, the fittest survived.

Let's not write off alien life in absence of water

19 July, p 13

From Christine Rogers, London, UK

"All life that we know of needs liquid water." All life that we know of also exists on Earth. If we are searching for alien life, it is perhaps convenient to concentrate on water, but the possibility that life might exist without it shouldn't be overlooked. Life might also exist at sizes too small or too large, or be too different for us to recognise and make contact with it.

Otroverts of the world will never be united

16 August, p 19

From Robert Sugden, Northmoor, Oxfordshire, UK

Rami Kaminski makes an interesting observation of a new personality type, the otrovert, yet creates a problem at the same time. I immediately recognised myself in his description and realised there is a group of other such people out there. But I also quickly realised that I can't, by definition, join this group of otroverts because I myself am an otrovert, the key trait of which is shunning group membership.

So the cohort of otroverts will exist and have many members, none of whom can belong to it. It seems to be analogous to the Apathy Society that nobody can be bothered to join.

Sign me up for this experiment, please

30 August, p 17

From Chris Morrish, Fareham, Hampshire, UK

I found the article exploring the variation in chocolate flavours depending on the microbes present during the fermentation process very interesting and thought-provoking. Mainly, how can I volunteer to be a chocolate taster for the recommended study extensions? Please? Pretty please? With chocolate sprinkles on top?

Want to get in touch?

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

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

For the record

A question about petrol lawnmowers (Last Word, 23 August) was posed by Hugh Meteyard.

The science and technology transforming life with dementia

As breakthrough medications are beginning to slow the progression of Alzheimer's disease, innovations such as virtual reality and AI are helping people with dementia live more active, richer lives

Few diagnoses carry the devastating weight of dementia, which heralds loss, decline and inevitable death. The condition is the biggest killer in the UK, and cases are set to soar.

"One in three people born in the UK today will develop dementia in their lifetime," says Richard Oakley, Associate Director of Research and Innovation for Alzheimer's Society. A 2024 report commissioned by Alzheimer's Society found that there are 982,000 people living with dementia in the UK – about one person in 70 – and that the number will rise to 1.4 million by 2040.

This poses an enormous challenge, both for biomedical research and for society. "Dementia is almost unique, in that it spans the health and the social care system in a way that I think no other disease does," says Oakley.

Despite the impact of dementia, progress has been slow. Now, this is beginning to change. For the first time, treatments have emerged that can slow the progression of Alzheimer's disease, a type of dementia accounting for 60 per cent of cases. A better understanding of the mechanisms underlying the different kinds of dementia are reshaping how researchers imagine the condition. Meanwhile, innovations in care – including advanced technologies such as virtual reality and artificial intelligence – are helping to improve quality of life for people with dementia and the people closest to them. "There's never been a more exciting time to be involved in dementia research," says Oakley.

Slowing disease

Since its founding in 1979, Alzheimer's Society has developed into a world-leading funder of dementia research. In 1989, the charity funded research led by neurogeneticist John Hardy into the role of amyloid proteins in Alzheimer's. This led Hardy and his colleague Gerald Higgins to formulate the "amyloid cascade hypothesis", which outlines how the buildup of amyloid plaques in the brain can disrupt its functioning and kill neurons.

Three decades later, treatments are targeting amyloid and removing it from people's brains in early stage Alzheimer's disease. "These drugs have been shown to slow down progression of the disease," says Oakley, although they don't reverse the damage or cure the condition.

These treatments are not currently approved for use in the NHS in the UK, but it is likely that more treatments will be submitted to regulators in the coming years. A study of the Alzheimer's disease drug development pipeline, published in June, found 182 ongoing clinical trials assessing 138 drugs. Some target amyloid, while others are aiming for other targets entirely, including the tau protein, neurotransmitter receptors, and inflammation. "About 30 of these [are] in phase three trials," which is the last step in determining whether a medication is effective as well as safe, says Oakley.

Alongside the search for treatments, Alzheimer's Society supports dementia research in multiple ways. The charity is actively funding over £50m in world leading dementia research, working with more than 400 researchers across the UK. Encouraging early-career researchers to choose dementia as their field of study is a key part of the charity's research strategy. And crucially, it is supporting research that could lead to improved diagnostic methods.

Diagnosis is a major challenge in dementia. While written memory tests are enough to confirm that a person has dementia, additional tests such as PET scans are required to determine the specific type of dementia. "Only 2 per cent of people get that kind of extra, more specific diagnosis," says Oakley. Alzheimer's Society wants many more to get a precise diagnosis promptly.

"The thing that's going to make a very big difference over the next year or two is the introduction of blood tests," says Paresh Malhotra, consultant neurologist

HOW TECH HELPS FIND MEMORIES

Alzheimer's Society enables technological innovations that can make a huge difference to quality of life for people with dementia. This entails partnering with innovators and entrepreneurs, and encouraging them to work in dementia.

One such company is Recreo VR, which has developed a virtual reality headset specifically for people with dementia, who often cannot tolerate having something covering their faces. But the dementia-friendly features of the Recreo VR headset, such as its lightweight design, means that about 85 per cent could use it, says Richard Oakley, Associate Director of Research and Innovation at Alzheimer's Society.

"Using the technology, we could take them back to a place where they lived when they were younger, a family holiday they went on," he says. Dementia patients who had been nonverbal for months often began speaking to carers about their memories. "It's being used in care homes across the country, which is fantastic."

and Head of the Division of Neurology at Imperial College London. Such tests would be a cheap and noninvasive way support the diagnosis of dementia.

To enable this, Alzheimer's Society, Alzheimer's Research UK and players of People's Postcode Lottery are funding the Blood Biomarker Challenge. The aim is to gather the information needed to introduce a simple blood marker to test for dementia in the UK healthcare system. Two studies are being supported. One study called READ-OUT, led by Vanessa Raymont at the University of Oxford, is looking at a large panel of potential biomarkers.

Meanwhile, Jonathan Schott and Ashvini Keshavan at University College London have launched a project called ADAPT, which focuses on a single protein called p-tau217 that is known to increase in the blood during the development of Alzheimer's disease. The hope is that measuring p-tau217 could support a diagnosis and quickly identify people who need further tests.

We already know the blood tests are reliable, says Malhotra. The new studies will help show how they can be integrated into the healthcare system.

Early and accurate diagnosis is crucial for dementia patients. Research shows that 'disease-modifying treatments' are most effective when given early. Early diagnosis means people can access care and support. It also means people can plan for the future. "You can play a role in determining the care you want at home, or how and when you move to a care home," says Oakley. Such preparations make it less likely that people with dementia will reach a crisis that requires emergency medical intervention.

Family support

Alzheimer's Society also aims to improve the lives of people with dementia and their loved ones. It offers support for families, such as online communities, telephone support lines, and social groups. It promotes wider awareness of dementia in society, enabling people with dementia to live fuller lives (see box).

The overall aim is to halt the march of devastation dementia causes. A true cure remains a distant dream, but even without one, enormous progress is possible. "If you shift back the onset of symptoms and delay how quickly the disease progresses, we could be talking a chronic condition that you manage well," says Oakley.

In a few decades, HIV has gone from a death sentence to something that is treatable, says Malhotra. Alzheimer's treatment could be similarly improved. "There are things that are happening at the moment, particularly around machine learning and AI, that have the potential to transform the field faster than I can imagine," he says.

In a few decades, a dementia diagnosis may not be the beginning of the end but something to manage. "I see a world where Alzheimer's disease is going to be like that," says Oakley. "And Alzheimer's Society is at the forefront of this progress."

Find out more at alzheimers.org.uk/newscientistlive

Inside the quantum landscape

A strange kind of geometry governs how particles move inside matter – and physicists have finally glimpsed its shape, discovers **Karmela Padavic-Callaghan**

IMAGINE you are out on a walk. Outside the house in the fresh air you may have left the walls behind, but even so there are boundaries that limit where you can wander. In a city, you are constrained by streets and sidewalks. In the countryside, fences bar your way, and if you come upon a hill, you will definitely feel that incline in your legs.

Now, consider the electron, the fundamental particle that carries a charge and lives inside all materials. One of its favourite things to do is to run alongside other electrons, forming electric currents. But just as when you set off on a walk, electrons can't just do anything they like. In fact, for years, physicists have suspected that electrons must navigate a hidden quantum landscape that constrains their motion.

Could we ever see this landscape? Its shape is set by the laws of quantum physics, while its texture is described by highly complex and abstract mathematics – hopes were never high. But recently researchers published the first full map of this previously unseen realm. "We can now see these hidden textures all of a sudden light up in the experimental data," says Riccardo Comin at the Massachusetts Institute of Technology, one of the researchers who created the map.

All this offers a new way to understand and design materials, perhaps leading to, for instance, super-efficient wires that conduct electricity with no resistance. A new view of what actually happens inside materials is bound to lead to new ways to improve them.

Our world is one of "stuff", whether it be wood for chairs, plastic for toothbrushes or the complex materials that make up magnetic and electronic devices that power modern life. But to understand how stuff behaves, we need to look under its surface. Here there lies a dense tangle of jostling atoms with electrons between them, and how those electrons behave often determines a material's properties.

A notable effort to paint a picture of this internal hustle and bustle came in 1929 from Swiss-American physicist Felix Bloch. He showed that the repeating pattern of atoms within a solid forces electrons to move between them in a periodic way too, similar to how a boat bobs up and down, buoyed by the steady rhythm of waves. He applied this insight to the electrons' wave functions, the equations that encode all the particles' quantum properties. This led him to prove that the wave functions repeat in space as well, which gave rise to a whole new picture of the electrons' world.

Based on its "Bloch wave function", an electron can't have just any energy as it whizzes through a material. Those energies are constrained to a range or "band". Thanks to Bloch's work, we now know that a solid's electrical character – be it a conductor, semiconductor or insulator – depends on how many electrons are corralled into the same band. For example, if the highest energy band is only partially full of electrons, there is still room for them to move around and carry current, like they do in a conductor.

Bloch's theory made modern electronics possible. But its framework didn't always align with reality, a problem that has only grown in the past few decades. In the 1980s and 1990s, physicists began studying materials, such as bismuth telluride, that acted as insulators, but displayed unexpected currents on their surface. And then, in 2018, there was graphene, one-atom-thick sheets of carbon, which conducted electricity with virtually no resistance when stacked and twisted – phenomena Bloch's theory couldn't explain.

But there were also clues as to what may be hiding within these materials. In the 1980s, British physicist Michael Berry realised that electrons could undergo subtle shifts in their wave function as they moved through quantum systems, especially in loops – one of the first clear hints that they were navigating a richer, more complex quantum landscape than Bloch had imagined.

Other elements of that topography had already been established. Even before Berry's work, French physicists Jean-Pierre Provost and Gérard Vallée laid some of the groundwork for mapping it out by offering a recipe for measuring the distance between electrons' ›

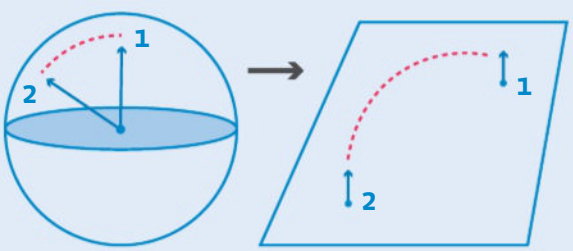
MICHAEL STREVENS

Charting the quantum realm

Researchers recently produced the first map of the quantum landscape inside solids. This tiny terrain can be described with a mathematical framework called the quantum geometric tensor (see main story). It has two key parts:

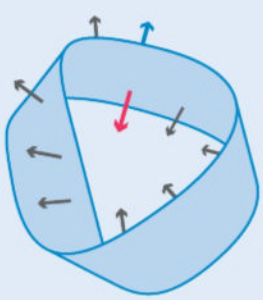
A quantum ruler

Electrons in a material can transition from one quantum state to another, and these states are defined by several parameters, including energy, location and momentum. To describe how easy these transitions are, we represent them as distances in an abstract space. The quantum metric is like a ruler that shows the shortest path between these transitions. Measuring distances in these abstract spaces can be tricky. The shortest path on a sphere (below left) can look curved (below right) when projected curved on a flat plane.



A quantum compass

A quantum state can do more than shift distances – it can twist. This rotation is captured by a measure known as "Berry curvature" that acts as a compass. This space can resemble a Möbius strip (right) with a quantum state, represented by an arrow. We can tweak the quantum state's properties, like its momentum, and move it around this strip until it completes a closed loop. Because of the space's unique curvature, the quantum state ends up rotated in the opposite direction (red and purple arrows).



quantum states. Their work, alongside Berry's, is now summarised by one key mathematical object, which is known as the "quantum geometric tensor" (QGT). It contains all the keys for charting the secret quantum geometry that might explain the behaviours that Bloch's model couldn't. An intrepid explorer of the microscopic world could use it to map the esoteric quantum landscape where electrons reside.

Imagine being dropped into an unfamiliar environment, like a dense rainforest or a desert undulating with sand. Two tools could help you find your bearings. The first is a ruler that determines the shortest path to some destination. The second is a special compass that tells you how moving in a loop reorientates you. It would tell you if you unknowingly turned while walking in a circle back to your starting point and ended up pointing in a different direction. In the quantum world, the QGT provides both (see "Charting the quantum realm", left).

"The shape of the quantum world that had been obscured for so long came into focus"

Mathematically, the QGT is a matrix, or a table of numbers, where each number represents some facet of quantum geometry. You can look at one number to get a reference for how to measure distances, then go to a different part of the table and find a number that describes what happens if you move in a loop.

The entire matrix can be theoretically calculated from electrons' wave functions, but in practice, the mathematics is often too complicated. A solid contains an enormous number of electrons and their wave functions have many more mathematical dimensions than the three spatial dimensions of any material. Because of this, experimentally measuring the QGT instead is the only way to understand it. Unfortunately, problems abound here as well.

Experiments that directly involve wave functions are devilishly tricky, since a wave function only captures a particle's probable states, rather than its concrete properties. Measuring the wave function causes these states to collapse, so measurements must be indirect and gentle. For years, this rendered the QGT little more than theory. "The presence of the QGT has been simply an assumption or belief since nobody actually had observed its presence," says Bohm Jung Yang at Seoul National University in South Korea, who collaborated with Comin to create the first quantum map of a solid.

Before Comin and Yang's work, researchers made progress on filling in some bits of the QGT table, but a full map of quantum geometry within a solid remained elusive. However, in the past decade, physicists have made great strides in engineering and controlling quantum objects, enough to snatch the first glimpses of the entire QGT. The first measurement came in 2020, when Nathan Goldman at the Kastler Brossel Laboratory in France and his colleagues measured the QGT of quantum bits, or qubits, embedded in diamond. These were, Goldman says,

"probably the most controllable qubits in the world", and he and his team extracted their QGT by repeatedly nudging them with precisely tuned circularly polarised light and measuring how their wave functions responded.

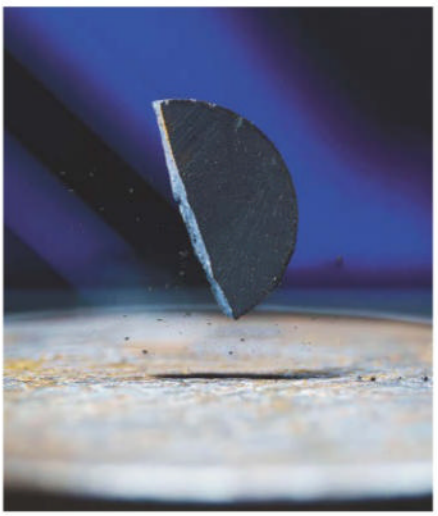
That same year, Guillaume Malpuech at the University of Clermont Auvergne in France and his colleagues did something similar with particles of light, or photons, trapped inside a semiconductor cavity. Once again, tight control over the photons made the difference. "You have, really, very direct access to the [photon's] wave function," says Malpuech.

However, materials that might prove useful for novel electronic devices are nothing like qubits or carefully controlled photons. They are much more complex. Even Goldman says that in his team's experiment, adding just one more qubit made the QGT measurement a lot more challenging – and materials, which contain myriad atoms, are immensely more complicated. "There is, a priori, no general recipe for extracting the quantum geometry of those [quantum] states," he says.

Mapping materials

This is the challenge that Comin and his team faced when they started thinking about measuring the QGT for electrons inside a material composed of cobalt and tin nearly five years ago. They turned to angle-resolved photoemission spectroscopy (ARPES), a staple technique in material science labs at many major universities. Here, researchers bombard a material with light, which knocks out electrons that land on a detector. From the detector's readings, researchers can determine what properties the electrons had while inside the material and map the material's bands.

Comin's team tweaked ARPES so the light wouldn't only dislodge electrons, but also spin them, allowing them to extract the QGT entries that explain what happens to an electron when it moves in loops. Yang's team then analysed the same data to excavate the parts of the QGT that would provide a ruler for quantum distances. The shape of the quantum world that had been obscured for so long came into focus. "We did it together," says Comin. "I was personally extremely excited." In November 2024, they had their topographical map, the first experimental measurement of a solid material's internal quantum landscape.



ROKAS TENYS/ALAMY

Quantum geometry might help us to find room-temperature superconductors. A material called LK-99 (above) was thought to be one – but proved not to be

More successes followed. In June of this year, Yang and a different team of collaborators repeated the experiment with black phosphorus, this time with even greater precision.

Just as Bloch's picture of where electrons live started the path towards the invention of transistors, the map revealed by the QGT may herald a breakthrough in creating other new materials. One exciting possibility is materials that conduct electricity with no resistance. These "superconductors" could replace traditional wires and help create electronics that are thousands of times more energy efficient, something especially important with the expansion of digital technology and AI. "In superconductors, we have huge scientific and technological potential, and it has been, in my opinion, a little bit underappreciated how big the potential is," says Päivi Törmä at Aalto University in Finland.

In 2022, Törmä and her colleagues were the first to invoke quantum geometry to explain the puzzling observation that stacked, twisted layers of graphene could superconduct. According to Bloch's theory, these materials have "flat" bands, which means that their electrons have the same energy no matter how fast they move or what direction they are moving in. An electron in a flat band is like one that exists in a perfectly flat landscape – there are no hills it could roll down and it has no incentive to ever really change its motion. Because of this, researchers expect electrons in flat bands to do next to nothing. Certainly, they don't expect them to form perfectly efficient supercurrents.

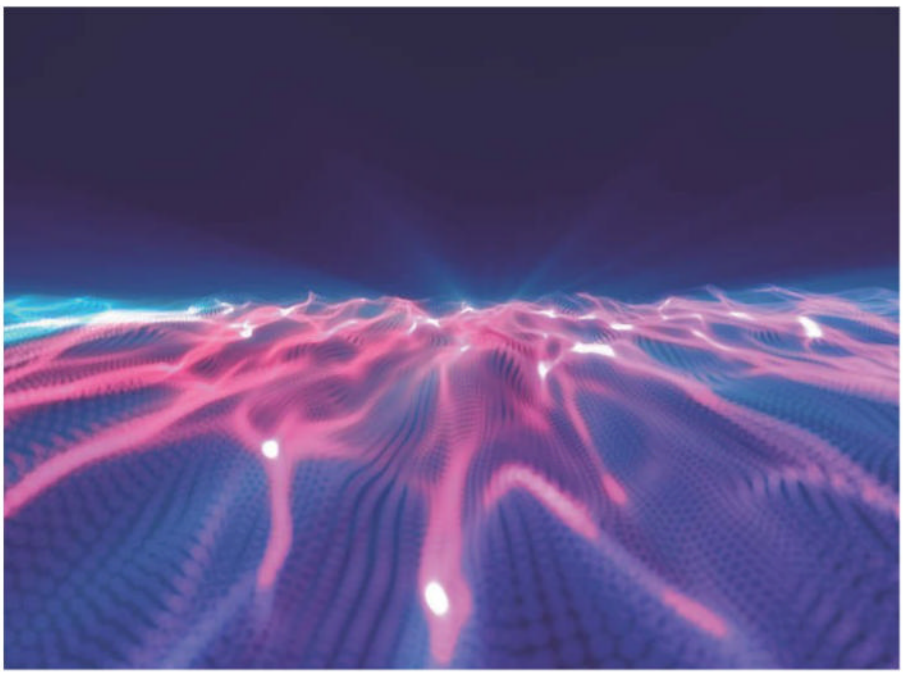
Törmä and her colleagues explained how they form supercurrents anyway by considering the material's quantum geometry. They found that when the stacked graphene layers are twisted just right, electrons' wave functions overlap enough to reshape their world. A bridge may suddenly appear in their quantum landscape, connecting electrons that were previously separated by a large distance, allowing once estranged charges to couple up and superconduct. This quantum geometry is richer than Bloch's theory alone can capture, and it potentially unlocked the secrets to the material's behaviour.

"This was very influential to the community. It gave us a hint that there was a solution," says Abhishek Banerjee at Harvard University. Since then, the idea that quantum geometry could be a key ingredient in future superconductors has been a major feature of Törmä's work.

She thinks that experiments like Comin's and Yang's could strengthen the case that values in the QGT and superconductivity are deeply connected. "In experiments, you'd like to measure both the physical response and the quantum geometric tensor to really establish this connection," she says. She currently leads the SuperC consortium, which aims to achieve a superconductor breakthrough by 2033.

But they have their work cut out for them. To form lossless currents, electrons need to form pairs, yet they naturally repel each other. More than a century after the first superconductor was discovered, the only materials of this type we know of still require either ultra-low temperatures or extremely high pressures to overcome this difficulty. If electrons could be nudged into pairing by the intrinsic geometry of their quantum world, that could lead to more practical superconductors.

To do that, what researchers need, says Törmä, is a checklist of key "ingredients" for a room-temperature and ambient-pressure ›



SHUTTERSTOCK/ALEXNAKO

The "terrain" where electrons travel may redefine how we create materials

"Quantum geometry could govern how some materials respond to light"

superconductor – and its accurate QGT may be an important entry on that list. "Most superconductors that exist now have been found by experimentalists' intuition," says Törmä. "If quantum geometry affects superconductivity positively, then we can use it as a design tool."

Banerjee is all for this idea. He and his colleagues are specifically experimenting with stacked graphene, the material that Törmä's team tackled in 2022. Earlier this year, Banerjee's team found a clever way to illuminate its graphene stack with microwaves and use its response to learn more about the behaviour of electrons in it when it superconducts. They quantified how much a supercurrent resists change, like a river of electrons being steered or sped up, a number that Banerjee expects to match one of the entries in the QGT table.

If he is right, then his team would have strong evidence for Törmä's theory that quantum geometry is behind its strange superconductivity. Scientists could then design the superconductor of their dreams by twisting and stacking graphene sheets, or some similarly thin material, in a way that maximises quantum properties linked to the QGT, such as stronger superconductivity. But for now, no one has managed to measure the full QGT in stacked graphene, and the samples are too small and thin to submit to techniques that work for chunky solids like the ones that Comin and Yang studied. Comin is also on his own quest to find a superconductor, but he is searching in bulky three-dimensional materials that are conducive to his ARPES method.

Nudging electrons

Remarkably, the list of electronic effects that stem from quantum geometry doesn't stop with superconductivity. A variety of exotic effects – like currents spontaneously forming in materials – have recently been linked with some parts of the QGT. One example is the anomalous Hall effect, where electrons veer to the side as if nudged by an invisible magnetic force.

These effects could emerge from the underlying geometry of quantum states, rather than classical forces, and may be useful in designing devices where directional control of current is key. Transistors – the building block at the heart of all existing electronics – perform exactly this current control function. Instead of needing multiple components to manipulate the flow of charge, materials shaped by quantum geometry may do this by default.

The same geometry could also govern how some materials respond to light, causing them to fill up with currents when illuminated. This could open the door for new kinds of solar cells or light sensors.

Anatoli Polkovnikov at Boston University in Massachusetts says that studying the QGT could even benefit a broader swathe of science that deals with materials. He first came across it while studying how systems change from one phase to another, the more complex quantum analogues of how liquid water changes into solid ice. In these systems, phase changes mark sudden shifts in big collectives of particles, like when a magnet flips its alignment. He found that the distance between quantum states, measured by the ruler in the QGT, can stretch or even diverge near this critical transition point. "I started seeing [quantum] geometry everywhere. It just appears in all aspects of physics," he says.

These days, Polkovnikov is interested in whether the quantum geometry of chaotic systems differs from those that never become chaotic. And he is convinced that quantum geometry could become an important concept in chemistry, where it helps explain what some electrons are doing during fast and abrupt chemical reactions.

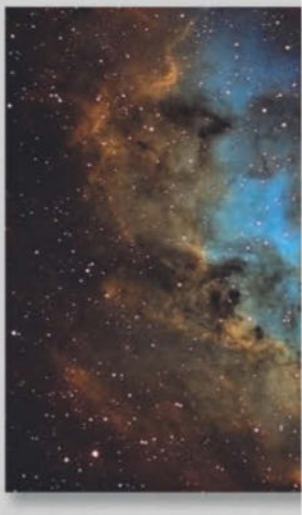
We are only just beginning to explore the hidden topography of the quantum world inside materials – the ink is still drying on those first maps. Even so, the interest is really growing, says Törmä. "In the beginning, I was kind of following every paper," she says. "Now, I have given up. There's so much." ▮

Karmela Padavic-Callaghan is a physics reporter at *New Scientist*

GALAXY
ON GLASS

SPECTACULAR WALL ART FROM ASTROPHOTOGRAPHER CHRIS BAKER





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The snot transplant

Loss of smell and a constantly blocked nose are an uncomfortable reality for many, but there is a novel solution, says **Graham Lawton**

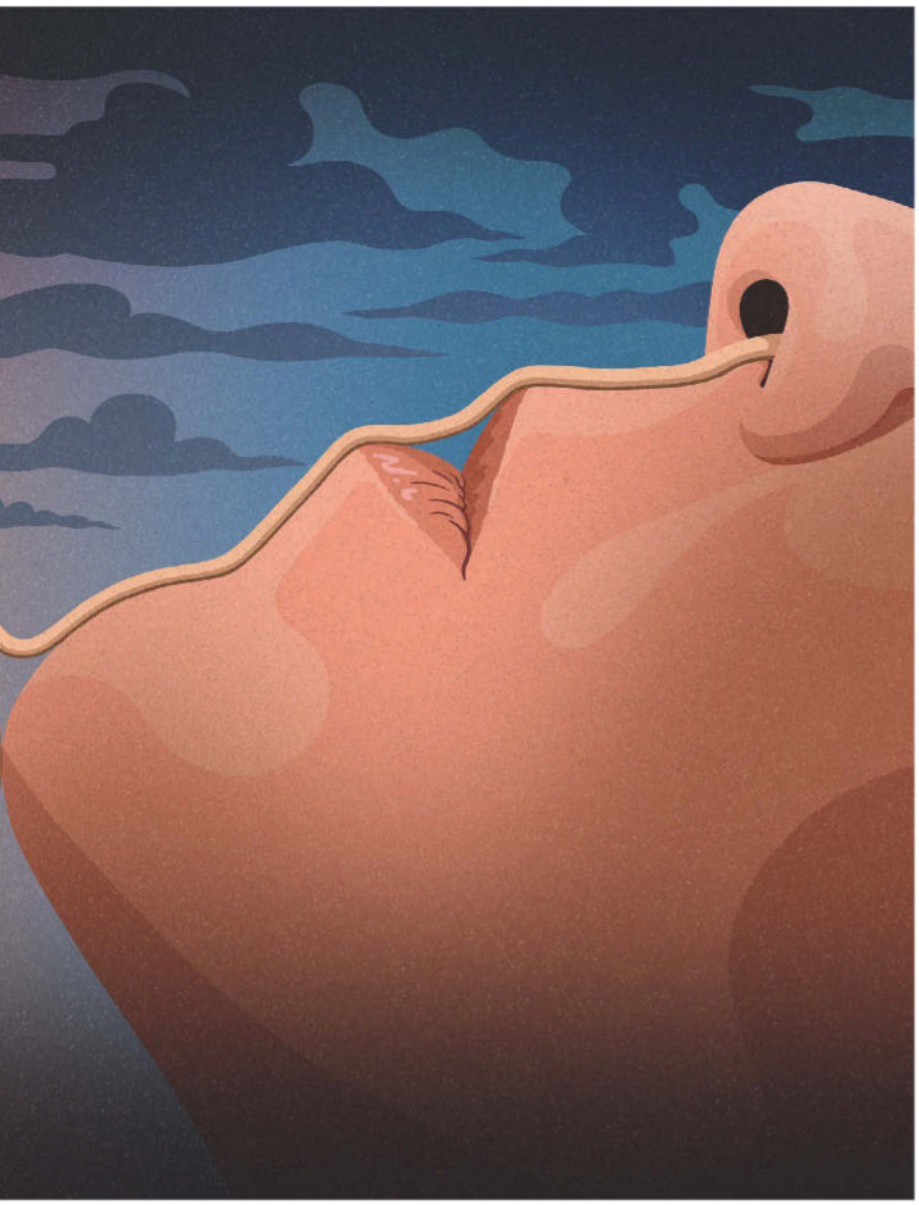
"IT HAS a huge, huge impact on almost every facet of life," says Duncan Boak. "Not being able to breathe properly. Being bunged up all the time. Blowing your nose constantly, snot running out of your nose constantly, not being able to sleep, facial pain. And it is one of the biggest causes of smell loss, which, for the majority of patients, is the most impactful symptom of the condition."

If that sounds awful, it is. Boak, who is the chief executive of UK-based charity SmellTaste, is talking about a little-known but common and deeply unpleasant condition called chronic rhinosinusitis. Many people with CRS grapple with their symptoms in silence, dismissed by doctors, unaware that they aren't alone or even that the condition exists. Those who do get proper treatment seldom shake the disease completely, and some don't respond at all.

But that bleak prospect might be about to change. A new hypothesis about the cause of the condition is offering up a radical new treatment: the snot transplant.

As its name suggests, CRS is persistent inflammation of the lining of the nose and paranasal sinuses, the four pairs of air spaces at the front of your skull that humidify and warm inhaled air. Anyone who has had a bout of regular sinusitis will be familiar with CRS's grim symptoms: thick, green snot, difficulty breathing, high temperature, facial pain, headaches, bad breath and a diminished or lost sense of smell and taste. Now, imagine having that for months on end or all the time, with little prospect of relief. That is the fate of hundreds of millions of unfortunate souls who have CRS, which is defined as sinusitis that persists for 12 weeks or more.

Despite its nasty symptoms, CRS is often dismissed as a minor inconvenience, says Christopher Chin, a surgeon at Dalhousie University in Halifax, Canada, who specialises



PETER REYNOLDS

in diseases of the nose and sinuses. "I think a lot of people are shrugged off by their doctor because of this perception that it's not really a big deal and it doesn't really affect them," he says. "But it does."

And quite a few people have CRS – the latest estimate of its global prevalence, based on research from 20 countries, suggests that around 10 per cent of people are living with it, up from nearly 5 per cent at the start of the century. That's twice as many people as have asthma. "It's a super common condition," says Chin.

It usually affects the middle-aged and is more common in women than men, but it can strike anyone at any age. And it can be a real blight. On average, those with the condition lose 20 days of work or education every year because they feel unwell or have to attend medical appointments, says Chin.

"It causes systemic inflammation, so it's a lot of fatigue," says CRS expert Anders Mårtensson at Helsingborg Hospital in Sweden. "Life quality decrease is on par with chronic heart disease. I think: 'Oh my God, this has to be painful, and really hard.'" One of the most distressing symptoms is loss of smell and taste. "A lot of people come in and say: 'I haven't been able to taste in years,'" says Chin. "People really get bothered by losing their sense of taste."

Perhaps unsurprisingly, people living with CRS are also more prone to depression. One study found the incidence of depression in people with the condition was 77 per cent higher than in people without.

CRS actually comes in two subtypes: one features nasal polyps, which are small, fleshy growths on the inside of the nose and sinuses; the other doesn't. More than 90 per cent of cases are the non-polyp variety. There is a marginal difference in symptoms between the two groups: those with polyps are more likely to have nasal obstruction and a loss of smell and taste, while those without polyps are more prone to facial pain. But they are essentially the same condition, says Chin.

What causes CRS has long been a mystery. There is a genetic component, says Chin, but there must be other factors too, possibly allergies, exposure to pollutants or persistent viral infections. The condition can also be triggered by a particularly serious acute infection. "Patients often describe that they had a really bad cold, and, after that, something shifted," says Mårtensson.

There is also an intriguing link with asthma: around 25 per cent of people with CRS have the condition, which is five times the rate in the general population. This trend is even starker for those with the polyp variety of CRS, of whom 70 per cent have asthma, suggesting a common causal factor. But exactly what this might be isn't clear. "The reality is we don't really know," says Chin. "It's frustrating that we don't know what causes it," says Mårtensson.

The lack of effective treatments is frustrating, too. The standard approach is to regularly wash out the sinuses with saline solution and apply anti-inflammatories called corticosteroids to the lining of the nose. This combo can provide relief, but only temporarily, according to Fernanda Cristina Petersen at the University of Oslo in Norway. Many doctors also prescribe antibiotics, but the evidence that these make any difference is weak.

The symptoms naturally ebb and flow. "Sometimes it's worse, sometimes it's better," says Mårtensson. This creates a dispiriting cycle of improvement and relapse. An aggressive oral dose of steroids can dampen down a flare-up, but, again, it doesn't provide long-term relief.

For people with polyps, drugs that were developed to treat other inflammatory ›

Feeling unwell? There's a transplant for that

Evidence suggests that many human diseases are caused by dysbiosis, or perturbation of the microbiome inhabiting our various orifices and surfaces. Transferring microbes from healthy donors into people with these conditions is increasingly being tested and, in some cases, has been used widely to cure them.

The most established is faecal microbial transfer, which is clinically proven to tackle hard-to-treat bacterial infections of the colon. Sinonasal microbial transfer looks promising for treating chronic rhinosinusitis (see main story), vaginal microbial transfer is being trialled in bacterial vaginosis and various forms of dermatitis appear to respond to skin microbiome transfers. Last year, the first-ever oral microbiome transfer was carried out in a cancer patient with oral mucositis, a painful inflammation of the mouth lining that is a side effect of chemotherapy. The procedure has also been proposed as a possible treatment for gum disease.

Other microbiomes are throwing up more possibilities. Christopher Chin at Dalhousie University in Halifax, Canada, says he has heard anecdotal reports of doctors treating persistent ear infections with earwax transplants. Even the testicles and prostate gland contain microbiomes, though in low abundance, and dysbiosis of these has been linked to male infertility. Maybe one day, testicular or prostate microbial transfers will help people who are struggling to conceive.

conditions, such as eczema and asthma, can be deployed against their version of the condition. These artificially produced monoclonal antibodies block parts of the immune system, easing inflammation, and for people with certain forms of treatment-resistant CRS, they can be transformative. "Patients that get monoclonal antibodies often describe it as they're young again," says Mårtensson. "They thought it was age that made them so tired all the time, but it was actually inflammation from the chronic rhinosinusitis."

Unfortunately, monoclonals don't treat the underlying problem and the relief doesn't last long, so people have to go back to be reinjected every few weeks. The drugs also don't work on non-polyp CRS, which has a different inflammatory profile and response to that of polyp CRS, meaning only a minority of people see benefits.

The treatment of last resort is surgery to remove inflamed tissue, polyps and sometimes small amounts of bone. This opens up the airway and provides some respite in about three-quarters of cases, says Chin, but it, too, doesn't solve the underlying problem. People with the condition still have to use steroids and saline sluices afterwards, and many require further surgery within a few years. "The treatments that we have are not like a one-time thing," says Chin. "It's lifelong maintenance."

For around 20 per cent of people, nothing works at all, according to Amee Manges at the University of British Columbia in Vancouver, Canada. "It's such a recalcitrant disease," she says.

What is really needed is a cure for CRS, rather than just a temporary sticking plaster. And there may be one on the horizon, if a new hypothesis about the condition's origins turns out to be correct.

The idea is that the root cause could be sinonasal dysbiosis, an unhealthy imbalance in the microbiome inside the nose and sinuses. Like all other cavities in the human body, the nose and sinuses harbour populations of microorganisms – a fact that was only definitively proven in 2009. In people with CRS, the composition of this microbiome is often very different from that of people without the condition. "There's been a lot of studies indicating that the nasal microbiome might be the culprit behind the disease," says Mårtensson.

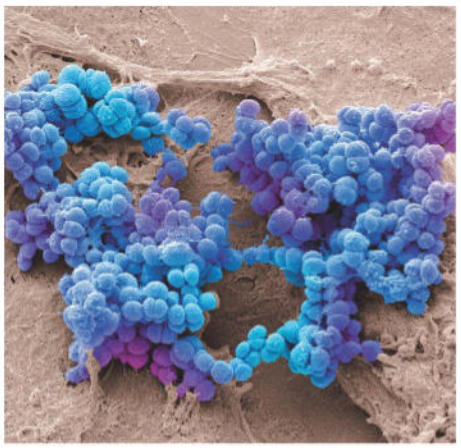
If it is, the solution to persistent snot may be yet more snot – from other people. Manges and Mårtensson are independently developing treatments in which mucus from a healthy donor is transferred to the nose and sinuses of a person with CRS. Essentially, a snot transplant.

The idea came to Manges in 2018, she says, when she was researching faecal microbial transfer. This well-established treatment for persistent diarrhoea caused by infection with the bacterium *Clostridioides difficile* is increasingly offered to people dealing with ulcerative colitis. In the technique, a stool sample from a healthy donor is transferred – either directly, via a colonoscopy or enema, or by swallowing a capsule containing freeze-dried live faecal microbes – into the recipient's colon. The healthy microbes in the donor stool then colonise the diseased gut, driving out invaders. It works, has been approved by various medical authorities and is now used routinely to treat *C. difficile* and ulcerative colitis in some countries. Other types of microbial transfer are being explored too (see "Feeling unwell? There's a transplant for that", left).

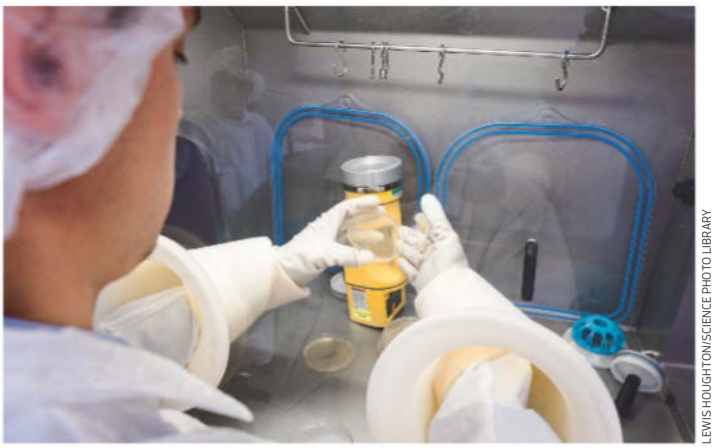
So Manges devised a protocol to do something similar for CRS. To test this new technique, called a sinonasal microbial transfer, she recruited three people with treatment-resistant CRS and three donors. She and her team suctioned as much mucus as they could from the donors' noses and a structure called the middle meatus, which serves as a drainage pathway for many of the sinuses, then washed them out with saline and collected that too. Finally, they dripped around

STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

A persistent runny nose (right) and damage to the cillia in sinus tissue (above) are symptoms of chronic sinus infections



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY



LEWIS HOUGHTON/SCIENCE PHOTO LIBRARY

Left: The bacteria *Staphylococcus aureus* may contribute to some chronic sinus infections. Right: The success of faecal microbiota transplants inspired similar transplants for the nose

5 millilitres of this snot-and-water cocktail into each recipient's nasal passage and sinuses. All three improved immediately, and two remained much better after six months. "We saw improvements in the symptoms and differences in the microbiome," says Manges.

That was a pilot study, but Mårtensson has since carried out a larger experiment, also with promising results. He and his colleagues recruited 22 people with polyp-free CRS and 22 healthy donors, who were mostly spouses or friends of the recruits with CRS. They first treated the recipients with antibiotics to clear out their sinonasal microbiome, then, once the groundwork was laid, washed out the donors' noses and sinuses with saline solution and collected it. On five consecutive days, they rinsed the recipients' noses and sinuses with the donor snot. Three months later, 16 of the 22 recipients reported improvements to their health and quality of life, and they also scored better on an objective measure of symptoms called the SinoNasal Outcome Test, or SNOT.

The idea that CRS is definitively caused by sinonasal dysbiosis is still a speculative one, says Sudhanshu Shekhar at the Czech Academy of Sciences' Institute of Microbiology in Nový Hrádek. "While numerous studies consistently demonstrate alterations in the sinonasal microbiota of CRS patients," he says, "it has yet to be determined whether these changes actively drive mucosal inflammation or arise as a consequence."

However, he and others are taking a punt that dysbiosis is in fact the root cause, based on the early success of sinonasal microbial transfer. Both Mårtensson's and Manges's teams are now recruiting for larger clinical trials, with a view to winning approval for the treatment towards the end of this decade. Shekhar, meanwhile, is working on mouse models of CRS to test and refine this type of microbial transfer. "[The treatment] has shown considerable promise," says Shekhar, who recently co-wrote a review of the procedure. "Early pilot studies and case reports suggest that it can help restore a healthier microbial community and, in some cases, lead to clinically meaningful symptom improvement."

SIMON MAYCOCK/ALAMY

"The solution to persistent snot may be yet more snot – from other people"

And if sinonasal microbial transfer works for CRS, that opens up the prospect of solving other hard-to-treat respiratory diseases too, says Shekhar. This could prove vital, given the growing threat of infections caused by antibiotic-resistant bacteria. Again taking inspiration from faecal microbial transfer, which has been used experimentally to eradicate resistant bacteria from the gut, sinonasal microbial transfer could help restore a healthy microbiome in people who have respiratory tract infections caused by superbugs. The nose and sinuses are often a reservoir for these microbes, he says.

Receiving someone else's snot might sound gross, to put it mildly. But if sinonasal microbial transfers end up easing the torment of CRS and aiding society's fight against resistant bacteria, they could be transformative. ▮

Graham Lawton is a staff writer at *New Scientist*

Shock to the system

Cleaning up air pollution has saved millions of lives, but it has had unexpected consequences for our climate, finds **Madeleine Cuff**

ANDREW TSANG

IMAGINE the year is 2050 and the world has devised a way to stop global warming. No, not by doing the hard work of cutting greenhouse gas emissions, but by spraying reflective particles into the stratosphere that dim the sun. The strategy works: temperatures at ground level stabilise, and life goes on as normal despite escalating carbon dioxide concentrations in the atmosphere.

Until suddenly, something goes wrong. The spray guns break down, the money runs out, a pandemic hits or a global war disrupts operations. Whatever the case, the planet starts to heat up, fast, as years of pent-up emissions kick into effect. Ecosystems can't cope, wildlife perishes en masse, societal chaos ensues.

This disastrous scenario and similar science fiction-sounding situations like it have been named "termination shocks" by climate scientists. But what most people don't realise is that, over the past few years, we have been experiencing a version of it firsthand.

Global action to improve air quality – by shutting down coal-fired power stations and cleaning up shipping fuels – has saved millions of lives in recent decades. But on the flip side, air pollution can also cool the planet. Removing it has released a surge of warming that has warped the weather around the world.

Thanks to advances in climate modelling, we are now starting to understand the true impact of our drive for cleaner air on lightning storms, heatwaves and ocean ecosystems. What's more, these changes could be a taster of what termination shocks of sci-fi proportions would look like. "It definitely provides a preview of what could happen," says Tianle Yuan at NASA.

If you wound back the clock to 2012 in China, you would find a country choked by poor air quality. There were more than a million deaths a year from cases of stroke, heart disease and lung cancer that were linked to particulate matter pollution. Public anger over the issue was mounting, with huge, violent protests erupting across the country.

The government was forced into action, imposing strict pollution controls on power plants and industrial sites and promoting renewable energy development over coal-fired power. It led to a rapid and dramatic drop in the rates of particulate matter and sulphur dioxide pollution, with emissions down by half and two-thirds, respectively, since 2012. In a similar vein, in 2020 the International Maritime Organization (IMO) introduced new rules on emissions from ships, curbing the amount of sulphur dioxide pollution ejected over smoggy port cities and the open oceans by over two-thirds that year (see "Plummeting pollution", page 42).

These actions have saved millions of lives, improved public health and curbed environmental problems like acid rain. But there's a catch: sulphur aerosols help to cool the planet. This happens in two main ways: first, they behave like tiny mirrors, reflecting sunlight back into space. Second, they act as nuclei for the formation of condensation droplets, helping to make clouds denser and whiter, and so more reflective. "If the number of aerosol particles is increased, it leads to a greater number of droplets, and the overall droplet surface area increases, resulting in a greater reflection of sunlight," explains Robert Wood at the University of Washington.

Climate scientists have known about this cooling effect since the 1970s. It has helped to dampen the warming effect of greenhouse gas emissions by about 0.5°C, they estimate – although uncertainty ranges are large.

So it isn't surprising that our efforts to improve air quality have come with a side order of extra global warming. Actions to reduce pollution in East Asia alone account for 5 per cent of global temperature increase since 1850, a study published earlier this year shows.

Extreme weather

What has startled climate scientists is how some parts of the world have experienced unusual, even extreme responses at a regional level to the removal of aerosol pollution. But thanks to improvements in climate models, which are now able to simulate these effects, we can understand in unprecedented detail how such efforts provoke hotspots of warming and changes to extreme weather around the world.

There are now fewer lightning strikes over shipping lanes, for instance, which is thought to be because there are now fewer aerosol particles from ships' smokestacks to generate electrically charged ice crystals. Meanwhile, other regions have experienced increases in tropical cyclones, the emergence of warm patches of ocean water or more intense heatwaves. These changes can only be explained when aerosol pollution trends are added to climate simulations. "I don't think it was fully realised how much this ›

LILLIAN SUWANRUMPHA/AFP VIA GETTY IMAGES

Coral reefs are at a greater risk of bleaching as the shipping industry cleans up its emissions

[pollution removal] would affect the regional climate," says Bjørn Samset at the Center for International Climate and Environmental Research in Norway.

Indeed, the scale and variety of these changes have prompted some researchers to describe the rapid removal of pollution aerosols as a "termination shock". Yuan, for instance, describes the impacts of IMO shipping regulations as an "inadvertent geoengineering termination shock with global impact".

"The intention for the fuel regulation was to limit the impact of these aerosols on human health, in coastal cities or general populations," he says. "But when you reduce those [kinds] of pollution emissions, it has the same effect as reducing the number of aerosol particles in the air." This is the opposite effect of proposed geoengineering strategies that inject aerosols into the stratosphere to reflect sunlight, so he describes it as a kind of "reverse geoengineering".

Unsurprisingly, some of the biggest shifts have emerged in China. In 2022, mainland heatwaves in eastern China were up to 0.5°C more intense because of the country's clean air improvements. But there are also strange "teleconnections", a term used in climate science to refer to when a change in one part of the world triggers a climatic shift tens of thousands of kilometres away. The sudden emergence of severe ocean heatwaves, dubbed "warm blobs", in the Pacific Ocean near Alaska over the past decade could be another result of China's aerosol pollution reductions.

Researchers suggested in a paper last year that the reduction of pollution emissions in East Asia triggered coastal regions to warm, setting off a chain reaction of weather systems that led to a surge in water temperatures in the Pacific. Fish die-offs and toxic algal blooms are commonly found in these warm blobs. "The impact of anthropogenic aerosol forcing is more complex and far-reaching than we thought," says Xiao-Tong Zheng at Ocean University of China in Qingdao, who co-authored the paper.

Relax the rules?

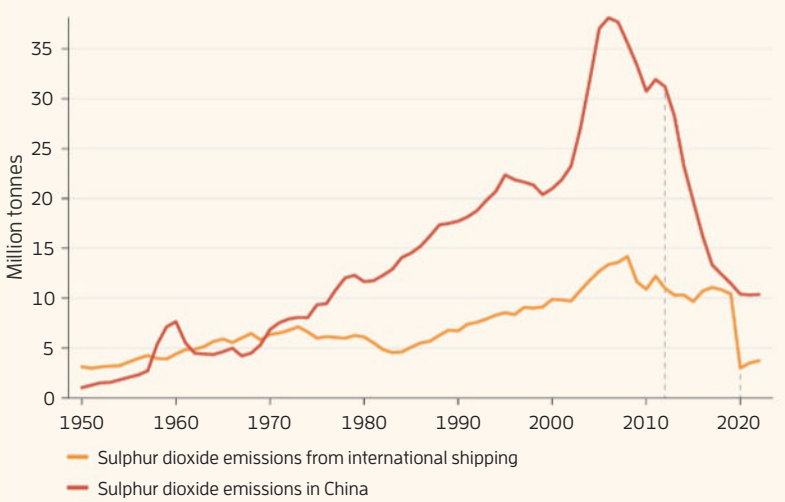
Damage to marine environments has also been caused by the reduction in sulphur aerosols from shipping. According to research that was published in June and is yet to be peer reviewed, Australia's Great Barrier Reef, already under pressure from climate change, has suffered further heating as a result of the shipping clean-up, putting its corals at greater risk of bleaching.

The effect has been so extreme that some researchers suggest the IMO should relax its pollution rules on the high seas to restore some of the cooling effect from sulphur. The idea is that in remote sea regions far from ports, the emissions from container ships are unlikely to have significant health impacts, so there is a greater need to consider ecosystem impacts like coral bleaching.

The findings suggest that aerosol pollution may be staving off some of the worst consequences of climate change elsewhere in the world. Samset points to the Indian monsoon, a vital summer downpour that supplies more than three-quarters of the country's annual rainfall. Overall, the monsoon rain in India has intensified in recent years, a consequence of greenhouse gas emissions strengthening monsoon winds over the Indian Ocean, which drives heavier rainfall patterns on land that lead to devastating flooding. But the effect has been significantly dampened by high levels of air pollution in India and China, says Samset,

Plummeting pollution

China's sulphur dioxide emissions have fallen by two-thirds since 2012 because of government regulations and pollution-curbing technologies. Similarly, in 2020, global sulphur dioxide emissions from ships plummeted by over two-thirds owing to new rules from the International Maritime Organization.



SOURCE: COMMUNITY EMISSIONS DATA SYSTEM 2024

JOHN FINNEY PHOTOGRAPHY/GETTY IMAGES

Weather systems are being warped by our efforts to curb air pollution

CHANDU LUMBURU/AFP VIA GETTY IMAGES

Without the Earth-cooling effects of aerosols, India's monsoon rains may further intensify

"Aerosol pollution may be staving off some of the consequences of climate change"

as aerosols cool the atmosphere and weaken the forces that create rainfall.

That is an important factor for India to consider as the country plans for a changing climate. Although ongoing greenhouse gas emissions will continue to intensify the monsoon, the expectation is that India will soon follow the US, Europe and China in cutting air pollution as it transitions to cleaner energy sources. That would remove the dampening effect of aerosols, says Samset. "Suddenly, you [would] see a very strong intensification of the monsoon," he says. "That's really the driving motivation for understanding the regional aerosol changes. We can better anticipate and better plan for future changes."

While the most extreme changes are regional, the rapid abatement of aerosol pollution has also had a global impact on the pace of warming. Yuan's 2024 research suggests the IMO shipping regulations could lead to a doubling (or more) of the warming rate of the global ocean in the 2020s compared with the rate since 1980. This would mean further record-breaking global temperatures could be in store this decade.

However, some researchers are wary of describing the planet's response to cleaner air as a termination shock. James Haywood at the University of Exeter, UK, argues that a full-scale shock, resulting from the abrupt halting of a geoengineering scheme, would be far more severe. The term applies when temperatures jump so rapidly and by such a large margin that ecosystems cannot cope, he says. "The termination effect only really becomes an issue if the magnitude of the leap [in temperatures] is unprecedented globally and regionally," he says.

The IMO shipping regulations, for example, have accelerated global warming by up to three years, says Haywood, meaning the margin of change isn't dramatic enough to be a full-scale termination shock. "There wouldn't really be a huge amount of problem with ecosystem adaptation to three years of global warming being released instantaneously," he says. "What would be a problem is if you had 30 years of global warming being released in a very short time."

Regardless of semantics, there may be important lessons here for understanding the potential risks and opportunities of any future, larger-scale geoengineering interventions. Research interest in solar geoengineering is increasing as scientists and entrepreneurs scramble for solutions to save some of the world's most fragile ecosystems, such as coral reefs and polar sea ice. Researchers, including Samset and Zheng, say that deliberate interventions like these could one day be informed by data on how changes in aerosol emissions feed through into weather patterns – including how the emission location, time of year and type of aerosol particle all feed into these downstream effects. Yet if handled improperly, warns Zheng, "geoengineering could exacerbate climate change signals and extreme events in certain regions."

It is a sentiment shared by Daniele Visioni at Cornell University in New York state. "To me, the biggest lesson is that there are no 'risk-free' decisions in our complex world. Geoengineering is not a magic wand and is not going to make our problems go away." ▮

Madeleine Cuff is an environment reporter at *New Scientist*

The back pages

Debunking gardening myths

Keep it simple

With so many fertilisers on the market, how do we pick the right one for our plants? **James Wong** goes back to basics

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

WANDER into any garden centre and you will find a wall of fertilisers, where colourful bottles promise perfect results for everything from lawns and roses to tree ferns and Japanese acers. But do home gardeners really need them? Let's look at the science.

Although plants require about 16 mineral nutrients, most are needed in only tiny amounts. In fact, at the core of plant nutrition – and therefore fertilisers – are just three macronutrients: nitrogen (N), phosphorus (P) and potassium (K), which fuel leaf growth, root development and flower/fruit formation, respectively.

The key difference between most plant food formulas is down to the ratio of these nutrients, which, manufacturers must display on the label after the letters "NPK".

If you want a lush green lawn, aim for a feed with a higher nitrogen value. For flowering or fruiting plants like roses or tomatoes, however, you will need more potassium. You don't need to scour every bottle for its mineral proportions or work out which plants they would match, since marketeers have helpfully labelled formulas depending on the plant they are best suited for.

But this is where things get trickier. I recently compared three "specialist" plant foods from a well-known brand: for roses, strawberries and tomatoes. All three had an identical NPK ratio, 4-2-6, so the only meaningful difference was the picture on the bottle. Here's the thing: plants draw up whatever they need from the soil, in the proportions they need it. For the vast majority, a balanced, all-purpose fertiliser will be fine. In fact, some "specialist" feeds are repackaged generalists.

SHUTTERSTOCK/ENCIERRO

Stocking up on a minibar of different bottles is expensive and unnecessary, and can also do more harm than good. Plants only need fertiliser to top up minerals missing from the soil. Overloading it with nitrogen, for example, has been shown to lead to soft, pest-prone growth and poorer-tasting produce. Excess phosphorus, meanwhile, often washes into waterways, contributing to serious environmental damage. This is especially true in places like the UK, where garden soils are pretty fertile, especially compared with agricultural ones, thanks to much less intensive management.

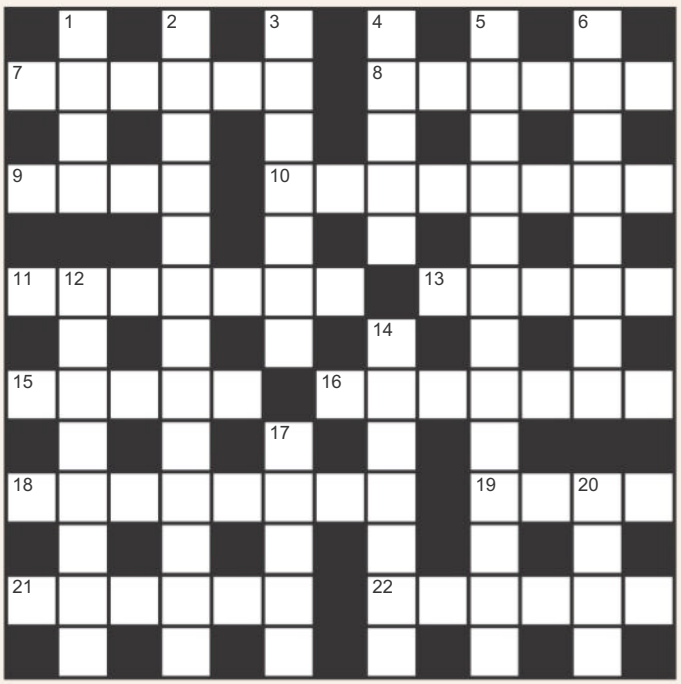
So what's the answer? Buy a cheap, easy-to-use home soil test, not unnecessary fertiliser. Of course, there are exceptions: plants like rhododendrons, which love acid, often need a boost of iron and manganese, as their roots can have difficulty absorbing them from more neutral soils. Likewise, container-grown plants (especially those in low-nutrient media like peat) usually need fertiliser top-ups during the growing season. But for most home-growers, including those keeping houseplants, a single, balanced plant feed, or none, is OK, leaving you time (and money) to just enjoy growing the plants. ▮

Debunking gardening myths will appear every four weeks

Next week
The science of exercise

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

Cryptic crossword #170 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Purchase paper on phone from one whose company pulled in two banks (6)
8 Proposition presented in *The Observer* leader really lacking in content (6)
9 Bear killing time in a whirl (4)
10 Recklessly teasing about sample size, they're likely to provoke a reaction (8)
11 Huge quantity in account, one that's charged (7)
13 Crustaceans in middle of Antarctic trapped in ice (5)
15 Bullish, perhaps, until losing head – then sheepish (5)
16 Where some birds go to nest, or to return, caught by physicist (7)
18 Knight seen in strange, tallish colonial constructions (8)
19 Return of portent for Verne hero (4)
21 What snowboarder wants is German article on comic book's impact (6)
22 Singer with Swiss tool (6)

DOWN

1 Make yellow and shiny, like a fish, reportedly (4)
2 Two different characters in one short Victorian novella (6,3,4)
3 Montage edited to convey great weight (7)
4 They're numerical facts, whichever way you look at them (5)
5 New recruit, e.g. gone to get detector (6,7)
6 Elderly relative, at first, universally loved – all rather sugary? (8)
12 Perhaps Edison's outlet covered with scrap iron (8)
14 Witness noticed rusty core in playground mechanisms (7)
17 Large, disordered, angry way to look (5)
20 Friendly, but not able to find mineral (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #319
set by Corryn Wetzel

1 Which website was the first to reach a billion users?

2 What is the scale for measuring tornado intensity?

3 A parsec, a unit of distance used in astronomy, is equal to about how many light years?

4 In probability theory, an event with only two possible outcomes is often called what?

5 What is the only living tissue in the human body that lacks blood supply?

Answers on page 47

BrainTwister
set by Katie Steckles
#90 Discount disco

You are buying an item that costs £50 and have a voucher for £5 off, a voucher for 10 per cent off and a voucher for £10 off. Discounts are applied one at a time, updating the cost after each.

If you apply all three discounts in the order given, what will the final price be?

What is the cheapest your item can be if you can choose the order in which to apply the discounts?

How many different prices can you pay, depending on the order you apply the discounts?

Solution next week

Turn, turn, turn

Sci-fi shows often feature "space ports" spinning slowly to create artificial gravity. Is this feasible, and how soon?

Alex McDowell
London, UK
They are entirely feasible and, with sufficient funding, we could build one within months or years!

Due to the effect of the Coriolis force on the semicircular canals (three tubes in the inner ear), humans would feel dizzy if the rotational speed of the space port exceeded about 2 revolutions per minute (rpm), in which case the centrifuge would need a diameter of 448 metres for the artificial gravity to be equivalent to that on Earth.

However, humans can adapt to rotational speeds of up to 23 rpm, in which case the diameter of such a centrifuge would need to be only 3.4m. Such centrifuges would overcome the detrimental health effects of prolonged weightlessness, like the loss of bone and muscle mass, for example on missions to Mars and beyond or extended trips to space stations.

"Astronauts could spend time inside centrifuges to avoid the health problems caused by living in weaker gravity"

In 1975, the Kosmos 782 satellite carried a centrifuge that gave animals on board artificial gravity. And on Skylab in the 1970s, astronauts ran round the circular wall of the capsule, giving the effect of running with some gravity.

These centrifuges could also be used where gravity is weak, for example, on the moon. Astronauts in such places could spend time inside centrifuges to avoid the health problems that prolonged living in weaker gravity would cause. In these centrifuges, the "floor" wouldn't be perpendicular to the ground outside: it would be at an angle where the components of the real gravity and the artificial gravity vectors add up to be perpendicular to the floor.

Ron Dippold
San Diego, California, US
The beautiful thing is that objects in space continue moving as long as nothing slows them down (in accordance with Isaac Newton's first law of motion). If you had a 30-metre-diameter space station (about 95m in circumference), you would only need it to be rotating every 8 seconds to get full Earth gravity at the edge. And once you got it up to speed, it would spin forever, except for space dust slowing it down. You could, of course, go half as fast, but any less than full Earth gravity seems to lead to nasty health problems.

There are two big problems. First, the difference in speed between feet and the head: in a 30m-diameter space station, a 2m-tall person's feet are 15m from the centre, but their head is 13m from the centre. So their feet are rotating at 12 metres per second and their head is at 10.5 m/sec. This is enough to cause disorientation. You can help this by making the station larger or (in a 30m-diameter station) just letting people get used to it. The smaller you make it, the worse it gets.

The second problem is docking rockets or shuttles. Good luck docking anything to the rim that is flying by at 12 m/sec! So rotating-wheel stations need a docking station at their axle. A fixed 3m docking hatch on a station rotating every 8 seconds would still be rotating at 1.2 m/sec at its edge, so you need a "despun hub" that is rotationally detached from the spinning station.

It would still need a little propellant to stay relatively still because it can't be 100 per cent detached and the rotation of the rest of the station would tend to make it rotate a bit, but it wouldn't take much propellant to counter that. Once a ship docked to the non-spinning hub, astronauts would ease into the centre of the spinning station, where it isn't spinning so fast, then get up to speed by hanging on to handles and slowly easing outwards to Earth gravity.

The International Space Station doesn't do this because, while it has been a huge success, it was accreted instead of orbited in its final form. It was designed so you could just bolt new sections on as needed, and they have done that. But if you want a spinning wheel design, you have to build the whole thing to start with, and that was too expensive and too much work at the time. But it could be done right now if any country or coalition wanted to commit to it.

CAVAN IMAGES/ALAMY

Why do dogs, like this good boy, bother to fetch sticks that are thrown for them?

This week's new questions

Go fetch! **Why do dogs bring back a stick if you throw it? If I were a dog, I would say to my owner: you threw it, you fetch it.** ***Jim Ainsworth****, Leominster, Herefordshire, UK*

Twinkle twinkle **If you could approach closely enough (which, of course, you couldn't), what would the surface of a neutron star look like?** ***Bob Humphrey****, Bristol, UK*

Gas or grass

I use a petrol lawnmower – does it emit more carbon than the grass captures?

Eric Kvaalen
Les Essarts-le-Roi, France
The accompanying photo for the question when it was first published shows someone using a lawnmower with nothing to catch the grass clippings. That means they will land on the grass and eventually rot, returning their carbon to the atmosphere. So the grass in the final analysis doesn't capture any carbon.

If you do use something to catch the clippings, then

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Tom Gauld
for New Scientist

maybe, theoretically, you could do something with them so they don't rot, but they probably will. If they decompose, then they will produce methane, which is worse than carbon dioxide from the point of view of climate change.

Another question is whether the petrol lawnmower puts more carbon dioxide into the air than the agriculture necessary to provide you with the extra calories you might need to consume if mowing your lawn with a push-mower!

Hillary Shaw
Newport, Shropshire, UK

Unless your garden soil level is slowly rising (carbon is being sequestered), your lawn superficially has a zero carbon budget, as its biomass stays roughly constant.

But the grass cuttings decay and release the carbon they absorbed. In fact, your lawn is a net carbon emitter because it takes energy to mow it: for petrol, the electric mower and also your human effort, which ostensibly also has a zero net carbon budget, but the food you ate to expend the calories used in mowing had to be grown and transported.

"The best thing for global warming might be to stop doing anything to gardens and to let them return to a wild state"

Your garden can be a net carbon sink (for a while) if you grow trees and shrubs, but these reach maximum size and then net-absorb no more carbon dioxide, and you may get complaints from the neighbours. But your garden will be more wildlife-friendly.

Sam Edge
Ringwood, Hampshire, UK

To the person who asks whether a petrol lawnmower emits more carbon than their lawn absorbs, the answer is always "yes". Unless all the grass trimmings are collected, compressed down into blocks and buried very deeply so that they turn into peat, coal or oil and then stay buried, they will rot or otherwise be consumed by organisms. These processes release as much CO_2 back into the atmosphere as the grass absorbed in the first place.

It gets worse. If the lawn is watered from the mains supply from time to time or chemical fertilisers or moss and weed inhibitors are applied, then the production, transport and supply also add to the lawn's "carbon turf-print". And if it is a manual lawnmower, then the extra energy needed to push it has to come from the operator's food – unless they are an organic vegan smallholder who grows their entire diet, then that is probably going to have a terrible effect too, because of the hugely inefficient and carbon-belching Western agricultural system.

The best thing for global warming might be to stop doing anything whatsoever to gardens and to let them return to a wild state. Failing that, invest in photovoltaics on the roof and get an electric lawnmower! ▮

Answers

Quick quiz #319 *Answers*

1 Google
2 The Enhanced Fujita scale
3 3.26 light years
4 Bernoulli trial
5 The cornea

Quick crossword #191 *Answers*

ACROSS 1 Screw propeller, **10** Ultra, **11** O positive, **12** Doppler, **13** Dawn Ape, **14** Alarm, **16** Odd number, **19** Timestamp, **20** Drain, **22** Bipolar, **25** E-ticket, **27** Laxatives, **28** Erwin, **29** RaLa Experiment

DOWN 2 Cytoplasm, **3** Email, **4** Pyorrhoea, **5** Ovoid, **6** Exit Wound, **7** Leica, **8** Roe deer, **9** Tundra, **15** Mistletoe, **17** Depressor, **18** Black swan, **19** Tubular, **21** Natant, **23** Pixel, **24** Rev up, **26** I-beam

#89 Digit differences *Solution*

There are nine numbers with digits 5 apart, one for each starting digit from 1–9. For digits 4 apart, there are 84 numbers. Some are fixed like before, but if we hit a 4 or 5, we have two options for the next digit. For each nine-digit number with 4s or 5s, this choice happens four times, giving us four fixed (starting with 2, 3, 6 or 7) and five flexible (starting 1, 4, 5, 8 or 9) options, or $4 + (5 \times 2^4) = 84$. For 3 apart, we get 240 numbers. If the first digit is 1, 2, 4, 5, 7 or 8, the previous logic applies, giving $6 \times 2^4 = 96$. But if the first digit is 3, 6 or 9, it gets more complex. Start by counting options for two-, three- or four-digit numbers, and you will begin to see part of a familiar sequence, which for nine digits gives 144 numbers.

In the name of...

One of science's greatest honours is to have something named after you. For example, geographer Alexander von Humboldt is remembered by a penguin, a Californian county, a mountain range and so much more.

Congratulations, then, to Harvard astronomer Abraham "Avi" Loeb, after whom a new scale may be named. Loeb, a regular in *New Scientist*, has spent much of the past decade considering the nature of interstellar objects passing through our solar system. The first was 'Oumuamua in 2017; this year, comet 3I/ATLAS dropped by.

Loeb attracted a lot of attention by arguing these objects might be artificial: probes or craft of some kind sent by extraterrestrials. His claims have, to put it politely, not convinced many of his fellow astronomers. The scepticism was compounded in 2023, when Loeb claimed to have identified pieces of an interstellar meteor on the sea floor. It turned out that seismic signals he said showed a meteorite impact were probably from "a moving vehicle traversing the road next to the seismometer".

Still, interstellar objects will keep popping up now that we can spot them, justifying the need for the scale proposed in a preprint (arXiv, doi.org/p4nd). It is intended to classify such objects by how likely they are to be artificial, and if they are going to hit Earth. The scale ranges from 0 (an object "consistent with known natural phenomena") to 10 (an object of "confirmed extraterrestrial artificial origin" and an "impact trajectory with global terrestrial consequences").

Feedback is mildly confused, as the scale appears to be measuring two things at once – and that isn't how scales work. If we ignore the impact stuff, the scale at 8 and above signifies that an object is definitely ET. The interesting stuff is in levels 2 to 7, which cover ever stronger evidence of artificial origin, from "non-gravitational acceleration" and "unusual shape" to "signs of being operational" and "responsive behavior".

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

Feedback is a little unclear just how we would decide some of these. Take the unusual shape of a space rock. Famously, Mimas, a moon of Saturn, looks like the *Star Wars* Death Star, but it is no space station. It is also hard to tell artificial electromagnetic signals from natural ones, hence the large number of alarms about alien radio messages.

It all seems a bit fuzzy, so Feedback decided to check out the creators of the Loeb Scale. Two are sports psychologists at Reichman University, Israel, who are evidently branching out. The third is, er, Loeb.

Dog utility vehicle

Feedback has often mused about unusual units of measurement, such as whether we can measure the rate of information transfer using a snail carrying a DVD.

Reader William Dockendorf emails to tell us about a wholly new one, and this will take some unpacking. There is apparently a new make of car in the US called a Slate. It is "a two-door electric pickup truck" that can be "customized again and again to transform into whatever you need it to be: even an SUV". Dockendorf notes that this is a configuration that "approximately no one will probably buy".

On the company's website, slate.auto, there is a long page of FAQs. One asks: "How much junk can I fit in the frunk and the cargo bed?" Before you ask, no, "frunk" isn't a typo: electric vehicles often have a storage compartment at the front, so it is a "front trunk".

Anyway, the measurements are given in feet and cubic feet, listing what William calls "relatively generic things" like a "55 in. flat screen TV (in the box)" that will fit on the cargo bed. But then it says that the cargo bed will also hold "about 30 dachshunds".

Williams says he now feels "a need to measure everything in approximate numbers of dachshunds". Feedback wants to know if these are live dachshunds, or something less space-filling like dead dachshunds, freeze-dried and packed together like sardines .

Latest farts

After learning of the Flavor Analysis and Recognition Transformer (FART) (Feedback, 16 August), we asked for more examples of high-quality acronyms – or, at least, hopelessly contrived ones. What follows is a selection from the deluge of emails. This will become a recurring item, at least until morale improves.

First, Thomas Kläger writes of the Regional Bus and Rail Company of Ticino, the only Swiss canton where Italian is the sole official language. In this tongue its name is the Ferrovie Autolinee Regionali Ticinesi SA. Feedback can confirm this is real, and that its official website is the delightful fartiamo.ch.

Years ago, physicist Paul Davies says he attended the opening of "an Australian-Japanese cosmic ray experimental set-up" near Woomera in Australia. This was the Collaboration between Australia and Nippon for a Gamma Ray Observatory in the Outback, also known as CANGAROO. "Full marks for creativity," says Davies.

But the last word must go to palaeoanthropologist John Hawks, who wrote on Bluesky (we don't even think he had read Feedback) about a paper he found in *The American Journal of Human Genetics*. It describes "a method for estimating mutation rates and recent demographic history from very large samples". By "very large", the authors mean a dataset of a million genomes. Naturally they called their tool "Diffusion for Rare Elements in Variation Inventories that are Large", or "DR EVIL".

"Well played," says Hawks. To which Feedback can only add: "Yeah, baby!"

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