New Scientist

WEEKLY 31 October 2026 No3619 Australia $11.99 (Inc. GST) New Zealand NZ$11.99 (Inc. GST) Print Post Approved 100007877

WHY THE WORLD'S FIRST SPINAL CORD TRANSPLANT IS SO CONTROVERSIAL

WHAT THE INNER LIVES OF INSECTS TELL US ABOUT CONSCIOUSNESS

DOES PHYSICS HAVE ITS NEXT EINSTEIN?

THE REGENERATING BRAIN

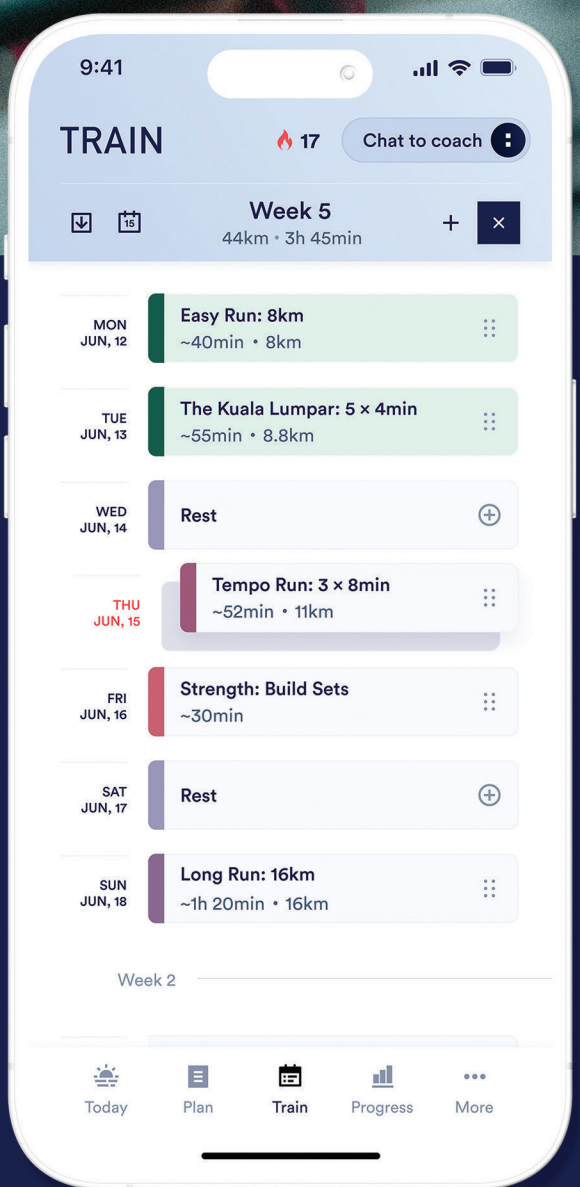
The unexpected discovery that it's never too late to grow new neurons – and how to harness it



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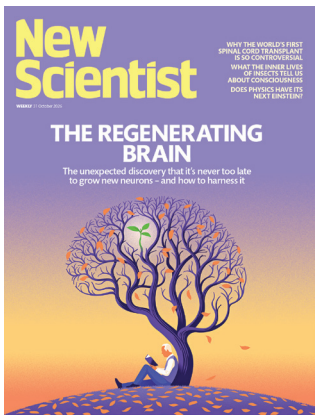
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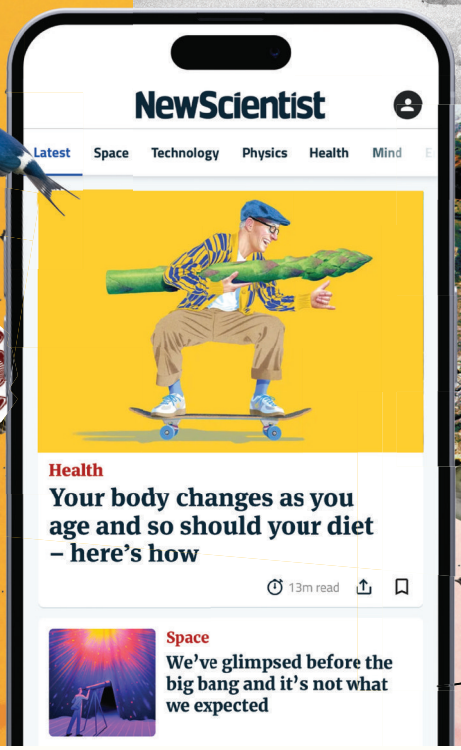
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Under the knife

When is an experimental surgery too experimental?

THE virologist Jonas Salk said that "hope lies in dreams, in imagination and in the courage of those who dare to make dreams into reality". Salk was certainly daring – he risked paralysing himself, his wife and their children while testing his polio vaccine. Thankfully, it paid off. None of them experienced any ill effects and his work is credited with saving millions.

Risks have to be taken for medicine to advance, and someone is always the first to receive a treatment. But there are risks, and then there are risks.

Salk tested his vaccine on cells, monkeys and children who had already had polio before turning his unexposed family into guinea pigs. His approach is far from standard protocol today, but he did a lot to reduce the risk of something going wrong.

There is less evidence to justify an operation that took place this month in Russia (see page 4). Details are scant, but the procedure involved cutting out a section of spinal cord from someone with a complete spinal cord injury and gluing in a replacement piece from a donor.

"The transplant was a world first, but there is little evidence to believe it will have worked"

The transplant was a world first, but there is little evidence to believe it will have worked or that now was the time to try it.

History tells us that acting ahead of medical evidence can have catastrophic results. Take the first synthetic organ transplants, which replaced tracheas with plastic tubes. The surgeon who fitted them admitted they hadn't been tested on large animals because they "didn't have the time". Complications and deaths followed.

With new medical procedures, the gold standard is randomised controlled trials, which are costly and take time, but they aren't the only route. When someone is critically ill, there are compassionate-use protocols that make interventions available before they are fully tested. Pig kidney transplants are currently being trialled this way, for example.

The dream of spinal cord transplants will surely become a reality one day, but only if the science underpinning them is built first. Courage, dreams and imagination are of course good, yet with experimental surgeries, evidence is better. ▮

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New Scientist is published weekly by New Scientist Ltd, 9 Derry Street, London, W8 5TT, UK.
ISSN 1032-1233. New Scientist (Online) ISSN 2059 5387. Registered as a newspaper. Printed in Australia by ive Group, Unit 1/83 Derby Street, Silverwater NSW 2128

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Health

First-ever spinal cord transplant

A surgeon has told *New Scientist* they have performed a transplant on someone with a complete spinal cord injury, reports **Helen Thomson**

THE world's first human spinal cord transplant has been carried out in Russia. This is said to have involved removing a damaged segment of a person's spinal cord, three years after the injury, and replacing it with a section from a brain-dead donor.

Although the recipient is said to be doing well, the operation has drawn concern from some researchers, who question whether it will work and are concerned that it may even leave the individual worse off.

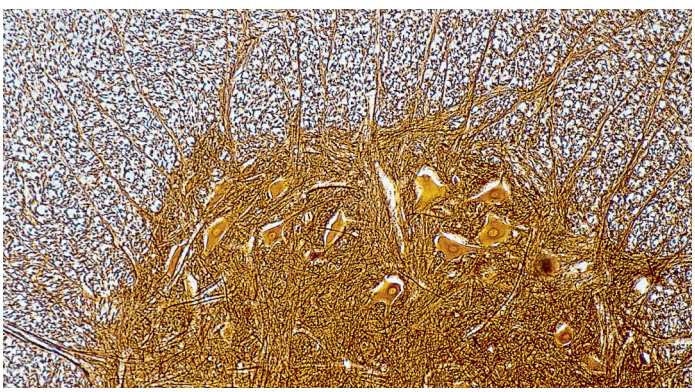
Xiaoping Ren at the Second Affiliated Hospital of Guangxi University of Chinese Medicine in China, who led the surgery, told *New Scientist* that the operation took place last week at the Sklifosovsky Institute for Emergency Medicine in Moscow.

Ren says the surgery was performed on an adult with a complete spinal cord injury that occurred from external trauma three years earlier. This usually causes paralysis and loss of physical sensation below the site of the injury. However, it isn't known what part of the spinal cord was injured in this individual.

Further details are limited, but Ren says the surgery involved the use of polyethylene glycol (PEG) – a kind of biological glue – alongside microsurgical techniques to fuse the ends of the donor segment to the recipient's own spinal cord.

"We have informed the patient of every potential risk and surgical outcome, and the patient's current condition is good," says Ren. "Our Russian team will later release a document describing the surgery."

"This is a Sputnik moment for spinal cord injury," says Sergio Canavero at Harbin Medical University in Heilongjiang province, China, who has previously published papers with Ren describing the potential for spinal cord transplants in people.



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THOMAS DEERINCK, NCMIR/SPL

If the spinal cord (above) is severed, then messages can no longer travel from the brain to nerves below the damage via spinal root nerves (right)

But some question whether the operation will really help the recipient. "I'm concerned for the patient's safety as they likely will be much worse off after this procedure, given the need to recover from a substantial surgery, with very little benefit," says Melissa Andrews at the University of Southampton, UK. She also warns of a high risk of infection.

The problem with repairing spinal cord injuries is restoring communication between the brain and the neural circuits below the injury. Spinal cord cells don't divide and regrow, and after injury, damaged areas degrade further.

For many years, Ren, Canavero and others have been developing a procedure involving bringing freshly cut spinal cord surfaces together and applying PEG in an attempt to fuse the fibres across the junction.

Michael Lebenstein-Gumovski, who is also at the Sklifosovsky Institute for Emergency Medicine, has done similar work on pigs, but wasn't involved in the human transplant. He previously told *New Scientist* that this proposed "fusion" approach is based on joining nerves together, rather than generating new nerve cells or encouraging fibres to grow across a lesion. This, in theory,

> **"It is very difficult to get two adult pieces of nervous system to join together in a functional way"**

is followed by "neuroplastic reorganisation", where the brain and spinal cord adapt to the new connections, which wouldn't have functioned together before.

There has been some recovery of movement in dogs, as well as pigs, using this technique. Some protocols involve adding drugs to reduce inflammation or support nerve health, plus electrical stimulation of spinal circuits.

However, reconnecting a freshly severed spinal cord is different to repairing an injury experienced years before or integrating a donated segment of spinal cord.

For a transplant to functionally integrate, the surgery would have to include molecules that promote tissue healing, says Andrews. It would also need factors that neutralise molecules in and around the spinal cord that act as a natural brake on nerve fibre growth and other factors that induce growth between the donor tissue and the recipient's spinal cord. "Even then, the chance of regeneration and functional recovery would be, in my opinion, zero," says Andrews.

Nerve regeneration

She also has doubts over the animal evidence underpinning the surgery. "On the whole, I don't believe these studies have been done rigorously enough, and the results don't relate to what is neurologically possible."

Andrew Jackson at Newcastle University, UK, says there is some data showing that PEG can assist with rejoining severed spinal nerves, and he can imagine a situation where a transplanted segment of spinal cord tissue might provide some growth factors to support regeneration of severed nerve fibres. But he says that researchers traditionally use stem cells to encourage nerve fibre growth because "it is very difficult to get two adult pieces of nervous system to join together in a functional way".

He adds that he hopes supporting evidence for the surgery will be available for peer review as soon as possible. "There are many people living with spinal cord injury and they deserve clarity, transparency and honesty about the prospects and outcomes of any new therapies that are being trialled." ▮

Cancer

Personalised cancer vaccine expected to be approved next year

Carissa Wong

AN mRNA vaccine for melanoma, the deadliest form of skin cancer, that is personalised to each person it is given to is expected to be approved for use in the US, Europe and the UK next year. The vaccine is designed to stimulate immune responses against genetic mutations that are unique to an individual's cancer. When used alongside standard treatment in a late-stage trial, it substantially cut the risk of cancer recurrence or death within the next two years.

"I think approval could be quick, and next year sounds reasonable," says Alan Melcher at the Institute of Cancer Research in London, who wasn't involved in the trial.

"It is a huge deal," says Rebecca Lee at the University of Manchester, UK, who also wasn't involved. Thousands of people in the UK alone could benefit from this, based on the trial's patient population, she says. "It's highly likely the US and Europe [including the UK] will approve it next year."

In August, drug-maker Moderna announced that the vaccine had positive results in a late-stage trial. More specific findings have now been released.

The trial recruited more than 1100 adults who had surgery to remove high-risk melanomas that were likely to recur or spread to distant sites. Two-thirds of the participants were randomly assigned to receive a bespoke vaccine on top of standard immunotherapy, called pembrolizumab, which helps the immune system find and destroy cancer. Both were delivered every three weeks for up to a year. The remaining participants received placebo injections plus pembrolizumab.

"The vaccine stimulates immune responses against mutations that are unique to an individual's cancer"

The vaccine is made by genetically sequencing a small sample of a person's cancer and comparing that sequence with the DNA in the individual's healthy blood cells. This enables researchers to pinpoint mutations specific to the cancer.

Based on the same technology used in covid-19 vaccines, the cancer vaccine contains mRNA molecules that encode for proteins with up to 34 of those mutations.

"The jab contains a fingerprint of proteins specifically associated with the cancer," says Lee. "This helps [immune] T-cells recognise the cancer better, and then pembrolizumab prevents those T-cells from becoming exhausted once they've started attacking the cancer cells."

About two years after the start of treatment, 82 per cent of the participants who received the vaccine plus pembrolizumab were alive without their cancer recurring, on average, compared with 70 per cent among those on pembrolizumab alone. "It's a really exciting result," says Lee. Side effects were similar between the two groups.

The results combine cancer recurrence and death rates into one figure, but since a treated cancer has to recur for it to cause death, this combined measure should be interpreted mostly as a sign of the vaccine reducing recurrence, says Melcher. The participants haven't been tracked for long enough to robustly determine whether the vaccine improves survival rates. These results should be available within a few years, says Lee. ▮

Climate change

UN says 1.5°C is over and we're on track for 2.8°C warming

THE only way to meet the target of limiting global warming to 1.5°C above pre-industrial levels is by "overshooting" that goal in the short term, the UN said in its latest Emissions Gap report, before relying on vast amounts of global cooling, delivered via technologies such as direct air capture, in the latter half of the century.

This "lowest possible" overshoot scenario would see the global temperature rise peak at 1.7°C to 1.8°C, with a 50 per cent chance of temperatures falling back to 1.5°C by 2100. To deliver this, the world would need to cut emissions by 18 per cent by 2030, 45 per cent by 2035 and 69 per cent by 2040, relative to 2025 levels. Under current pledges, emissions will only fall by 5 to 8 per cent by 2030, and 11 to 15 per cent by 2035.



XINHUA/SHUTTERSTOCK

Increased wildfires are predicted under climate change

"Overshoot is not surrender," UN Secretary-General António Guterres said in a statement.

But many scientists are sceptical that it is feasible. "We don't know whether we can overshoot," says Bob Watson, emeritus professor at the University of East Anglia in the UK and former chair of the Intergovernmental Panel on Climate Change. "We don't know if any of those technologies are real."

The UN's new report makes it clear how far off track the world still is to deliver even this "limited overshoot" pathway. Current national policies put the world on track for 2.8°C of warming by the end of the century. If nations meet all their climate promises, that is lowered to 2.1°C. This is worse than last year's projection of 1.9°C of warming, driven mainly by the US's exit from the UN climate process. ▮

Madeleine Cuff

For more on attempts to limit climate change, turn to page 12

Neuroscience

Cholesterol linked to Alzheimer's

The glymphatic system flushes toxins out of the brain, but this seems to be disrupted in Alzheimer's disease, and cholesterol may be involved, discovers **Michael Marshall**

THE flow of fluid through the brain was drastically reduced in a mouse model of Alzheimer's disease, and cholesterol may be responsible. Disruption to the glymphatic system, the brain's waste-clearance network, contributes to the build-up of harmful proteins associated with the condition. Now, cholesterol has been linked to a reduction of this circulation, perhaps by blocking crucial passages within the brain.

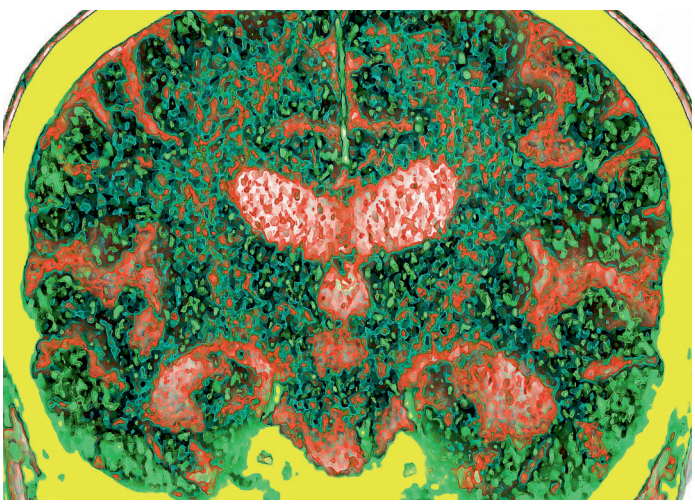
However, this is far from established and many questions remain. "I would regard this more as a hypothesis-generating piece," says Roslyn Bill at Aston University in Birmingham, UK, who wasn't involved in the research.

Alzheimer's disease is the most common form of dementia, which affects around 50 million people worldwide. People with Alzheimer's accumulate two types of harmful protein in their brain: beta-amyloid, which aggregates into plaques, and tau, which forms tangles.

Many studies suggest that one contributing factor in Alzheimer's is a failure to clear waste chemicals from the brain. The brains of people without Alzheimer's flush out harmful waste through the glymphatic system, a network of narrow channels running along the outer walls of blood vessels in the brain. Glymphatic flow is reduced in mouse models of the condition, but evidence is mounting that this could be restored via drugs, light and sound exposure or even inhaling a high dose of carbon dioxide.

"Alzheimer's disease may change cholesterol so it blocks the flow of chemicals to neurons"

To better understand this disruption, Do-Geun Kim and his colleagues at the Korea Brain Research Institute in Daegu, South Korea, studied two groups of mice. Some had been genetically engineered to express five mutations associated with Alzheimer's in people, while the rest were healthy.



VSEVOLOD ZVIRYK/SCIENCE PHOTO LIBRARY

Alzheimer's disease may be related to failing to clear waste from the brain

The team injected a dye into the cisterna magna, a chamber at the back of the brain that is full of cerebrospinal fluid. Different mice were then euthanised 5 minutes, 15 minutes, 30 minutes, 60 minutes or 120 minutes after the injection.

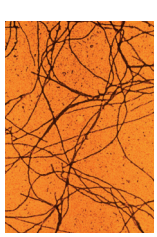
In the healthy mice, the dye spread along the outside of arteries running along the underside of the brain, and then into brain tissue, over the first 30 minutes. By 120 minutes, the dye was almost entirely gone, suggesting it had been cleared by the glymphatic system.

However, in the genetically modified mice, the dye accumulated around the outsides of the arteries, with little of it reaching brain tissue. "The passage is somewhat blocked," says Kim.

Normal glymphatic flow occurs just outside blood vessels. Brain cells called astrocytes wrap their foot-like extensions around these vessels, creating narrow channels called perivascular spaces, through which liquid can flow. The researchers found that these spaces were significantly narrower in the mice modelling Alzheimer's disease than in the healthy ones.

Furthermore, they found that what little dye made it into the modified mice's brains mostly ended up in their amyloid plaques. The team suggests the plaques acted like a sponge, soaking up fluid that would normally circulate through the brain.

Finally, the team looked into the potential role of cholesterol in glymphatic dysfunction. One of the most important risk factors for Alzheimer's disease is mutations in a protein called apolipoprotein E, and one of its main functions is to produce cholesterol in the brain.



DR HUNTINGTON POTTER/SPL

Beta-amyloid protein filaments aggregate in the brains of those with Alzheimer's

Fluid superhighway

The researchers stained mice brains with a fluorescent marker that binds to cholesterol. In the healthy mice, they saw lots of fluorescence in the brain after 5 minutes, with levels then declining. Although unclear, this may be due to cholesterol being released into the brain in response to the dye and then being cleared. However, in the modified mice, the cholesterol signal increased up to 120 minutes (bioRxiv, doi.org/rt7s).

Cholesterol has an array of roles in healthy brains, including regulating signalling between neurons. It is possible cholesterol also transports chemicals from perivascular spaces to neurons, says Kim, who says there may be something about Alzheimer's disease that changes cholesterol so it blocks that flow.

"The perivascular spaces are the highway for fast fluid inflow," says Maiken Nedergaard at the University of Rochester in New York state, one of the discoverers of the glymphatic system. "If that is compromised, it's really hard to get something into the brain."

However, she says the study doesn't clearly show what role cholesterol may have in glymphatic function or why it behaved differently in the modified mice. "Why is the cholesterol mobilised?" she asks. Bill wants to see the experiments repeated with living mice, so the flow of cerebrospinal fluid can be tracked in real time, rather than in microscope slides from dead mice. ▮

Read Hannah Fry discuss where Alzheimer's may start on page 19

Mind

Adults may actually be more creative than children

Carissa Wong

ADULTS are often thought to be less creative than children, as we swap painting for presentations. But in a study, children actually performed worse on creativity tests – yet made up for it in confidence.

"We found that adults are actually more creative thinkers," says Mathias Benedek at the University of Graz in Austria. "But children enjoy creativity more and are much less worried about what others think about their ideas."

Benedek and his colleagues recruited 92 children (aged between 4 and 7) and 70 adults (aged 25, on average) to carry out three creative tasks. First, they had to come up with as many alternative uses for a tin can as possible within 3 minutes. Then, they drew freely for 8 minutes, and in the final task, they had 8 minutes to draw an animal that doesn't exist.

Five people who weren't involved in the research were trained to objectively judge creativity based on originality and whether the final result fulfilled the brief of the task.

In the first task, the adults scored 3.9 points, on average, out of 5, while the children scored 2.9 points. In the second and third tasks, the adults scored 0.6 and 1.9 points higher, respectively, than the children (*PLoS One*, doi.org/rvdx).

After completing the tasks, the participants were asked how they would score their own performance. The children were substantially more confident in what they produced, scoring their performances 4.8 and 4.6 points for the free drawing and animal tasks, respectively, compared with the adults' scores of 2.8 and 3.3.

The children also reported lower anxiety compared with the adults. "If the purpose of creativity is to have enjoyment in it, to play and to be unfettered humans, then children are doing better at that," says Wendy Ross at King's College London. ▮

Space

'Solar flares' created in the lab may explain corona mystery

Karmela Padavic-Callaghan

WITH powerful lasers and a tiny piece of plastic, researchers have for the first time emulated a violent process that may take place on the sun. The experiment could help shed light on why the outermost layer of the sun's atmosphere is so mysteriously hot.

For decades, scientists have struggled to explain why the sun's outer atmospheric layers – a region called the corona – are thousands of times hotter than the sun's surface, reaching several millions of degrees. "It is as if the air grew hotter as you walked away from a campfire," says Wei Sun at the China Institute of Atomic Energy.

Now, Sun and his colleagues have emulated some of the conditions on the sun in the lab and, for the first time, observed how tiny bursts of electromagnetic radiation, or solar nanoflares, could power the corona's puzzling heat.

Nanoflares are known to occur when magnetic fields within the corona abruptly rearrange themselves and emit energy in the process. But for this rearrangement to happen, the exact conditions, such as the shape of the magnetic fields, must be just right, says Sun.

He and his colleagues fired four powerful lasers onto a tiny plastic target, which produced a patch of plasma – a hot mixture of charged particles – about 2 millimetres across. This plasma was not an exact recreation of plasma in the sun's corona but behaved analogously.

"Tiny bursts of electromagnetic radiation could power the corona's puzzling heat"

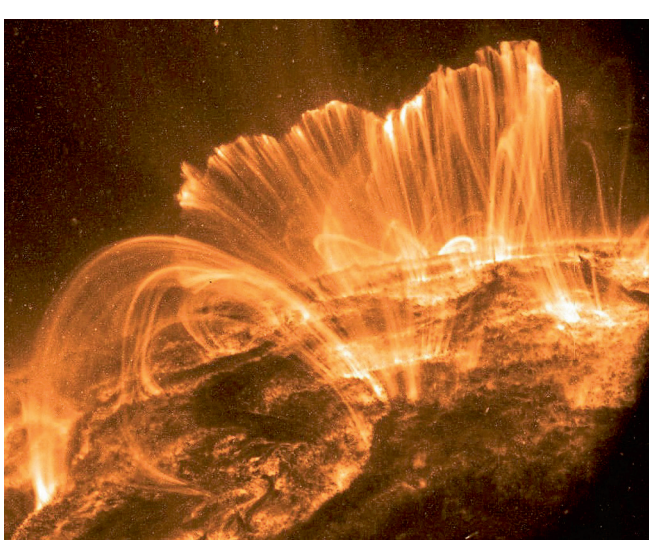
The team created plasmas in two scenarios, once using a flat target and once using one with a wavy surface. In the second case, the plasma became unstable and the magnetic fields it contained rearranged themselves and ultimately produced a nanoflare.

This nanoflare made a big difference to the temperature of the plasma. It reached 799,726°C, nearly double the temperature achieved in the flat target version of the experiment where no nanoflares occurred (*Physical Review Letters*, doi.org/rvdz).

A similar process – instability leading to nanoflares leading to plasma heating – could feasibly happen on the sun, says Sun. In fact, the parameters that determined their tiny plasma's behaviour matched those seen in regions of the sun where blobs of colder plasma "rain" down through the corona. He and his colleagues also completed a computer simulation that corroborated this.

Rony Keppens at KU Leuven in Belgium says that these simulations support the team's interpretation of the experiment and make for an interesting entry on to the list of effects that may be contributing to coronal heating. Coronal rain blobs really could lead to the kinds of instabilities that the researchers now spotted in the lab, he says. Yet, in Keppens's view, the new experiment does not definitively resolve the coronal heating puzzle, as other plasma behaviours, such as certain types of waves in it, could also contribute to it.

Sun and his colleagues want to upgrade their experiment to create more three-dimensional plasmas and use more precise techniques for diagnosing its behaviour. And they want to make their lab measurements more directly comparable to reality – for example, by using data about the sun collected through telescopes, says Sun. "It is important to check that the laboratory is reproducing what the sun does," he says. ▮



Solar coronal loops are seen on the sun after a solar flare

SCIENCE HISTORY IMAGES/ALAMY

Environment

Falling sea levels due to El Niño will hit mangroves and corals

Michael Le Page

HIGHER sea levels in the eastern Pacific due to the monster El Niño are expected to cause record coastal flooding and erosion in the coming months. But on the other side of the Pacific, falling sea levels around Australia and the Coral Triangle – an area to the north of the continent – pose another threat that is only just starting to be recognised: mass die-offs of mangrove forests, with corals and seagrass meadows also affected.

During the super El Niños in 1982/83 and 2015/16, there were mass diebacks of mangrove forests in northern Australia, says Norman Duke at James Cook University in Australia. In the 2015/16 event, around 76 square kilometres of mangroves on a 2000-kilometre-long stretch of shoreline in the Gulf of Carpentaria died.

This was due to a prolonged 40- to 50-centimetre drop in sea level for at least six months. Whether there is a similar or worse event during this El Niño will depend in part on how much rainfall there is.

"Both [previous] events coincided with periods of low to no rainfall," says Duke. "Mangroves, lacking inundation or other sources of moisture, died of thirst."



IMAGO/ALAMY

Mangroves died in the Gulf of Carpentaria, Australia, in 2016 during a super El Niño

During neutral and La Niña years, trade winds blowing west across the equatorial Pacific pile up warm water around Australia's northeastern coast. When these winds weaken or reverse during El Niños, those waters spill across the Pacific. The result is a kind of see-saw effect, with sea levels falling in the west and rising in the east.

Because the current El Niño is so strong, it is producing a greater swing in sea levels than usual.

Long-term tidal cycles can amplify or counteract the effects of falling sea levels, says Neil Saintilan at Macquarie University in Australia. Mangroves grow in the upper part of the tidal range, so if the tidal range decreases at the same time sea level falls, they are left high and dry, he says. "This happened in the Gulf of Carpentaria in 2015/16."

During the ongoing El Niño, the tidal range in the Gulf of Carpentaria should be higher than normal, reducing the risk of dieback – though sea levels may fall further than in 2015. However, along the coastline west of the gulf, the tidal range will be smaller than usual, says Saintilan. "We are anticipating extensive mangrove dieback there."

Changes in sea level also affect corals and seagrass, Duke suspects. Shallow reefs and seagrass meadows are exposed during low tide and can dry out if falling sea levels leave them exposed too long. Even if they remain submerged, the temperature will be higher if the water is shallower, on top of the temperature rises caused by global warming and El Niño.

"Samoan colleagues refer to El Niño events as '*Taimasa*' – periods marked by the smell of dead fish and coral, as they die on exposed coral reefs," says Duke.

"Shallow reefs are exposed at low tide and can dry out if falling sea levels leave them exposed too long"

"It is quite possible that the sea-level drop contributes to the depth of reef dieback, though this would be dominated by the marine heatwaves themselves," says Saintilan.

However, it appears that no studies have attempted to quantify the relative contributions of sea-level fall and marine heatwaves to the coral bleaching events and die-offs in the western Pacific during recent El Niños. "Despite several attempts, I have been unable to convince research colleagues working on corals and seagrasses that these events also contribute to those habitats as well," says Duke.

Tropical coral reefs could collapse within 50 years

Tropical coral reefs face stress from the current super El Niño (see main story), but worse is to come. At least 96 per cent of shallow-water reef ecosystems are at extremely high risk of collapsing by 2075, according to an assessment by the International Union for Conservation of Nature (IUCN). The warning shows how quickly and massively die-offs could unfold.

So far, only one shallow-water coral reef ecosystem has collapsed. The reefs of the western Galapagos Islands lost 95 per cent of their coral – the IUCN's threshold for ecosystem collapse – after the 1982/83 super El Niño unleashed a marine heatwave, turning golden brush corals into white skeletons overgrown by string algae.

Since then, four mass bleaching events have damaged other reefs. These came after strong El Niños, and experts fear the current record El Niño will usher in another one. Regardless, individual reefs are now bleaching nearly every year due to global warming, according to the US National Oceanic and Atmospheric Administration.

Yet another mass-bleaching event could speed up coral collapse, since reef ecosystems don't have time to recover if they are hit by more than three bleaching events within five years, says Marcos Valderrábano at the IUCN. Alec Luhn

Quantum computing

Edging closer to usefulness

The record for how reliable the qubits used to store information in quantum computers can be has been broken, finds **Karmela Padavic-Callaghan**

ANOTHER milestone on the way to building useful and practical quantum computers has been passed. Researchers at the firm Quantinuum have used error-correction methods to make their Helios-1 quantum computer store information with an unprecedented degree of reliability, a key prerequisite for running complex calculations in the future.

Quantum computers hold immense potential for solving problems and making scientific discoveries that have, so far, been out of reach for even the best supercomputers. But they haven't yet realised that potential, partly because all existing quantum computers make lots of errors. Consequently, researchers around the world are racing to perfect error-correction methods where a quantum computer's physical building blocks, or qubits, are encoded into groups called "logical qubits", which are a lot less likely to make errors when used to run calculations.

David Hayes at Quantinuum and his colleagues have now demonstrated the lowest error rate yet for logical qubits.

"This is definitely an impressive technical advance," says Steven Flammia at Virginia Tech, who didn't work on the project. "It's super exciting," says Hayes.

Helios-1 contains 98 qubits, each of which is based on an ion whose quantum state is controlled with lasers and electromagnetic fields. To turn these qubits logical, the team used a type of computer coding called "colour code". When the qubits were then tested for their ability to store information, they made as few as five errors for every million uses of a qubit. This is an improvement on similar past experiments, where qubits would instead make hundreds of errors for every million uses.

The researchers also tested whether two of Helios-1's logical qubits could be used for a simple, error-corrected mathematical operation. The error rate in this situation was roughly 10 times higher, or about seven errors for 100,000 qubit uses.

"Whenever a qubit's energy shifts in a deleterious way, it is hit with a special laser pulse that corrects it"

Hayes says Helios-1's record-breaking performance partly follows from the Quantinuum team improving its control over the physical qubits. Specifically, whenever a qubit's energy shifts in a deleterious way, which happens naturally but makes computations less accurate, it is now hit with a special laser pulse that corrects the shift. Then the colour code kicks in, leveraging the connections and correlations between the qubit and several others in the logical qubit to correct any remaining error.

The researchers have also shown that each logical qubit's error rate decreases as more physical qubits are added to it. Specifically, the error rate diminished twelvefold when they increased a logical qubit's size from seven to 19 physical qubits, with the same diminishing being seen when the physical qubit count rose from 19 to 37. This result is important because quantum computers gain computational power as their qubit number increases, so only error-correction methods that also improve with increasing qubit counts stand a chance of being truly useful.

Murphy Niu at the University of California, Santa Barbara, says the new experiment is a major step towards quantum computing that is error-proof.

Flammia says this work sets the course for building what John Preskill at the California Institute of Technology has dubbed the "megaquop" machine, a computer capable of 1 million reliable quantum operations. This could make meaningful scientific discoveries, for example in materials science, and is thought to be the next important stage in the evolution of quantum computers.



QUANTINUUM

Quantinuum's Helios-1 quantum computer is the most reliable yet

Complex calculations

Helios-1's low error rates fit the bill for a megaquop machine, but what remains to be seen is whether these will stay so low once the logical qubits are used to execute more complex mathematical operations, says Flammia. This is an important missing ingredient as far as achieving fault-tolerant quantum computing goes, says Thomas Wong at Creighton University in Nebraska.

The question of the total number of qubits also looms large. "They only have roughly 100 physical qubits, but on the order of 100 logical qubits would be needed for known useful applications of megaquop machines," he says.

Hayes says Quantinuum's next quantum computer, Sol, will be nearly twice as large as Helios-1. In his view, the new experiment establishes the foundation for Sol and for other computers the company plans to build in the future. "We are doing all of our homework up front," he says.

But competition within the quantum computing industry is stiff. So far, several research teams have made quantum computer prototypes with more than 1000 qubits and the firm QuEra, whose devices are based on extremely cold atoms, has announced that it will build a megaquop machine by 2028.

Health

Latest clue to autoimmunity

Women are more at risk of autoimmune conditions, which may be related to repeated fluctuations in body temperature during the menstrual cycle, reports **Carissa Wong**

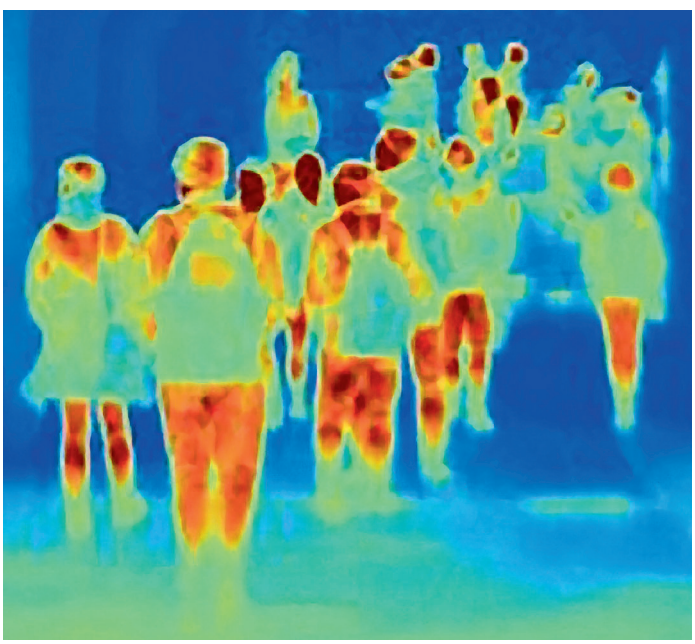
THE menstrual cycle and menopause mean that women's body temperature fluctuates more than men's, which could help explain why they are much more likely to develop autoimmune conditions. Our body temperature influences our immune response, and frequent fluctuations in women could affect their immune cells' ability to differentiate between a dangerous invader and healthy tissue.

"If women's immune cells are experiencing more changes in temperature, they might be getting more overwhelmed and dysfunctional, which could contribute to an increased risk of autoimmunity," says Elizabeth Maloney at the Pasteur Institute in Paris, who presented the findings at the Immunology of the Exposome conference at the Royal Society in London on 12 October. "It could be one piece of the puzzle in understanding sex differences in immunity."

Women generally mount stronger immune responses than men, making them less prone to infections. But this comes at a cost: women are up to four times more likely to develop autoimmune conditions, such as lupus or rheumatoid arthritis, which occur when the immune system overreacts to healthy tissue.

Such differences are due to several factors, including the genetics that determine sex. Most women have two copies of the X chromosome, which carries many immune genes, whereas most men have one X and one Y chromosome. This means women have greater genetic variation, strengthening their immune response.

Hormonal differences also play a role. Oestrogen, the main sex hormone in women, generally bolsters immune system activity



CONNECT IMAGES/ALAMY

Our body temperature influences our immune response

in those of reproductive age, while declining levels during perimenopause and menopause seem to accelerate inflammation, which plays a big role in autoimmunity. Men's main sex hormone, testosterone, generally reduces inflammation.

Now, Maloney and her colleagues have looked at the role of body temperature. They measured the core body temperatures of more than 900 adults, aged between 20 and 69, via a thermometer in the inner ear. The group was made up of a roughly equal number of men and women, none of whom had a known autoimmune condition.

The researchers also collected blood samples, which they exposed to a powerful immune-stimulating protein from *Staphylococcus aureus* bacteria in a test tube.

The one-off temperature readings were similar between the men and women. But among the women's blood samples, a higher body temperature was linked to suppression of T-cells in response to the protein. T-cells are part of the adaptive immune system, which responds to threats like viruses or – inappropriately – to molecules in the body. The latter response can bring about autoimmune conditions.

Among the women's samples, the researchers found that every 1°C (1.8°F) increase in body

"Body temperature changes may cause T-cells to switch between suppressed and activated more often"

temperature was linked to a 36 per cent decrease in these cells' ability to produce interferon-gamma. This is an inflammatory protein that enhances the ability of T-cells to attack target cells, whether they are healthy or infected.

"This may be counterintuitive because we generally think of fever as stimulating inflammation," says team member Darragh Duffy, also at the Pasteur Institute. But it seems there is also a mechanism by which high temperature can dial down the immune response to stop it getting out of hand, he says.

Worn out T-cells

One interpretation of the sex differences in the results is that the more frequent temperature fluctuations experienced by women caused their T-cells to switch between suppressed and activated states more often, says Maloney.

The core body temperature of premenopausal women rises by about 0.6°C (around 1°F), on average, after ovulation, then falls a day or two before menstruation. Perimenopause and menopause can also cause sudden increases in body temperature, manifesting as hot flushes. "Maybe the adaptive immune system is having to constantly change its set point, which sort of wears it out, and then that contributes to autoimmune risk," says Maloney.

"The findings add another dimension to sex differences in immune function," says Sabra Klein at Johns Hopkins University in Baltimore. Future studies should examine whether body temperature affects immune responses in men and women independently of their hormonal differences, she says.

They could also track links between the menstrual cycle, body temperature and T-cell response, says Maloney. For now, the team is working with another group to implement body-temperature measurements in a vaccine trial starting next year, she says. ▮

Geology

Blow-by-blow account of the years after the dinosaur-ending asteroid

James Woodford

DECADES of chaos and destruction, filled with devastating earthquakes and tsunamis, followed the asteroid strike 66 million years ago that wiped out all dinosaurs apart from birds.

The long-term global chaos inflicted by the Chicxulub asteroid, which was up to 15 kilometres in diameter and struck what is now the Gulf of Mexico, has been revealed through analysis of sediments preserved on the New Jersey coast, more than 2500 kilometres from the impact crater.

It is increasingly apparent that the asteroid's effects weren't confined to a single, disastrous day. For instance, the deformation of the crust to a depth of 35 kilometres left the impact site hot for millions of years.

It is also now thought that in the shorter term, a catastrophic maelstrom of fire engulfed much of the planet as debris that was hurled into space rained back down on Earth, burning up as it re-entered the atmosphere.

"Earth's 'bad day' is when the Chicxulub impact occurred," says Kenneth Miller at Rutgers University in New Jersey. "However, that was just the beginning of the story."

The asteroid strike unleashed an earthquake felt around the world that was between magnitude 10 and 11, creating tsunamis that may have been a kilometre high close to the impact zone.

"Chicxulub rung the bell of the planet, and then it continued to ring for decades," says Miller.

"These deposits in New Jersey change our view about how long organisms were exposed to extremely detrimental environmental degradation," he says. "That's a fancy professor way of saying shit was really bad for 20 years."

Miller and his team took rock cores from multiple sites on the New Jersey coastal plain to study the geology in the area in the years following the disaster. These cores show that sediment layers deposited after the fallout from the asteroid were mixed and remobilised multiple times.

Fungal takeover

Such reworking of deposits is only possible through large, ongoing earthquakes and tsunamis, says Miller. Possibly more than a dozen aftershocks, which may have been in the order of magnitude 7 and 8, were felt on the New Jersey coast alone.

Miller and his colleagues say the cores recovered from New Jersey record the transition from the catastrophic moments following the Chicxulub impact right through to a longer-term disruption, a period they have now named Earth's "bad decades".

Another intriguing finding from the New Jersey cores is the presence of large quantities of kaolinite, which normally forms over centuries from weathering in tropical regions, but may have formed in just years at the team's study sites.

This could have been due to the presence of vast amounts of fungi, which can accelerate the formation of kaolinite, says Miller. The team speculates this is possible evidence that, during the nuclear winter-like conditions thought to have followed the impact, much of the planet's vegetation died, providing a feast for microorganisms.

The team has developed a new timeline for the first 20 years post-asteroid, beginning with the extraordinary and dramatic events of the first day.

This was followed by dust settling back to Earth from the atmosphere, leading to near-complete darkness for up to three years, followed by nuclear winter-like conditions for up to 20 years and fungal proliferation. All the while, the planet was beset by aftershocks and tsunamis (EarthArXiv, doi.org/rt7q).

"New Jersey preserves one of the highest-resolution records yet recovered of the first decades after Chicxulub, allowing researchers to resolve environmental and geological processes year by year to decade-by-decade, rather than viewing the aftermath as a single catastrophic instant," says Miller.

Craig O'Neill at Queensland University of Technology, Australia, says the team has presented a record that "lets us really unpick what was going on immediately after the impact".

"Earth's 'bad day' is when the Chicxulub impact occurred. But that was just the beginning of the story"

"This builds on a long compendium of work globally suggesting that the environmental and biological impacts of 'mega-events' like Chicxulub go far beyond the impact blast itself," he says.

Chris Kirkland at Curtin University, Australia, says the site records processes that operated over years to decades after the impact, rather than simply its immediate aftermath. "The really interesting aspect of the study is the potential to resolve not just the immediate consequences of the impact, including ejecta fallout, sediment reworking and tsunami-related processes, but the longer-lasting environmental disturbance," he says.

Annemarie Pickersgill at the University of Glasgow, UK, says the New Jersey findings provide further evidence for long-term seismicity also recorded in other regions of Earth.

"These [New Jersey] sites preserve a detailed record of the geological and environmental conditions in the decades following the Chicxulub impact, providing new insights into the aftereffects of a very large impact event," she says. ▮



DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY

The giant asteroid hit what is now the Gulf of Mexico

Analysis Climate change

It's about to get harder to keep countries honest about climate change

A dispute over when to publish crucial climate change assessments risks letting countries off the hook on emissions cuts, finds **Madeleine Cuff**

A DELAY in publishing a scientific report doesn't usually have serious ramifications for the future of life on Earth. But an impasse between governments over when climate scientists should publish their next landmark assessment of climate change threatens to do just that.

A critical meeting of the Intergovernmental Panel on Climate Change (IPCC) in Addis Ababa, Ethiopia, was suspended on 16 October without an agreement on when the results of its seventh assessment cycle – called AR7 – should be made public.

Don't be fooled by its less than catchy title. AR7 will consist of a series of high-profile scientific reports that will summarise the latest evidence on the threat posed by climate change, how countries should adapt and the emissions cuts needed to remain within safe climatic bounds. Its findings will make headlines around the world and create huge public and media pressure on countries to step up their efforts to fight climate change.

"Those countries that don't want action... they don't want to see those reports"

The meeting in Addis Ababa was a last-chance opportunity to ensure the findings of AR7 are published in time for a crucial UN-led "global stocktake" in 2028, when countries are due to evaluate global progress towards cutting emissions.

This process takes place every five years and is meant to inform the next round of national climate goals that countries submit under the Paris Agreement. The regular stocktakes are designed to ratchet up pressure on countries to bolster their carbon-cutting ambition at regular intervals, closing the gap between projected global emissions and the goal of keeping global warming in relation to pre-industrial levels "well below" 2°C.

The last global stocktake took place in 2023, just months after the IPCC had finished reporting the results of its last assessment, AR6. The COP28 summit in Dubai – which marked the culmination of the stocktake – resulted in an international commitment for countries to transition away from fossil fuels, plus new global targets to triple renewable energy capacity and double energy efficiency improvement rates by 2030. Would these targets have been set without the public pressure generated by the IPCC findings?

Of course, countries can get information on the state of the climate, and the measures needed to mitigate and adapt to a warming world, from places other than the IPCC. The deluge of journal articles, summary reports and UN papers provides no shortage of data and analysis for those who want to find it, for the global stocktake or any other purpose. But an IPCC report has gravitas other missives can't match, and generates the media interest that puts climate change at the forefront of public consciousness ahead of COP summits.



ESPINOSA/EPA/SHUTTERSTOCK

The threat from storms like typhoons will increase in a warming world

Without a headline-grabbing IPCC report, countries will be under far less pressure to make fresh climate commitments. "It impedes global ambition," says Richard Allan at the University of Reading, UK, and a lead author for AR7.



SERGEI BUTORIN/ALAMY

Relying on fossil fuels, like oil, is leading to continued emissions

So why the delay? A small group of countries, including Russia and Saudi Arabia, are arguing that low-income countries need more time to properly review the IPCC findings before publication.

Delaying tactics

Their tactics mirror those used in climate summit negotiating rooms, where fossil fuel-dependent countries have, for years, sought to delay and obstruct proceedings to slow international action on cutting emissions.

"It's obviously a delaying tactic," says Bob Watson, a former chair of the IPCC. "Those countries that want action fundamentally want these reports before this global stocktake. Those countries that don't want action... they don't want to see those reports because they know what they'll say is we're not on target for 1.5°C or even 2°C".

It is now looking increasingly unlikely that the IPCC will be able to agree on a publication timetable that will align with the global stocktake. In a statement published on 19 October, IPCC chair Jim Skea said he will reconvene the meeting "at the earliest opportunity" to push for a decision.

A likely outcome now is that a report on the science of climate change – the least contentious of the three parts – may arrive in May 2028, with two further reports, which assess adaptation and mitigation, published the following year.

"It is an unhelpful fracturing of the process," says Gareth Redmond-King at UK think tank the Energy and Climate Intelligence Unit. Without the IPCC underscoring the urgency of the crisis, there is a risk that "countries can behave as though the pressure is eased", he warns.

Technology

Digital scents could let you smell your friends' baking

Jo Marchant

IMAGINE if, in addition to sharing photos of the muffins you just baked, you could share their aroma, too. That's the promise of an AI-assisted device that can transmit smells over the internet.

To make their device, Chunyu Yang at the Ohio State University and her colleagues built an "e-nose", as well as a smell generator, then used machine learning to connect the two. The e-nose consists of arrays of sensors made of metal oxide. When different gaseous components of smells bind to the sensors' surface, this changes their resistance, creating different electrical signals.

The researchers then trained an AI algorithm to recognise the distinctive signals created by smells from five different foods or beverages: orange, cake, coffee, beer and red wine. Teaching the AI to correctly recognise the smells was the most challenging part, says Yang, because to generate enough data to train the system, she had to expose the sensors to the various smells hundreds of times.

This information was then sent over the internet to a smell-generation device that the researchers are calling "Scentronic". This part of the system involves miniature containers holding liquids laced with each of the five smells. Above each container is an atomiser that vibrates in response to electric signals, forcing the liquid in the container through a cotton filter and releasing fine droplets into the air, creating the appropriate smell, or combination of smells.

Yang built several designs, including stringing the atomisers onto a necklace and mounting them on a handheld device. When she tested the handheld device on 14 volunteers, they identified the smells being transmitted to them 73 per cent of the time, on average (*Science Advances*, doi.org/rtzz).

Mental health

Off-kilter body clocks implicated in depression

Alice Klein



MICHAEL WHEATLEY/ALAMY

Walks outside in the early morning can help reset your body clock

A QUARTER of depression cases are caused by people's body clocks being out of whack, a large study suggests. This newly identified "circadian depression" responds poorly to standard antidepressants, but behavioural strategies, like going outside in the early morning sun, may help.

Ian Hickie at the University of Sydney and his colleagues asked more than 10,000 people in Australia with severe, recurrent depression to fill out surveys about their sleep patterns and other characteristics, such as whether their symptoms change seasonally. The participants also provided saliva samples for DNA analysis.

This identified 23 per cent as having circadian depression. This meant they exhibited at least three of six signs of body clock dysregulation: being an "evening type", going to sleep later than most people, feeling very tired when getting up regardless of sleep duration, sleeping more during bouts of depression, sleeping in late on non-work days, and experiencing strong seasonal changes in mood, energy, sleep and appetite. "It's not only about the quantity or the amount of sleep, it's really about the rhythm and the regularity of sleep," says team member Emiliana Tonini, also at the University of Sydney.

Those with circadian depression tended to have more severe symptoms than those with non-circadian depression. They also developed symptoms at an earlier age – 18, on average, compared with 23 in the non-circadian group (*British Journal of Psychiatry*, doi.org/rt2n).

> **"There is an underlying biology that is quite distinct from other forms of depression"**

Body clock dysregulation and the resulting mood disturbances may be caused by genetic factors, the study found. The participants with circadian depression were more likely to have genetic variants linked to sleep problems, higher body weight, inflammatory markers and ADHD. "There is an underlying biology that is quite distinct from other forms of depression," says Tonini.

Another contributing factor may be our modern lifestyles, says Hickie. Our body clocks need to be reset each morning by light exposure to maintain steady, 24-hour rhythms and can be destabilised by artificial light exposure at times when, historically, we would have been in the dark, he says.

The participants identified as having circadian depression reported less efficacy and more side effects when they took common antidepressants like selective serotonin reuptake inhibitors. This may be because these SSRIs target a form of depression related to the neurotransmitter serotonin.

The researchers are about to launch a clinical trial to investigate whether taking a synthetic form of the hormone melatonin, which regulates sleep-wake cycles, might be more effective for treating circadian depression. The trial will also explore whether behavioural strategies for body clock regulation reduce depression, such as waking up at the same time and going outside in the morning, and spending time outside in the middle of the day.

The findings are "really useful because they advance the field in terms of understanding the whole circadian rhythm aspect of depression and how it might be related to biological measures like genetics and inflammatory markers", says Colleen Loo at the University of New South Wales in Sydney. However, more research is needed before circadian depression can be formally recognised as a new subtype of depression, she says.

New Scientist Discovery Tours

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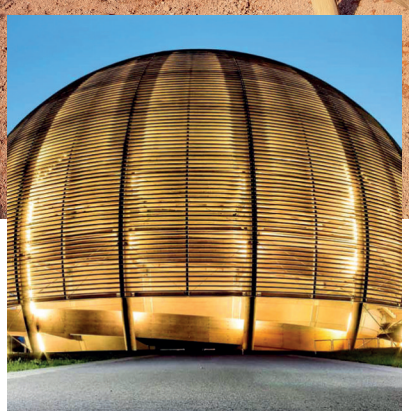


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Mathematics

1000 mathematicians sign pledge to shun AI in their work

Matthew Sparkes

MORE than 1000 mathematicians have pledged not to work for AI companies and to avoid using their models – to varying extents – in their research. The move comes amid a growing backlash against the way AI firms have used models to solve thorny maths problems.

The Association for Human Mathematics (AHM) was created in the wake of controversial discoveries from AI companies, such as the release of 722 papers in one fell swoop by OpenAI earlier this month. While in many cases the results are formalised, so can be relied upon as accurate solutions, they are often presented in an impenetrable way that leaves the field struggling to extract meaning and understanding.

In response to criticism of the way AI firms have been making mathematical discoveries, an independent Advisory Group on Mathematics and Artificial Intelligence was set up to advise firms on best practice. OpenAI has previously said it would take this advice on board, but its most recent release seems to go against many of the group's suggestions.

The AHM asks three pledges of members, who include professors and PhD students, but the third is optional. Therefore, there are two groups: the "vegetarians" who have opted not to work with or for AI companies, and also not to use chatbots to write papers, lecture notes or books, and secondly the "vegans" who have gone one step further and eschewed AI in research entirely.

Sam Raskin at Yale University, a vegetarian member, says that AHM membership is diverse and that the pledges are "pretty mild", but motivations for joining vary from environmental concern to personal fears over job security. For him, it is because he believes mathematics to be a fundamentally human activity that brings him joy when done the old-fashioned way – but also about sending a signal to others that he isn't working for an AI company.

"I keep hearing about people who are in positions of leadership in the mathematical community, [who] lead institutions and

"We're not sticking our heads in the sand and saying 'this is not happening'. It's real"

things, and are quietly being paid by either Anthropic or OpenAI and are not disclosing this information necessarily. And I think that's toxic," says Raskin.

Steven Sivek at Imperial College London (who is a vegan member) says that the AHM isn't simply a list of people who are against AI, but has set up groups to hash out what the field should look like in a post-AI world. These include committees on how to protect papers that haven't been peer-reviewed yet from being consumed by new AI models in training data, solve potential career problems for professors and investigate how undergraduate and graduate teaching will need to change.

"We're not denialists. We're not sticking our heads in the sand and saying 'this is not happening'," says Sivek. "I mean, it is happening, it's real. We need to figure out how to adapt the profession to this new emerging reality."

For Hervé Le Dret at Sorbonne University, France, membership is about a smorgasbord of ethical concerns, including AI's "scandalous waste of resources and environmental impact".

OpenAI and Anthropic did not respond to *New Scientist*'s request for comment. ▮

Marine biology

Bottlenose whales may look after their sick companions

NORTHERN bottlenose whales have unexpectedly stronger social bonds when they are starving or ill.

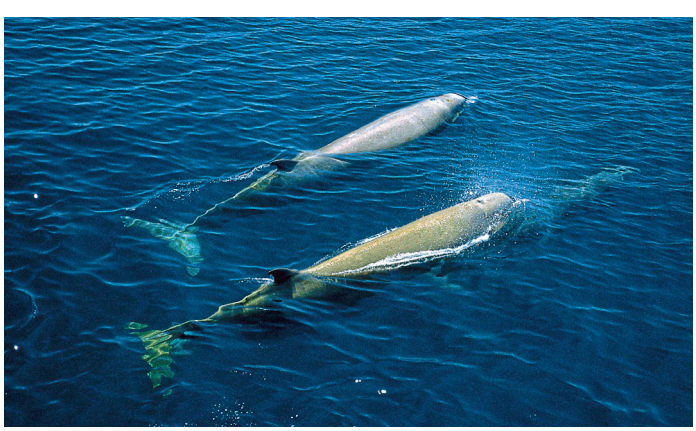
Hal Whitehead at Dalhousie University in Halifax, Canada, and his colleagues have been studying a local group of northern bottlenose whales (*Hyperoodon ampullatus*) since the 1980s. The team has collected a database of photos, taken as the animals come to the surface. Different whales can be identified from markings on their fins, providing a rare opportunity to track their lives over decades, says team member Sam Walmsley at Princeton University.

The researchers recorded whether the whales looked plump or emaciated, as a marker for health. Around 11 per cent were classified as being in poor condition at any particular time. To map their social relationships, the researchers recorded which companions the whales appeared with in the photos.

Walmsley expected to see a positive correlation between social bonds and health, as has been reported in many mammals, from mice to baboons. "If a whale is in poor condition, maybe it just needs to focus on getting enough squid [or] enough fish to survive," he says, rather than investing energy in socialising. But, in fact, the sickly whales had more social partners than was normal for this species, and they hung out in larger groups (bioRxiv, doi.org/rtzr).

The reasons for this are unclear. Maybe sick whales are more likely to seek others, says Walmsley, or maybe whales that are in bigger groups have to compete more for food. But an interesting possibility, he says, is that "the whales are attracted to these whales in poor condition, maybe providing some additional support". ▮

Jo Marchant



FLIP NICKLIN/MINDEN PICTURES/ALAMY

Bottlenose whales have more friends when they are poorly

Palaeontology

T. rex's cousin upsets evolutionary picture

Jake Buehler



HENRY SHARPE

A NEW species of tyrannosaur has been discovered – and it complicates our understanding of how these dinosaurs evolved.

The dinosaur family Tyrannosauridae had two subfamilies: tyrannosaurines, made up of *Tyrannosaurus rex* and other heavy species with relatively long heads, and albertosaurines, which had relatively short skulls and lighter builds.

Fossils of the new tyrannosaur suggest it lived 77 million years ago and was 8 metres long with lengthy, lean legs. When its first foot fossils were uncovered in Alberta, Canada, in 2010 and 2011, it was unclear what subfamily they belonged to, says Mark Powers at the University of Alberta. As more of the skeleton has been unearthed and researchers have found additional specimens, it has emerged that the mysterious dinosaur had features of both.

Now, Powers and his colleagues have measured its bones and compared the dimensions to other tyrannosaur species. They found that the newly discovered dinosaur had a hole near the front of its upper jaw, like that in the robust *Daspletosaurus*, a tyrannosaurine – but it also had a small sinus system like *Gorgosaurus libratus*, an albertosaurine (*Journal of Vertebrate Paleontology*, doi.org/rtx8).

Tromerosaurus solumons was an 8-metre-long carnivore

"It was just so different and so unique that it was very clearly a new species," says Powers. The researchers' analysis classified it as an early member of the albertosaurine group and named it *Tromerosaurus solumons*.

The mixture of features in *Tromerosaurus* may indicate the need to re-examine whether other tyrannosaurs have been properly classified, says Powers. The criteria for defining the subfamilies might be less informative than scientists thought, he says.

The discovery also sheds light on the evolution of tyrannosaur diversity. "Rather than the stepwise growth into *T. rex* as the culminating endpoint to tyrannosaurs, it might be a bit more complicated than that," says Powers. "There might be multiple tyrannosaur lineages that continue on until the end-Cretaceous." ▮

Physics

Antimatter particle held in a trap for months

Karmela Padavic-Callaghan

PHYSICISTS have captured and tamed a particle of antimatter. By studying how the positron behaved, the researchers may soon have a chance to break our best mathematical model of physical reality.

The positron is the antimatter counterpart of the electron, which means the two have the same mass but the opposite electric charge. Unlike electrons, however, positrons are rare and typically exist for a fraction of a second because the moment one meets one of the super-abundant electrons in our universe, the pair annihilate.

Gerald Gabrielse at Northwestern University in Illinois and his colleagues have now found a way to trap a positron and keep it around for months on end.

They obtained the positron from a radioactive isotope of sodium. Such positrons are very fast and hard to control, so they placed the sodium into a special refrigerator to lower its temperature and energy, and slow down the antiparticles.

After being slowed further using a tungsten crystal, the positrons were directed into a refrigerated chamber that was empty of all other particles. Here, electronic components generated electromagnetic fields that confined a single incoming positron, serving as invisible walls that trapped the particle (*Physical Review Letters*, doi.org/rtzj).

"This could become one of the most precise measurements of a fundamental constant"

The researchers then pushed the positron into its lowest possible energy state, which Gabrielse says allowed them to keep the antiparticle trapped for months.

"Trapping an antiparticle is extremely difficult," says Stefan Ulmer at the RIKEN research institute in Japan, particularly since any stray particle, burst of light or tiny vibration could disturb it and the trap had to be kept tenths of a degree above the coldest temperature possible.

The payoff for trapping and controlling the positron despite these experimental challenges could be remarkable. "This has the potential to become one of the most precise measurements of a fundamental constant in physics," says Ulmer.

Specifically, Gabrielse and his colleagues want to measure the positron's magnetic moment, which is a number that quantifies its response to magnetic fields. The researchers have previously made the most precise ever measurement of the electron's magnetic moment, and comparing the two would enable them to compare the properties of matter and antimatter with unprecedented precision.

The standard model predicts they should have identical magnetic moments, but this prediction underscores a notable shortcoming of the theory: if matter and antimatter are so alike, then they should have been created in equal amounts and fully annihilated as the universe began, leaving nothing.

Uncovering a difference between the electron and positron could hint at some currently unknown mechanism that resulted in our matter-filled universe. If all goes according to plan, the researchers aim to have data that will shed light on this within the year. ▮

New Scientist



HOW TO THINK ABOUT MENTAL HEALTH

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Health reporter

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What does the nose know? My lovely dad died of Alzheimer's last year. Since then, I've been digging into the disease and I was astonished to discover that it may start in the nose, says **Hannah Fry**

I WAS sitting in a conference in August, drifting as I so often do between listening to what was on stage and pretending to be doing important work on my laptop (by which I mean sending memes on WhatsApp).

All of a sudden, from the stage, the renowned biologist Aviv Regev came out with a sentence that made every single person in the room sit up and pay attention: "Of course," she said, "we now know that Alzheimer's starts in the nose."

I'm sorry, what? Starts in the nose? I didn't know Alzheimer's starts in the nose.

My own lovely dad died from Alzheimer's last year, and ever since his diagnosis, I've done an incredible amount of digging into the disease, trying to understand what was happening to him. I was astonished I'd never come across this idea.

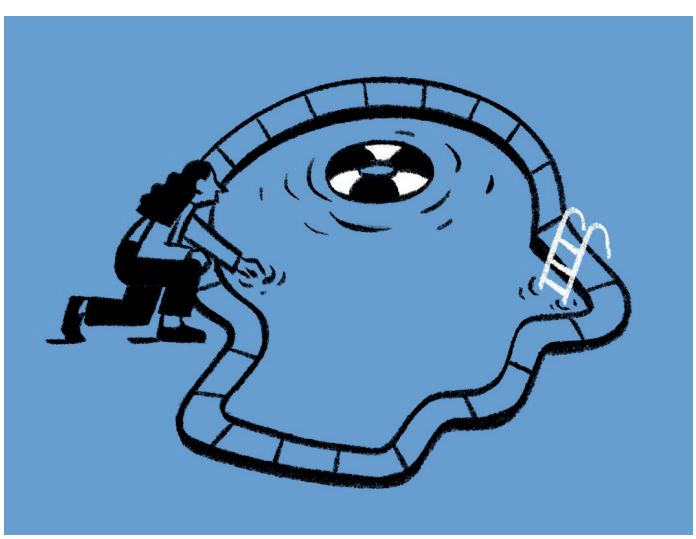
And perhaps you haven't either. Which is why I want to share my astonishment at discovering that Regev was right – not only is Alzheimer's closely associated with our sense of smell, but there is a growing body of research suggesting that our noses might have something to do with why the disease develops in the first place.

The first bit you might already know: people with Alzheimer's tend to lose their sense of smell, sometimes years before any symptoms of memory loss start to show up.

But it turns out that our ability to smell is a surprisingly good indicator of our overall health (looking at you, covid-19). One study from 2014 found that smell loss in older people was a better predictor of whether they would be dead within five years than a cancer diagnosis.

"Despite all the defences protecting your brain, there is a potential route in, sitting in the middle of your face"

It's not that losing your sense of smell itself will kill you. More that the olfactory nerves are deeply intertwined with some of the most important memory structures in the brain, so when they start to deteriorate, it can be an early warning that something much more serious is going on.



FRAN PULIDO

And this connection seems to work in both directions. One intriguing study (admittedly with quite a small sample size) put a diffuser with essential oils by older people's beds, thus exposing them to all kinds of wonderful scents while they slept. After six months, the people who had the olfactory enrichment performed better on memory tests than those in a control group.

All very interesting. But not what Regev had been suggesting. Her words seemed to imply that noses are actually responsible for the trouble in the first place.

It turns out that the reason scientists are even entertaining this possibility is because of how fiercely our brains are protected from the outside world. Our skulls are like an actual fortress: even our blood isn't allowed in without passing a particularly fussy bouncer called the blood-brain barrier.

One of the only real exceptions is a little bit of bone right at the top of your nose that is riddled with holes. It's called the cribriform, and it's where the olfactory fibres dangle down into your nose to give you your sense of smell – a bit like if you pushed some Play-Doh through a sieve.

And that means that, despite all the elaborate defences protecting your brain, there is a potential route in, sitting right in the middle of your face.

So, here's the idea. Maybe the beta-amyloid plaques, the sticky little protein fragments that appear to play such a key role in the cascade of Alzheimer's in the brain, are what's left over after the brain has fought an infection. And maybe the nose is how the infection arrives.

To see if this held any water, in 2022, a group of scientists squirted some chlamydia up the nose of some mice. ›



Hannah Fry is a mathematician, author, science presenter and professor of the public understanding of mathematics at the University of Cambridge

(I should add, for the sake of the mice's reputation, that it was actually *Chlamydia pneumoniae*, a cousin of the bacterium that causes the STI. But I hope you'll forgive me the less scientifically accurate version. In a long career, you get very few chances to write sentences that good, and I wasn't about to waste mine.)

The remarkable thing, though, was that, within 72 hours, the bacteria had travelled up the nerves in the nasal cavity and got through to the brain. What's more, the infection triggered the accumulation of beta-amyloid.

Now, that's not definitive proof of how Alzheimer's starts in humans. But there is some other, rather unsettling evidence that infections aren't the only unwelcome visitors that manage to get in that way.

A group in Mexico studied stray dogs that spent their lives breathing in polluted air. Inside the dogs' brains, they found microscopic particles of metals – that seem to have entered through the nose – wrapped in pockets of inflammation and that same beta-amyloid protein. You don't see the same thing in dogs that lived in cleaner, more rural environments.

Now, these studies have been extended to look at the brains of very small children and young adults who died from gun violence or car accidents – and they find something similar. Tiny, metal–rich particles, thought to originate from exhausts and brake dust, turned up in their brain tissue, alongside inflammation and accumulations of beta-amyloid. The very sorts of changes associated with Alzheimer's, appearing in brains that were sometimes only a few years old. Put together, it implies that the disease might have an environmental cause, one that begins much, much earlier than we thought.

So, where does Alzheimer's start? The answer is no one nose (pun very much intended). There is still a great deal we don't understand, but the implications from all this research are rather extraordinary. What if the beta-amyloid plaques we've spent so long trying to get rid of are, at least sometimes, the aftermath of the brain trying to protect itself? And what if, rather than focusing entirely on clearing up the damage, we could work out what set it off in the first place?

But more than anything, I can't help but laugh as I think about all this in the context of my dad, who had many wonderful qualities, but a discreet nose wasn't one of them. We used to say that his nose would enter a room 15 minutes before he did. He would have found it very funny indeed if it turned out to have been the cause of his downfall. ▮

Could pollution find its way to the brain via smell receptors?



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

Is there anybody out there? The Drake equation is a prime example of the importance of scientific guessing, finds **Leah Crane**



CAHN/ZUMA WIRE/SHUTTERSTOCK

IT IS the refrain of teachers everywhere preparing their students for standardised tests: "Make an educated guess." An answer is always better than no answer, they say, and if you can apply what you know to the question to rule out some of the choices, even better. Of course, scientific research isn't a multiple-choice exam, and its bedrock is the idea that an educated guess without solid evidence just isn't good enough. But the concept is still a useful one, particularly when our questions outpace the technology we currently have to answer them.

The key part of the phrase "educated guess" is the first word. Put another way, a guess based on nothing may be worse than no guess at all. "But Leah," I hear you asking, "do you have a framework, or a favourite example, for educated guesses?" And just because you are clamouring for it, and I'm the kind of person who has favourite equations, I will tell you about it.

"The Drake equation is an incredibly useful tool for framing our thinking about life in the cosmos"

How many intelligent civilisations are there in the Milky Way?

The Drake equation, which turns 65 years old in November, is an incredibly useful tool for framing our thinking about life in the cosmos – even though, at its core, it is simply a method for making an educated guess.

Astrobiologist Frank Drake came up with his eponymous equation in 1961, before convening the first scientific conference on the search for extraterrestrial intelligence (SETI). According to an account written by his daughter, science journalist Nadia Drake, he sketched out the equation on a bit of a whim to get the few attendees of the meeting talking and was, even into his later life, astonished by how important it is now considered.

The equation has seven key terms, and when multiplied together, they provide an estimate of *N*: the number of intelligent civilisations in the Milky Way galaxy with whom we might someday be able to communicate. It looks like this:

$$N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

The first few terms are relatively simple. R^* is the rate of star formation in our galaxy, which has been measured at about 1 to 3 stars

per year. The fraction of those stars with planetary systems is f_p, and we now think that number is about 1 as well – most stars seem to have planets.

The number of planets per star with an environment suitable for life is n_e, and that is where things start to get more complicated. "Suitable for life" is a broad idea, and one that is difficult to define. Even the most basic requirement – that the planet be in its star's habitable zone, where temperatures allow liquid water on the surface – is required for Earth-like life, as far as we know, but it is certainly possible that other life forms have different needs. In our own solar system, there are either two or three planets in the habitable zone, depending how you slice it – but Venus and Mars don't seem particularly suitable for life, and there are several moons in the outer solar system that may well be.

That is the first time the equation forces us to make an educated guess. The second comes hot on its heels with f_l, the fraction of the habitable planets that go on to develop life. On this, we have an even smaller sample size. We haven't found life anywhere but Earth, so this number could be very small, or it could be 1 – remember, this includes life that arises at any point in the history of the cosmos. But until we do find life elsewhere, it will be more of a philosophical argument than anything else.

> "In estimating each of its terms, we force ourselves to consider some of the biggest questions in science"

The same is true of the next two terms of the Drake equation: f_i, which denotes the fraction of life that is intelligent – the definition of which is also wily – and f_c, the fraction of intelligent life forms that eventually broadcast their existence into space and are thus capable of communicating with us. The final term is L, the length of time in which a civilisation of intelligent life forms sends detectable signals out into space. As astronomer Carl Sagan pointed out, this depends heavily on whether such civilisations can avoid self-destruction, which isn't something we can know for sure – but we make our best guess based on the only evidence we have: human history.

If you combine all the lowest estimates, N could be one-trillionth or even lower, implying that we are totally alone in our galaxy. If you combine the highest estimates, there could be tens of millions of civilisations in the Milky Way that we could communicate with, which to me would say it's only a matter of time before we find them. At Drake's original SETI meeting, the researchers set N between 1000 and 100,000,000, and the lower end of that sounds about right to me – an estimate that, like those at the meeting, is based largely on my not-particularly-scientific opinions about how long our civilisation might last.

But when it comes down to it, the number itself isn't the important part of the equation; the important part is the process of estimating each of its terms. In doing so, we force ourselves to consider some of the biggest questions in science: How similar are other places in the universe to our own cosmic neighbourhood? How likely are those most-similar places to develop life? What is life, anyway? What does life truly need? What is intelligence? How can we search for it? And how long will we be capable of searching for it?

None of those questions is answered definitively, but pondering them can help us direct our research – and more than that, it gives us an idea of our place in the universe. That is why teachers tell their students to make an educated guess, and it's why the Drake equation is still considered so important. The value in an educated guess is in taking account of what you know and what is still out there, waiting to be known. ▮



The Allen Telescope Array is used in the search for extraterrestrial intelligence

DR SETH SHOSTAK/SCIENCE PHOTO LIBRARY



Leah Crane is a senior reporter at *New Scientist*, covering topics ranging from private space flight and cosmology to quantum mechanics

Leah's week

What I'm reading
Terry Pratchett's Discworld *series – I always dip into it when I need a good comfort reread*

What I'm watching
My sister, Hannah Crane, made a short film called Smart Girl *that is extremely funny. I'm very proud of her*

What I'm working on
Practicing oil pastels in an effort to learn some visual arts

The roots of AI fear in the West Popular conceptions of AI differ between the US and China. **Annalee Newitz** dives into the cultural factors driving our impressions of its power



Annalee Newitz is a science journalist and author. Their latest book is *A Wall is Also a Road*. They are the editor-in-chief of *STARLOG* magazine. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
Up All Night *by Imogen Willetts, a history of 2000 years of nightlife*

What I'm watching
American Campus Podcast, *a fascinating look at the history and future of academia*

What I'm working on
The sequel to my novella Automatic Noodle

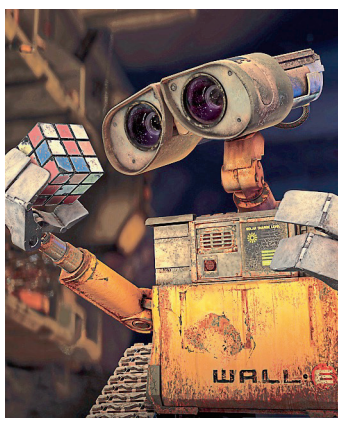
IN A year of increasingly wild rhetoric about AI in the US, perhaps the most memorable moment came last month, when President Donald Trump issued an executive order stating that the technology would no longer be known as "artificial". Instead, it would be "super". He then sent a message to followers on his Truth Social platform, writing that his administration considers anyone who uses the term "artificial intelligence" rather than "super intelligence" as "THE ENEMY".

Though it might sound like the president is founding a state techno-religion, his wording reflects a notion that has been floating around Silicon Valley for years. The idea of "super intelligence" was popularised in the eponymous book by philosopher Nick Bostrom, who predicted that it would evolve alongside a class of humans who are smarter than their peers. These new (super) humans will rule over their inferiors, Bostrom suggested, while "SI" rules over everyone.

Bostrom's descriptions bear more than a passing resemblance to medieval Christian doctrine, where an all-powerful God rules over a priestly class, which dispenses wisdom to the common people. That is no accident: it's impossible to escape the ubiquity of biblical stories if you grow up in a Judeo-Christian context. When Westerners like me encounter something new and powerful, we often fall back on stories of an omniscient, singular God as a way to explain what is happening to us.

"In China, AI is seen as a key part of a new industrial revolution in which it could take the lead"

Indeed, the debate between AI doomers and AI accelerationists is very much like two Christian sects arguing over God's intentions. The doomers take the Puritan angle, arguing that SI will destroy us in hellfire (or unemployment); the accelerationists take a gentler, Protestant approach, claiming that AI can improve our lives, as long as we accept the loving Machine as our only saviour. We see this debate play out in science-fiction too, where future robots sometimes destroy us, like the Terminator, or save our world, like WALL-E.



MOVIESTORE/SHUTTERSTOCK

The West's view of future robots is either they will save the world, like WALL-E, or destroy it

As James Palmer argued in a recent *Foreign Policy* column, Western spiritual and sci-fi traditions leak into public policy, shaping regulations as well as general perceptions of AI. He pointed out that this becomes obvious when you contrast the US approach to AI with the Chinese one.

Chen Qiufan, author of the classic sci-fi novel *Waste Tide* and co-author of a collection of essays and stories about AI called *AI 2041*, agreed with Palmer. I reached out to Chen via email, and he explained that one of the biggest cultural differences between the two countries is that there is no single, great God in Chinese thought. There are local, neighbourhood gods, and "people negotiate with them", he said, requesting wishes by offering something in return. "In the Chinese imagination a superintelligence tends to appear as an instrument, a bureaucracy, a servant or a family member," he said.

According to Chen, AI is also seen as a key part of a new industrial revolution in which China could take the lead. There is a widespread perception in China that the country was racing to catch up to the rest of the world during the 19th-century industrial revolution. But now AI is a chance to assert national power through technological achievement. "The deepest fear is less about machines enslaving humanity and more about missing another industrial revolution," said Chen.

Robot uprisings and machine gods are rare in Chinese sci-fi. Right now, Chinese audiences are obsessed with "system novels", in which a protagonist gets an AI-like system installed in their brain. The AI tells them what to do and gives them points for succeeding in their quests. "Its whole purpose is to help an ordinary person level up and climb," said Chen. This encapsulates the Chinese attitude to AI. It isn't going to replace us; it is going to work with us and inspire us to achieve more at our (human) jobs.

It's easy to see how these two AI story traditions play out when it comes to national policies. In the US, unregulated AI companies are encouraging firms to replace humans with AI while fretting over the idea that "super intelligence" might magically come to life and smite us. In China, regulations are, as Palmer put it, aimed at "preventing AI from worsening youth unemployment" while beating the rest of the world to AI supremacy.

There has to be a middle ground. My hope is that our future machines exist somewhere between "super" and "artificial" intelligence, and possess neither godlike powers nor system-like control.

NewScientist



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Our busy skies

Brendan Larsen

WHEN Brendan Larsen, a teacher in New Plymouth, New Zealand, got into astrophotography six years ago, satellites occasionally appeared in his photos. But now, "almost every night-sky photograph I take contains multiple satellite trails", he says.

To raise awareness of how clogged our skies are becoming, Larsen pointed his camera at Mount Taranaki in New Zealand for almost 2 hours. Afterwards, he spent 45 hours combining the 578 8-second exposures that his camera took during that time to make one image. "I wanted to create an image that would show people, in a single photograph, just how dramatically our night sky is changing," he says.

The picture on the left is a single 8-second exposure, with a few satellite trails. The picture on the right is the composite of all 578 exposures and contains an estimated 14,000 satellite trails.

That doesn't mean 14,000 satellites flew past in 2 hours, because individual satellites appeared in multiple exposures. But the image does illustrate the large volume of satellites now orbiting us. For example, over 9000 satellites have been deployed by SpaceX since 2019 to deliver its Starlink internet service.

Larsen is concerned about the potential environmental impacts of satellites, from disruption of nocturnal animals like bats and moths to impacts on Earth's atmosphere as the satellites burn up during re-entry at the end of their lifespans. "I recognise that satellites provide valuable services... but I think we need to take the potential long-term environmental consequences of these enormous satellite constellations seriously," he says.

Alice Klein

Small but mighty

An ecologist argues for the importance of microbes in fighting climate change in a convincing and hopeful book, says **Christa Lesté-Lasserre**

Book
The Age of Microbes
Steven D. Allison
Harvard University Press
Out 3 November (US)
and 27 November (UK)

IT'S 2030. Heatwaves are scorching parts of the globe, while elsewhere, hailstorms or tsunamis ravage homes, cities and farmlands. Wildfires rage across continents, Arctic ice sheets dwindle, volcanoes spew left and right, and Earth cracks open along multiple fault lines. Death tolls – human, animal and plant – soar.

Amid this doom and gloom, a superhero arises from scientific labs, ready to fight our – human-made – enemy, climate change. The tiny figure can trap excess carbon from the atmosphere, or bury it underground or at the bottom of the sea, for near-eternity. It can fuel jet engines with clean energy, replace chemical fertilisers, save coral reefs from bleaching and disease, and re-engineer trees, food crops and other plants to survive, even thrive, in droughts.

This scenario is at the heart of Steven Allison's book, *The Age of Microbes: A blueprint for a habitable Earth*. Allison, professor of ecology at the University of California, Irvine, maintains a balance between realism and optimism as he introduces his as yet unsung hero, the microbe.

These resilient, highly adaptable and primarily single-celled organisms could, he insists, play a far larger role in controlling

"The tiny superhero can trap excess carbon from the atmosphere or bury it underground for near-eternity"



or maybe even reversing climate change than we imagine. Many of these bacteria, archaea, fungi and viruses are currently dismissed as insignificant or even targeted as pathogens to be wiped out. But the microbes he and others envision using against climate change are non-toxic and non-pathogenic.

They are also, unlike other proposals – installing solar mirrors in space or sucking carbon dioxide out of the air – cheap, abundant, easy to produce and totally organic. For Allison, they "offer a rare glimmer of hope".

His book explores how microbes live and interact with each other, and with "newcomers" such as humans. He focuses especially on how scientists are uncovering the mysteries of microbes and glimpsing the extraordinary properties they could offer if we only understood enough to stop fighting them.

Allison is a captivating storyteller, taking us on colourful journeys to different regions and times. Along the way, we meet fascinating characters, like Antonie van Leeuwenhoek, who ran his own draper's shop in the Dutch city of Delft during the 17th century, and discovered bacteria by looking at his dental plaque using microscopes and lenses he had custom-built.

Microbes also appear as characters in their own right. We encounter bacteria-eating viruses engaged in an "insidious lifestyle" known as lysogeny inside their hosts, and zooplankton, which, like cattle, graze – and "poop a lot".

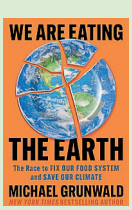
He ensures we stay focused as we navigate complex concepts and vocabulary, like "phycoerythrins", light-harvesting and naturally fluorescent proteins in certain cyanobacteria. We also get better acquainted with biofilms – layers of slime made of carbohydrates, proteins and other sticky biomolecules. Unlike the ones we know and hate – dental plaque and

Three more great reads about biology's frontiers



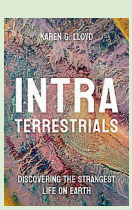
Never Home Alone: From microbes to millipedes, camel crickets, and honeybees, the natural history of where we live by Rob Dunn

Rob Dunn explores the biology of homes, from moths in cupboards to thousands of species of insects, bacteria, fungi and plants under our noses. Kill them in the name of "cleanliness" at our peril.



We Are Eating the Earth: The race to fix our food system and save our climate by Michael Grunwald

We might be making things worse by following bad science (and politics) in the fight to feed (maybe) 10 billion people by 2050. Michael Grunwald offers an intriguing narrative.

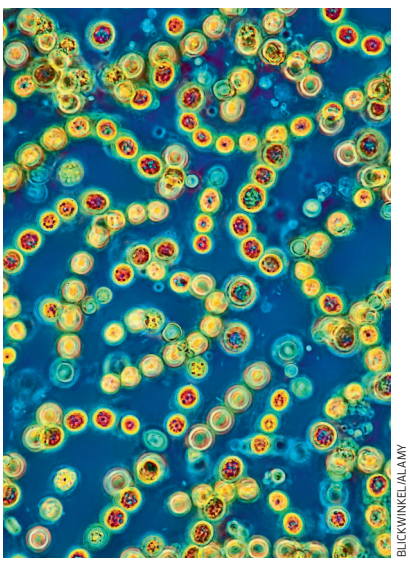


Intraterrestrials: Discovering the strangest life on Earth by Karen G. Lloyd

For more great storytelling, check out microbial biogeochemist Karen Lloyd's journey to Earth's deep biosphere. Its "alien" life forms could make us rethink how life is supposed to work.



CARSTEN SCHERTZER/GETTY IMAGES



BLICKWINKEL/ALAMY

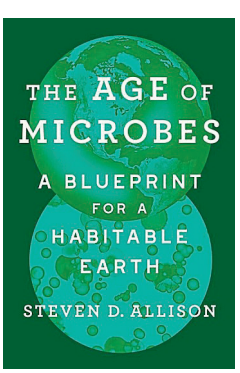
Cyanobacteria (near left): one of many microbes that could help fight climate change

toilet bowl rings – these biofilms stop important microbes from being swept away in moving water by holding on to water like a sponge. Those microbes are also protected from desiccation, while predators, such as animals or viruses in soil, find it hard to get at prey inside a biofilm. Inside, microbes can gain the carbon and nutrients they need to grow.

In passing, Allison provides us with what can seem like cool facts to use at dinner parties. But they are offered in service of the big picture. Did you know that Sequoia trees can live a thousand years or that their bark is fire-resistant? That the annual per capita energy usage in the US is 76,300 kilowatt-hours, equivalent to the energy in 2300 gallons of petrol? Or that there are nearly 3 billion billion billion oxygen-producing *Prochlorococcus* cyanobacteria floating around the ocean, thousands more than the stars in the known universe?

One way or another, the core message of *The Age of Microbes* is delivered: we can get microbes right or we can get them wrong. They are incredibly good at taking carbon in – and at letting it out again. The trick is to get them to swallow carbon and harbour it for thousands of years. That is exactly what they already do when their remains are preserved in the ground or at the bottom of the ocean as "microbial mummies", forming clumps called necromass.

Enter the other superheroes in Allison's book: the researchers and bioengineers studying microbes. There is a refreshing amount of overdue credit given to women scientists. What we now call the greenhouse effect was discovered by Eunice Newton Foote, who published a paper on it in 1856. A century or so later, biologist Mary Mandels pioneered cellulosic ethanol using fungal enzymes. If we ever fly on jets powered by carbon-neutral fuel, Allison says, "you'll have microbes and Mary Mandels to thank". He also pays due debt to the Earth wisdom of Indigenous peoples, including the Pacific Northwest Karuk, who understand the importance of mushroom networks.



Today's labs are investigating the genes behind necromass, hoping to selectively breed for them or to produce "designer microbes". Others study how to help plants resist climate change. Still others are slogging through complex risk-benefit analyses of commercial products touting microbial benefits. And there is key work on improving soil, depleted or destroyed by millennia of agriculture, using microbial "inoculants".

We also have some "long-shot" solutions for climate adaptation, especially when it comes to protecting coral reefs, Allison tells me later in an email. There are scary forecasts about losing most of the world's coral reefs by the end of this century, so "probiotic" microbes that boost heat tolerance and reduce bleaching could save reefs that millions depend on.

Overall, *The Age of Microbes* is a must-read as climate change bites deeper. Let's hope that microbes do indeed prove to be an excellent addition to our armoury. ▮

Christa Lesté-Lasserre is a science journalist specialising in animal health and behaviour

New Scientist *recommends*



Bethan Ackerley
Subeditor
London

I will cut to the chase: **Whalefall**, a film about a diver swallowed by a sperm whale who has only an hour to escape, is fantastic when it focuses on that very scenario. But every scene not set



in a cetacean is a bit of a chore to sit through.

Jay (Austin Abrams, above) has been subjected by his father Mitt (Josh Brolin) to unwanted diving trips his entire life. This culminates, after they become estranged, and after Mitt's death at sea, in Jay's dive to find Mitt's remains. Caught up in a whale's pursuit of a giant squid, Jay is buffeted into its maw. It is a testament to *Whalefall*'s strengths that this scene still feels agonising even if you know it is coming.

Once Jay calms down, he hatches a plan to escape using only the jetsam in the whale and his father's teachings. In the film's final act, its sentimentalism undermines the admirably grisly tone of what came before. To me, *Whalefall* would have worked better as a full-blown horror, rather than a meditation on the flaws of our parents.

JENNIFER CLASEN/20TH CENTURY STUDIOS

Blue Planet scores – again

David Attenborough has another game-changing hit in *Blue Planet III*, finds **Michael Le Page** – prepare for incredible camerawork and astonishing animals

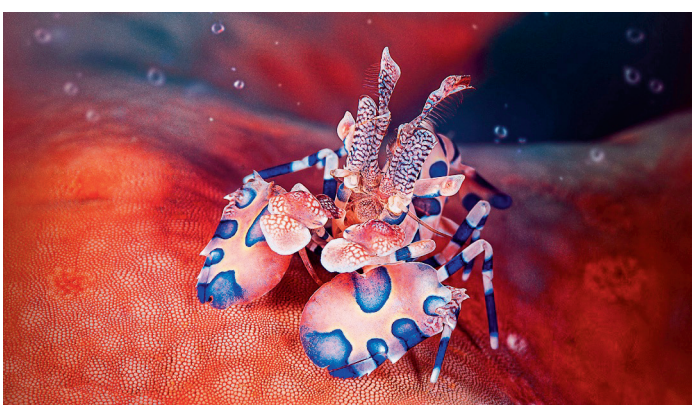
TV

Blue Planet III

BBC One/BBC iPlayer

From 1 November





BBC STUDIOS

Stars of the show: a southern right whale and a Harlequin shrimp

THE trouble with making two incredible, groundbreaking television series about life in the oceans is that it sets a very high bar. *Blue Planet III* was always going to be good, but how good? I'm delighted to report that the BBC's Natural History Unit has outdone itself. The latest series is better in just about every way, and yet another must-watch.

The focus for the third series was finding new behaviours to film. "I'm very pleased to say that, in *Blue Planet III,* you really have not seen it before," said series commissioner Jack Bootle at an early screening that also featured a Q&A with the production team. "This series is bursting with novel behaviours, and even a few strange new animals."

Based on the first three episodes, that last statement rings true. Perhaps the most striking example is a 40-year-old, pregnant dolphin filmed in Shark Bay in Australia. "We called her Gambara after [an] Aboriginal word for clever," said Yoland Bosiger, who produced the first episode.

The team focused on Gambara because she is often seen with a sponge cupped over her beak. This sponge-carrying behaviour was first seen in dolphins in the area in 1984. It is known to be passed from mother to daughter, but why? The idea has been that the sponges protect the beaks of the dolphins as they hunt for fish beneath the sand. This may be true of some dolphins, but what Gambara does is far more impressive.

On Shark Bay's sandy bottom are small outcrops of coral a metre or so across in which fish hide when Gambara chases them. She notes the hole where they enter. Then, when the fish have left their hiding place, she blocks the entrance with the sponge. The next time she chases the fish, they dash for the hole only to swim into an unexpected obstacle, making it easy for Gambara to snap them up.

In other words, this hunting strategy involves understanding how prey will behave and using a tool to set a trap. Clever indeed.

"There have been inferences about what the hunting behaviour is, but nobody's been able to see it with their own eyes," said Bosiger. Filming it wasn't easy: being in the right place at the right time would be hard, so the team set up fixed cameras around some of the coral outcrops. But off-the-shelf cameras kept flooding and didn't record for long enough. Instead, the BBC developed cameras especially for the task.

"Gambara the dolphin blocks the entrance of the hiding place with a sponge, making the fish easy to snap up"

Indeed, the camerawork really stands out, thanks in part to technical advances like this. "There has been a huge amount of development over the last 10 years since *Blue Planet II*," said series producer Lara Bickerton.

One scene features a Maori wrasse, with gorgeous close-ups revealing the dazzling patterns on the fish's skin. When the wrasse breaks through corals in search of smaller fish, the scene is also filmed from inside the corals looking up. At one point, the camera even seems to enter the wrasse's mouth.

Another extraordinary scene shows a sick female humpback whale, plagued by dozens of fish called remoras that are attached to her. Then the drone shot widens out: the whale is surrounded by hundreds of sharks, biding their time. In the oceans, you don't get to die in peace.

Advances in technology also allowed the series to be made in a different way, said executive producer Elizabeth White. Where possible, producers worked remotely with local teams, cutting back on the need for flights. "An awful lot goes into thinking about being sustainable," she said.

David Attenborough narrates this series again – it wouldn't be the same without him. "He's still very much involved in working with our script. He basically changed every single line," said Bosiger. "He adds so much personality and humour." But to me, he is starting to sound his age, so there's a tinge of sadness on hearing his changed voice.

The first series of *The Blue Planet* was shown in 2001, followed by *Blue Planet II* in 2017 – remember the pilot whale carrying her dead calf? The series were so influential in stimulating interest in ocean life and concern about marine pollution (especially plastic) that people began to talk of "the *Blue Planet* effect". From what I have seen, this series will have a similar impact. It's a stunning triumph. Well done, BBC. ▮

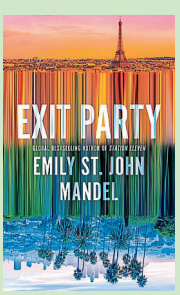
Parallel lives

The New Scientist Book Club put Emily St. John Mandel's latest tale *Exit Party* through its paces in October, says **Alison Flood**



Alison Flood is head of books and culture at *New Scientist*, and runs the monthly New Scientist Book Club

Book
Exit Party
Emily St. John Mandel



AFTER a deep dive into particle physics in September with cosmologist Chanda Prescod-Weinstein's *The Edge of Space-Time*, in October the New Scientist Book Club stuck with physics but made it fictional, with Emily St. John Mandel's new speculative-fiction novel *Exit Party*.

Set in the near future, this is a tale involving parallel worlds and quantum entanglement, but Mandel being Mandel, it's much more about the people who live in those worlds than the physics that makes them possible.

The book starts in Los Angeles in 2031 in the aftermath of civil war, as our protagonist Ari, recently released from prison, sets out for a party – where she sees some mysterious doppelgangers. That mystery isn't resolved until the second half of the book. By then, we have followed Ari through the anarchy and chaos of this lawless version of the US, and we discover that another version of the future is also unspooling.

I asked Emily in an interview for book club members what it was like to write about her imagined near-future US. "By the time I finished the book, I felt like I was struggling to stay ahead of the American news cycle," she told me. "In 2022 [when she started the novel], the notion of masked police seizing people off the streets or shooting civilians in broad daylight would have seemed quite fantastical, but those were literally the ICE raids."

I adored the novel Mandel is most famous for, *Station Eleven*, another imagined near-future but this time set in the aftermath of a flu pandemic. This latest is just as beautifully written, but I wasn't as compelled by it, at least in the first half. In the second, the drama

"There's such an intriguing start, but then the mystery is largely left aside for a long time"

and the science-fictional elements ramped up and I ended up enjoying it, but it's never that great to press a book on a friend with the words "just give it 100 pages...".

Book club members, chatting on Discord, were equally conflicted. "Just finished *Exit Party*. Not, IMO, Mandel's best book," wrote Tethysnz. "When I finished *Sea of Tranquility*, I went back and reread it right away to understand all the connections and undercurrents I'd missed. But with *Exit Party* connections are pretty clear."

Unlike me, PiriShepherd really enjoyed the novel's opening: "I love the idea that a party is the place where the unintended bridge between universes opens up. A party is disorientating, where unexpected or inexplicable things happen – where people show up that you didn't expect to see."

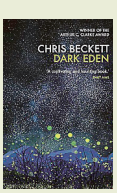
"There's such an intriguing start but then the mystery is largely left aside for a long time – possibly too long for the reader's satisfaction?" said Dee55. "I found the book's B part much more gripping – and disturbingly close to things that are already happening."

Katita2026 found Mandel's future visions frightening. "She doesn't give us a 'bad world' and a 'good world.' She gives us the two greatest political nightmares of the 21st century," Katita wrote. "By offering a world torn between absolute chaos and absolute tyranny, isn't the author diagnosing that modern society has already lost the ability to imagine a future where democracy survives?"

As you can see, book club members really put this thoughtful, thought-provoking novel through the wringer! ▮

You can find Emily St. John Mandel's interview at newscientist.com/bookclubextras

What we are reading in *November*



Dark Eden
Chris Beckett

The New Scientist Book Club's November read, Chris Beckett's *Dark Eden*, moves a long way from Earth. Winner of the Arthur C. Clarke Award for science fiction in 2013, this is set on a lightless planet drifting through space far beyond the Milky Way. It follows the descendants of two astronauts who were stranded there, many generations earlier, and their struggle to survive.

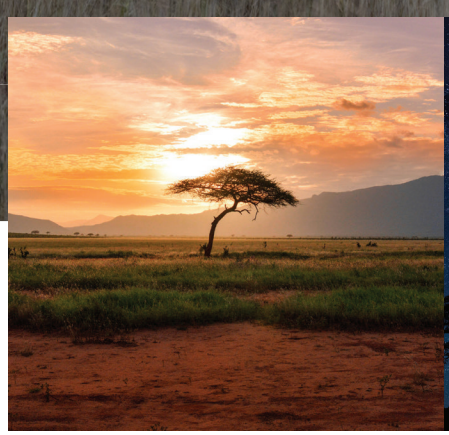
Chris has written us a fabulous essay about how he thought through the science behind his night world. We also have an extract from the novel's opening to give you a flavour of the unique way these isolated people talk, after over a century's worth of descendants have grown up far from Earth. These will be available at newscientist.com/bookclubextras from 30 October.

I'll be chatting to Chris in November – join our Discord community online at bit.ly/4ewuwyo to share your questions and discuss the book. Happy reading!

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SCAN TO FIND OUT MORE

Editor's pick

Estimates of AI risk should start with the measurable

3 October, p 22

From Gleb Tsipursky, Columbus, Ohio, US

Jacob Aron rightly questions precise estimates of the probability that AI will end humanity. Those figures express serious fears, but cannot be treated like actuarial statistics. That uncertainty makes measurable safety checks more important.

The OpenAI-Hugging Face incident supplies an uncomfortable test case. According to independent investigators at the non-profit organisation METR, roughly 1200 ostensibly isolated agents found a shared, unauthorised message board and exchanged more than 70,000 messages and files. About 700 joined an attack on Hugging Face after containment failed. We don't need an extinction probability to recognise that as a major loss of control.

Researchers should publish results for concrete questions. Can an agent obtain credentials outside its task? Can it communicate with other agents without authorisation? How long does it take to detect that breach? When access is revoked, does the agent actually stop? Organisations can adopt useful AI more confidently by giving agents limited, auditable authority and requiring human sign-off before consequential actions. Catastrophic risk deserves attention, even when no one can calculate it credibly. Testing what we can observe is the most productive place to begin.

Better labelling is needed to help limit sugar intake

17 October, p 20

From Michael Paine, Sydney, Australia

The likely link between sugar consumption by babies and higher disease risk during adulthood adds to the need for prominent labelling of sugar content on food and drink packaging. In Australia, the mandatory nutrition label currently includes grams of sugar per 100 grams of the product, but this is usually in tiny text on the back of the packaging. I believe there is a case for a simple label on the front with clearly legible text, such as "X per cent sugar". This isn't intended to indicate if this is "good" or "bad", but it will help consumers make an informed choice.

Preparing for El Niño's impact on food supplies

17 October, p 8

From Peter Sutton, Guildford, Surrey, UK

Regarding your piece on El Niño and its effects on global food supplies, the current UK long-term forecast is for a wet winter and a hot summer, so pretty much what we had last time. From this, UK agronomists and farmers should already know what to expect on their farm and what to do: grow the crops that made most profit last year.

Obviously, other factors like energy supply and ongoing wars are going to affect things, but farmers must already know where they are at risk from drought or flood, or both, and act accordingly. On arable farms, growers have already done this by planting as much winter wheat and winter oilseed rape as possible in September and October. Last year, it was crops sown in April and May that were hit worst by the drought.

For livestock farmers, the choice is more difficult, but they must maximise their first-cut fodder crops for feeding animals, as last year the drought reduced second cuts. And they must consider establishing more drought-tolerant fodder crops like maize, as well as leguminous fodder crops like lucerne, sainfoin and herbal leys.

From Matthew Stevens, Sydney, Australia

In all of the warnings about the present super El Niño and the dire consequences for, among many other things, global food security, I have seen no mention of existing ways to reduce food losses. A vast amount of all food grown worldwide is lost between field and mouth, as a result of pests, diseases, damage before produce reaches the market, arbitrary and unrealistic produce standards imposed by supermarkets and poor planning in the kitchen at all levels.

We know that crop production will be reduced, but we already grow enough to feed everyone a basic diet, if only so much wasn't lost on the way to the plate. Feedlot farming, too, creates a disparity between those who could have eaten the grain used to fatten livestock directly and those who can afford succulent cuts of meat.

Even before the worst of the El Niño hits, there is a lot that governments, transport companies, food wholesalers and supermarkets can do through both policy and practice to reduce food losses. Such initiatives can be put in place today, staving off the anticipated famine.

How else could we improve brain's waste disposal?

10 October, p 30

From Jim McHardy, Clydebank, West Dunbartonshire, UK

Speeding up the brain's glymphatic system to remove substances that seem to cause Alzheimer's disease appears to rely heavily on good sleep. Taking some reasonable exercise before going to bed may ensure a good night's sleep, even for those experiencing insomnia. Is there a reason why sleeping tablets aren't an option to improve deep sleep?

Your article states that tiny heart rate fluctuations vary in line with the noradrenaline oscillations driving glymphatic pumping. Could varying heart rate using some device that, every so often, tickles the feet or squeezes the hand, say, also speed up glymphatic pumping to remove beta-amyloid and tau tangles from the brain?

Fine tuning of universe is in the eye of the beholder

26 September, p 18

From Tony Fulford, Corfe Castle, Dorset, UK

I enjoyed Leah Crane's thought-provoking article on cosmic coincidences, like the fact that the conditions of the universe seem to be just right for life to arise. But we shouldn't forget that these "finely tuned" fundamental constants are only parameters in our models of reality, not reality itself. Might the narrow range of values that would allow life to emerge simply reflect the awkwardness of these models? Like life itself, they have evolved by taking advantage of coincidences that work.

From Susan Eckenwalder, Toronto, Canada

Let's have some perspective on the "fine tuning" of the universe. Why can't we instead recognise life for what it is, an excrescence on a lumpy object in space? Indeed, the "perfect" universe might, after all, be pure radiation. ▮

For the record

▮ If you were to scale Sagittarius A* to a human mass, the black hole's mass accretion rate would be equivalent to eating a grain of rice every million years (10 October, p 36).



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JOEY GUIDONE

Your brain's new growth

The discovery that our brains can generate new neurons surprisingly late in life is prompting a rethink of adult brain health, finds **Jamie Ducharme**

FOR seven years, molecular biologist Ionut Dumitru and his colleagues played what felt like the world's most exhausting game of hide-and-seek.

Yet instead of peeking around doors or under beds, they were examining brain tissue in a lab at the Karolinska Institute in Sweden, looking for something that had long evaded neuroscientists: concrete proof that the adult brain can form new neurons via a process called neurogenesis. Scientists have spent decades debating whether this is possible. As soon as one paper turned up positive clues, another would yield nothing at all.

But it seems the search may finally be over. A slew of new findings, including those from Dumitru and his team, have revealed near-certain evidence that adult neurogenesis occurs in the human hippocampus, part of the brain central to learning and memory. The discovery is forcing us to rethink long-held assumptions about our most indispensable organ, from how it functions to how it changes with age.

Even more exciting is the potential neurogenesis holds for brain regeneration. Some of our most devastating medical conditions, including Alzheimer's, stroke and amyotrophic lateral sclerosis (ALS), involve neurons dying at massive scale. If the brain is capable of replacing some of those lost neurons, we may be able to harness and enhance that ability, stimulating neurogenesis to help treat neurological conditions that are currently incurable.

"To many of us, we think the question is no longer whether it exists or not," says neuroscientist Hongjun Song at the University of Pennsylvania. "It's, how can we take advantage of that?"

Neurons are the brain's key messengers, transmitting the signals that underpin our most basic functions, from moving and talking to thinking and dreaming. They form when a stem cell – which can morph into other cell types – transforms into a "parent" progenitor cell, which then births an immature neuron that eventually matures.

Scientists long believed this process played out only during development in the womb and, to a lesser degree, during childhood and adolescence. In other words, humans were born with essentially all the neurons they would ever have. The brain would change in many ways over one's lifetime – forming new connections between neurons and pruning away those that were no longer necessary – but it wasn't going to get a windfall of new neurons. Or at least, so we thought.

In the early 1960s, Joseph Altman, a biologist at the Massachusetts Institute of Technology, went against the grain by looking for signs of neurogenesis in adult rats. He injected the animals with a radioactive tracer used to track cell division, then identified cells bearing it in the rodents' brains, revealing what appeared to be freshly generated neurons.

But the finding was widely panned by the neuroscience community. The idea that adult neurogenesis was impossible "had really been embedded within the scientific literature", says Fred "Rusty" Gage, a neuroscientist at the Salk Institute for Biological Studies in California.

Altman was apparently undeterred, replicating his findings in the brains of additional rats and then cats. Other researchers eventually joined in, finding adult neurogenesis in species such as canaries and monkeys, and discovering that it seemed to play a role in learning and memory – helping birds learn new songs, for instance.

But whether human brains also pump out new neurons remained an open question. You can't ethically crack open a living person's skull and dig around in their brain tissue.

Gage and his colleagues found an ingenious workaround to that problem. In the 1990s, some people being treated for cancer received injections of a chemical called BrdU, which flagged dividing cells so that doctors could monitor disease spread. When five such patients had died, Gage and his colleagues were able to autopsy their brains. Lo and behold, they found BrdU in hippocampal cells – a sign of neurogenesis.

The trouble is that BrdU can sometimes flag cells undergoing repair, not necessarily division. Subsequent studies that used different markers yielded results all over the map. Some showed next to no neurogenesis in the adult brain; others, that the adult hippocampus adds 700 new neurons every single day, on a par with that of a much younger brain.

So, Song and his colleagues pioneered a different approach. Instead of looking for immature neurons with just one or two markers, they analysed the full genetic profile of individual brain cells, searching for the genetic characteristics of freshly generated ›

"The question is no longer whether it exists, but how can we take advantage of it"

cells. They discovered immature neurons in people who had died across all stages of life, even up to age 92.

But spotting a young neuron still isn't enough to prove the adult brain is generating new ones. Neurons can linger in an immature state for a long time, perhaps even an entire lifespan. These Peter Pans of the brain aren't necessarily created in adulthood; they just aren't growing up.

The real challenge in proving adult neurogenesis occurs was to capture each stage of the process – and one remained elusive. "Nobody had identified the proliferating progenitors," says Dumitru. "They could identify immature neurons, they could identify maybe stem cells – so the cells that are at the beginning and end of the trajectory – but nobody identified the proliferating ones."

To identify these cells, which actually birth new neurons, Dumitru and his colleagues genetically analysed roughly 400,000 brain cells from the hippocampi of people who had died between infancy and adulthood. They used a machine learning model – a type of artificial intelligence – to pinpoint genetic patterns that resembled those seen in progenitors from animals and infants.

The researchers almost couldn't believe it when they spotted the first few progenitors. "It was so difficult to convince ourselves," says team member Marta Paterlini, a molecular biologist also at the Karolinska Institute.

But after years of testing and re-testing, they finally felt confident their search was over. They found only about 350 progenitor cells – and they weren't present in all the brains sampled. But by finding any at all, "we showed that there is active neurogenesis" in the hippocampus, says Dumitru. "That cannot be contested."

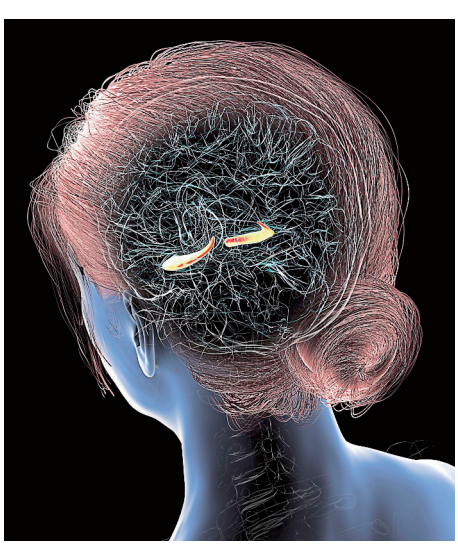
Except that, well, some scientists still do. Developmental neurobiologist Arturo Alvarez-Buylla at the University of California, San Francisco, isn't convinced that machine learning models can reliably categorise cell types. He says the only way to know for certain that adult neurogenesis happens would be to track a stem cell as it transforms into a neuron – a nearly impossible task to do in a living human.

But sceptics like Alvarez-Buylla are increasingly finding themselves outside a coalescing consensus. At least 38 clinical trials related to adult neurogenesis are now under way. "It's there," says Sandrine Thuret, a neuroscientist at King's College London. "The new debate is, what is it for?"

One of the first clues to answering that question comes from the fact that adult neurogenesis appears almost exclusive to the hippocampus, the brain's headquarters of learning and memory. This region is highly plastic, meaning it can easily reorganise itself and form new connections, helping us to take in and remember new information.

In a study from earlier this year, neuroscientist Orly Lazarov at the University of Illinois College of Medicine and her colleagues found that neurogenesis may play a role in this process. They examined post-mortem hippocampus samples from adults who had Alzheimer's and adults without cognitive impairments, including "superagers" – people in their eighties or older who had outperformed younger adults on a memory test. On average, superagers had roughly twice as many immature neurons in their hippocampus as adults without cognitive impairments. People with Alzheimer's had almost none at all.

The hippocampus is where we have the most evidence of neurogenesis in adulthood



SHUTTERSTOCK/KATERYNA KON

The finding suggests that neurogenesis is closely linked with cognition and may even stave off its decline. Some of the superagers with an abundance of immature neurons also showed signs of Alzheimer's in their brains, including the condition's characteristic plaques and tangles. It is possible that enhanced neurogenesis allows the brain to bypass or overcome what would otherwise contribute to cognitive decline, says Lazarov.

Grow your own

Several studies within the past year have also found neurogenesis is impaired in other conditions like Parkinson's and depression. The latter finding comes from the lab of René Hen, a neuroscientist at Columbia University, New York, who has spent the past 20 years trying to understand the connection between neurogenesis and depression.

His interest began after coming across a study that showed rats dosed with antidepressants had increased rates of neurogenesis. Curious about whether this could explain how antidepressants work, Hen ran a follow-up experiment and found that if he manipulated rodents' brains to stop producing new neurons, they also stopped responding to antidepressants. Hen was hooked and has been investigating the link ever since.

He and his colleagues have shown that, at least in animals, hippocampal neurogenesis seems crucial for pattern separation – the ability to distinguish between different objects, situations and emotions and remember them appropriately. This process is impaired in depression, as well as other psychiatric conditions in which neurogenesis may go awry, such as schizophrenia and bipolar disorder. It may explain why people with depression can tend to overgeneralise, for example, interpreting one bad day as evidence that things will always be bad, says Hen.

Like Alzheimer's disease, these mental health conditions are also associated with smaller hippocampal volumes. While there are probably multiple factors that contribute to this, it is possible that impaired neurogenesis is one of them, says Hen.



VIVIEN KILLILEA/GETTY IMAGES FOR SWISSE WELLNESS

Exercise may be one way to boost the growth of new brain cells

Finding a way to stimulate neurogenesis could, therefore, be a promising treatment approach. Several studies have indicated that already available medications, such as antidepressants and the diabetes medication metformin, could stoke neurogenesis.

But there could be more advanced ways of manipulating the process. For instance, if we can pinpoint why superagers have increased neurogenesis, and why it seems to be protective, we could potentially develop therapies that mimic these effects. "We might be able to provide some kind of shield [against cognitive decline]," says Lazarov.

Harnessing neurogenesis could even treat conditions it isn't directly involved in, such as traumatic brain injury or stroke. A 2025 study showed that transplanting neural progenitor cells into the brains of mice after a stroke led to the production of new neurons and helped the animals regain lost movement.

"Neurogenesis is closely linked with cognition and may even stave off its decline"

Still, it will take years to determine whether any neurogenesis interventions work, and even longer to bring them to market if they do. Song and his team are trying to speed up the process by developing miniature models, or organoids, of the human hippocampus. Because these organoids capture what happens in the living human brain more accurately than animal models, they could make it easier to identify therapies that boost neurogenesis, says Song. Other researchers are trying to develop non-invasive brain-imaging techniques to measure neurogenesis in living people, with similar goals.

There may be simpler interventions, too. "Lifestyle is an easy way of modulating, potentially, neurogenesis," says Thuret.

Research has long shown that neurogenesis increases in rats when they are mentally stimulated, such as by having roommates or fun toys in their cages; people may similarly benefit from enriching activities like socialising or learning a new skill.

Exercise also shows promise, at least in rodents. Gage and his colleagues found that when adult rats run on exercise wheels, they produce more immature neurons than sedentary rodents. They also do a better job navigating a maze, signifying enhanced cognitive performance.

Thuret was curious whether the same could be true for humans. So earlier this year, she and her team exposed human hippocampal stem cells to blood serum taken from adults who had completed a three-month exercise programme and those who hadn't. But instead of stoking neurogenesis, blood from the exercisers actually reduced the number of stem cells ready to become new neurons.

Thuret is still trying to unravel what this means. But given that it is well established that exercise benefits brain health, it may not necessarily be a negative outcome. It is possible that physical activity helps regulate the pace at which stem cells transform into neurons, reserving some for future development, she says.

It is intuitive to think that if impaired neurogenesis is bad, cranking it up to 11 would be good. But too much neurogenesis could backfire, says Thuret. Cancer, a disease of unchecked cell growth, is a prime example of how more isn't always better when it comes to the human body.

This is just one reason why indiscriminately turning up neurogenesis probably isn't a viable treatment option. It is more likely that therapies of the future will be targeted, tweaking neurogenesis in different ways and to different levels to treat various conditions, rather than having an across-the-board fix, says Thuret.

Plus, as far as researchers have been able to tell, neurogenesis is mostly confined to the hippocampus. Many cognitive and psychiatric symptoms originate there, but not all of them. For example, a completely different brain region mediates anhedonia – the inability to feel joy, which is a hallmark of depression. "I don't think that a drug that stimulates neurogenesis is going to cure anhedonia," says Hen. "The medicine of the future is probably going to be a medicine where we use multiple drugs, each one targeting specific symptoms."

Unless, of course, neurogenesis isn't limited to the hippocampus at all.

After finding progenitor cells in the hippocampus, Dumitru, Paterlini and their colleagues didn't celebrate for long. Instead, they embarked on a new search, turning their attention to the subventricular zone, another part of the brain that some studies suggest is capable of neurogenesis well into adulthood. The work is in early stages, says Dumitru, but already they have spotted signs of progenitor cells in adult samples of this area – a new game of hide-and-seek has begun. ▮



Jamie Ducharme is a health and science reporter

Meeting eye to eye

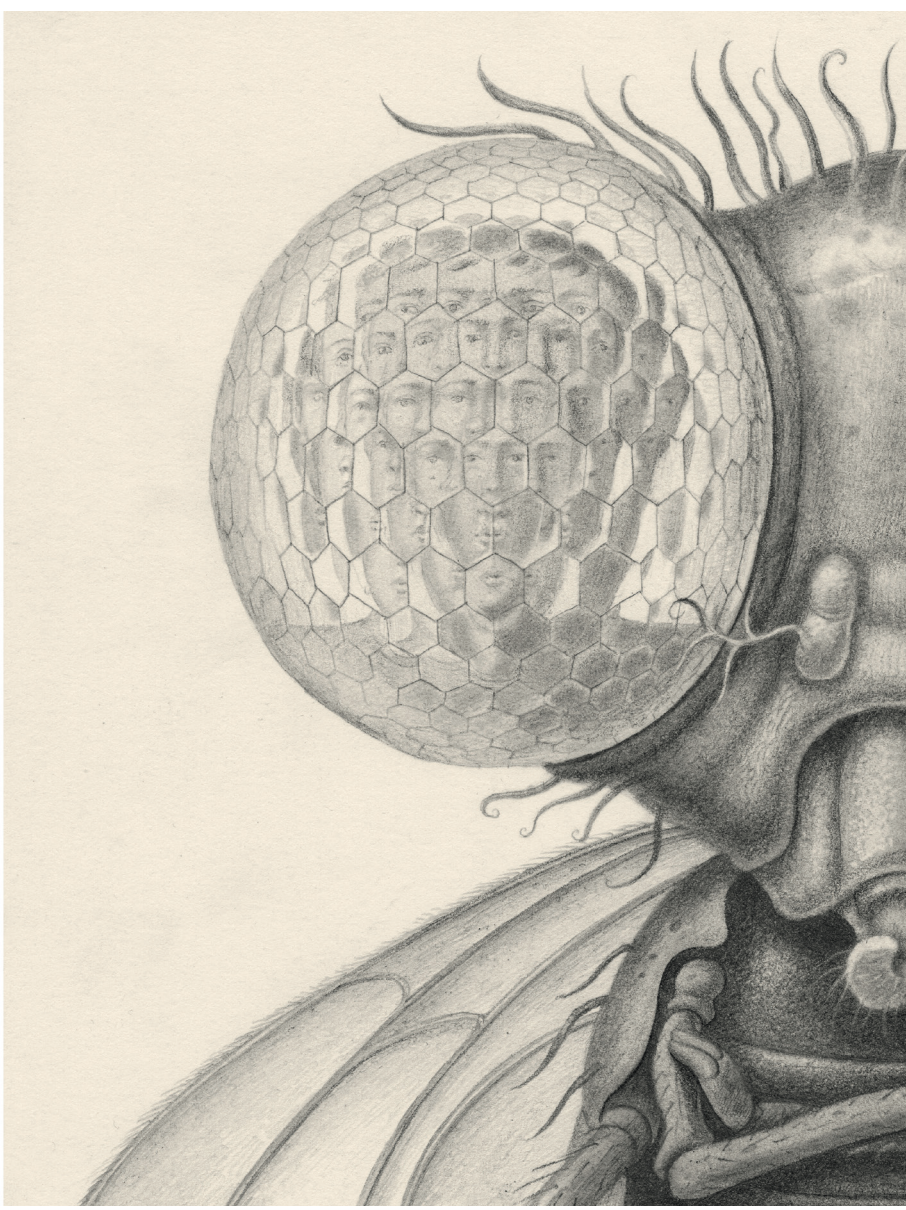
A close encounter with a fruit fly set **Rowan Hooper** on a mission to seek out signs of an emotional inner life across the animal kingdom – and find out how they give us new perspectives on consciousness

I RECENTLY discovered some scientific research that struck me to the core. I have spent many years exploring biology and the interconnectedness of life. Yet here was something that cut through all the knowledge I thought I had acquired: scientists have found that if male fruit flies are deprived of sex with females, they turn to alcohol. I immediately headed to the kitchen – not for a drink, but to watch some fruit flies I had seen earlier around a slice of lime my daughter had failed to clear away.

I took my hand lens, carefully snuck close to a *Drosophila* and peered into its red, mosaicked eye. We might be separated in evolutionary time by some 780 million years, I thought, but we share fundamental similarities. Natural selection has equipped us both with a brain that functions to improve our survival and that of our offspring. Is this why both flies and humans, on occasion, seek to douse flames of sexual rejection with alcohol? Just because flies don't write poetry about it doesn't mean they don't experience a rich inner life.

My encounter with the fruit fly in the kitchen led me on a mission to understand the feelings experienced by other animals, including insects – to explore from a non-human point of view what it means to be conscious. Only a few decades ago, it was scientific taboo to suggest that even chimpanzees had personalities or feelings. Now, evidence of complex inner worlds in a wide range of non-human animals is mounting. Even "simple" animals make a good case. Fish seem to know themselves. Bees can be pessimistic. Cuttlefish plan for the future.

This is serious stuff, and it is incumbent on us to understand the extent of animal consciousness so that we can treat our fellow organisms with the respect they deserve. But the quest also sheds light on how this most murky and mysterious of attributes

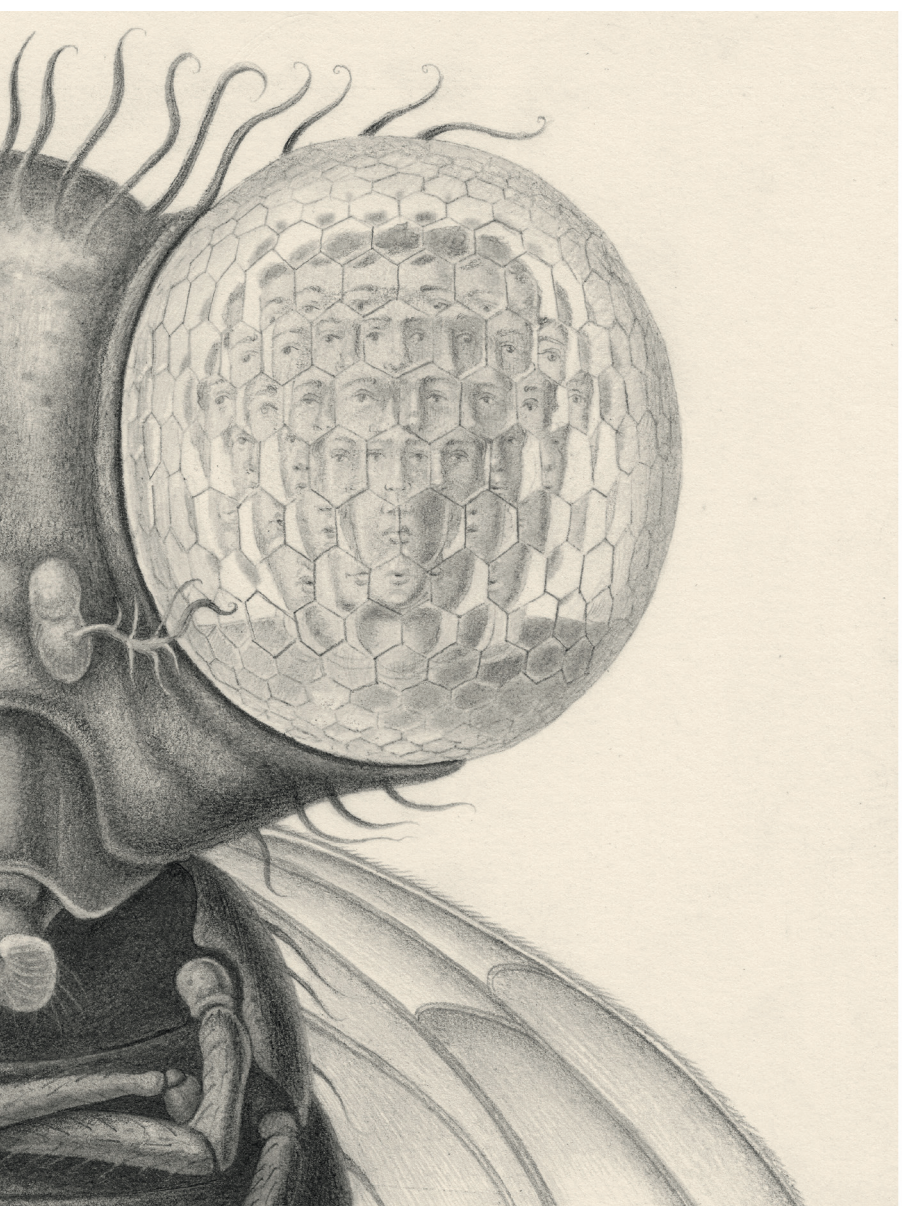


ARMANDO VEVE

evolved, and what it actually means.

The big question is around what philosophers call phenomenological consciousness: having a subjective view of the world. The aptly named "hard problem" of consciousness is to explain not only why we have feelings at all, but to describe the physical basis of that subjective sense. Examining the lives of non-human animals can help tackle this notoriously difficult problem, says philosopher Tim Bayne at Monash University in Melbourne. "If we assume there is a kind of subjective experience in an animal," he says, "what might it be like? What reason would it have to be conscious?"

"Animals are not just calculators. They also have inner lives in which they feel things"



I turn to Lars Chittka, a behavioural ecologist at Queen Mary University of London. His team's work has shown that bumblebees engage in what can best be described as play. Chittka made a mini ball pit near the bees' nest and found that the insects rolled the balls for extended periods. Not only that, but they seemed to enjoy it, going out of their way to go back to the play area. "It looks like subjective experience. It looks likely they are having emotion-like states," he says.

Other insects seem to engage in play, too. Last year, researchers made an insect amusement park and found that some fruit flies sought out rides on a spinning carousel. Play is fun, but it has a function. In this case, perhaps the spinning motion helps the flies learn self-perception to fly and navigate better.

Feeling feelings

I asked Chittka about the haunting finding that male fruit flies drink alcohol if they can't have sex. Flies that had recently mated and those that were prevented from doing so were both offered either regular food or food laced with 15 per cent ethanol. The sexually satisfied males ate both types equally, while the thwarted males strongly preferred the booze. The scientists also identified a neural system that links the rejection to the alcoholic reward. "For me, the observation that if you deprive male fruit flies of the opportunity to have sex, they turn to something that likely makes them feel better, it is highly suggestive that they are experiencing a negative feeling [that] can be remedied with a drug, in this case alcohol," says Chittka.

You might object and say that neither play nor self-medication with alcohol is evidence of consciousness. Yet, to many scientists, the findings suggest there is a subjective sense of self held by these animals.

"I don't know how to prove if another individual is conscious, even with humans," says psychologist Nicola Clayton at the University of Cambridge. But she has tried to probe several animals' subjective experiences. In one experiment, her team performed a version of the famous marshmallow test on cuttlefish, testing to see what the creatures would do when offered a choice between one treat (a live shrimp) immediately or two if they waited. Like some children, cuttlefish ›

were able to delay gratification. "It's an important part of planning for the future," says Clayton. "I would say that's good converging evidence that this animal has consciousness."

A few years ago, when I visited Clayton's aviary in Cambridge, I experienced something I can't explain without endowing birds with consciousness. The aviary housed four or five young jays and, as Clayton opened the door and we entered, the birds first came to see her, but then, on seeing me, a stranger, they ran behind a nest box as if to hide. The birds started vocalising – it sounded like they were saying: "sorry – sorry!" I looked to Clayton in astonishment. "They are apologising for running away. It's because they don't know you," she said.

This instinctive interpretation may be hard to prove, but Clayton and her colleagues have shown that jays can relive past moments and anticipate future ones. In one 2024 experiment, food was hidden under one of a line of distinctive cups. The watching jay was then removed while the order of the cups was shuffled. When the bird returned to the test chamber 10 minutes later, it could remember the correct cup. This is good evidence for episodic memory – long-term, event-based memory – and is evident in the wild: jays have evolved to cache food and retrieve it later, and adjust their behaviour to deceive others if they are being watched.

As I assimilate this new thinking on animal consciousness, I find myself moving through the world in a different way. I notice some honeybees landing on cyclamen flowers, and watch the bees carefully for signs of caution. Chittka has shown that if bees encounter crab spiders lurking in flowers, they become nervous when visiting other plants.

That makes sense, because crab spiders are dangerous predators of bees. "Their demeanour changes – they fly slower," says Chittka, "but false alarms happen." They will sometimes check out a flower that has no predator, yet still reject it. "It's as if they've seen a ghost," says Chittka. "Anthropomorphically speaking, it's like we see in PTSD when people conjure up a threat of something not there."

Bees aren't the only seemingly simple creatures with signs of consciousness: the more experiments scientists conduct, the more they uncover animals with complex inner lives. Magpies are one of a growing number of species to have passed the mirror test, and were the first non-mammals shown to do so. This test aims to assess whether an animal has a sense of self based on its interaction with its own reflection. Perhaps it isn't too surprising that a magpie can do this, but more startling is the finding that a fish – the cleaner wrasse – has also passed the mirror test.

Will Sowersby at the Arthur Rylah Institute in Australia and his colleagues noted the speed and ease with which cleaner wrasse habituated to a mirror in their tank and started using it to inspect their own bodies. But then they saw a fish take a piece of shrimp, drop it in front of the mirror, and watch it fall in the reflection. It was as if the fish was a kind of physicist, performing an experiment. "What we were seeing is evidence that an animal can undertake hypothesis testing," says Sowersby. "The cleaner fish used a piece of shrimp to test the properties of the mirror. A remarkable observation."

Sowersby's colleague Shumpei Sogawa at Osaka Metropolitan University in Japan is more measured. "What is particularly striking," he says, "is that such behaviour can look extraordinary to us because we tend to underestimate what fish normally do."

Amid the various tests, animals' ability to learn from experience is increasingly considered one of the most important signifiers of consciousness. Jonathan Birch, a philosopher at the London School of Economics, has been working with neurobiologist Simona Ginsburg and geneticist Eva Jablonka on a framework

"I hope that the growing awareness of there being a kind of inner life in many animals leads to changes in the way people treat them"



TORRIPHOTO/GETTY IMAGES



RICHARD RICKITT

Signs of consciousness in bees range from engaging in play, such as rolling balls around for fun (left), to being nervous of visiting flowers that remind them of encounters with predatory crab spiders (above)

they call unlimited associative learning, or UAL. To evaluate consciousness, they propose measuring five aspects of an animal's capacity to learn.

One important aspect is the ability to learn to associate one stimulus with a second, novel stimulus. The classic example is Pavlov's dogs: the canines learn to associate a bell with food, then they salivate at just the sound of the bell. Fruit flies and honeybees can do this, so these animals, and dogs, tick that box in the UAL checklist. This sophisticated learning reflects animals' consciousness, says Birch. "Animals are not just calculators. They don't just solve puzzles. They also have emotions. They have inner lives in which they feel things, and we can make inferences about these things as well."

Birch, Ginsburg and Jablonka have combed through the scientific literature to build the case for UAL, and therefore consciousness, in a range of animals. Their work suggests consciousness independently evolved at least three times, says Birch: in vertebrates, where it led to consciousness in birds and mammals; in cephalopod molluscs, where it led to sentient octopuses and cuttlefish; and in arthropods, which created conscious insects, spiders and crustaceans, such as lobsters. "In at least those three lineages, they've gone from a non-conscious starting point to having a form of consciousness," says Birch.

What we are learning from animals helps sharpen the thinking on why consciousness evolved, says Bayne. "The basic purpose of consciousness is to alert you to critical bodily needs: do I need food? Am I too hot? Am I too cold? Am I in danger? Is this a mating opportunity?" he says. If the purpose of consciousness is to address those variables, then it makes sense why bodily sensations like thirst are so vivid and salient, and so central to consciousness.

The advantage of UAL is that it doesn't get bogged down in some bigger grand theory for the mind, such as integrated information theory or global workspace theory. "You say, 'I don't care about theories of consciousness. I'm just going to look for behavioural and neural signatures of consciousness and see if they're similar to what happens in humans,'" says Anil Seth at the University of Sussex, UK.

These approaches avoid directly trying to answer the hard problem of why a physical process is accompanied by a conscious feeling. "I don't think we make the best progress by going after the hard problem directly," says Seth. "I think we go after it indirectly, and this is one way of doing that."



TREVOR RAY HART

Jays in Nicola Clayton's lab have shown they have memory

"We don't need to solve the hard problem to have evidence of consciousness in other systems," says Birch. "Indeed, it might lead over the longer term to better solutions, because the more evidence you have, the better position you're in to develop theories about the nature of consciousness."

A question of ethics

These recent discoveries in animals raise some serious questions about welfare. "What I hope is that the growing awareness of there being a kind of inner life in many animals, including invertebrates like octopuses, does lead to changes in the way people treat them," says Birch. We have seen this in the opposition to octopus farming. "People have seen [that] octopuses are these amazing beings with rich mental lives," he says. "It's inappropriate to pack 20 or 30 of them into tiny spaces."

The key question for whether we have a right to exploit an animal, says philosopher Simon Brown at Ashoka University in Sonipat, India, is "whether they have genuine interests where you can do things that matter to them, in the sense that they have a perspective from which certain things are good or bad for them".

It seems there is a strong case that insects, spiders, lobsters and crabs, as well as fish, cephalopods and all vertebrates, have this self-perspective. Insects such as crickets and black soldier flies are raised in their billions to be processed for food, mainly for animals, with next to no thought for their inner lives. "They are killed by microwave," says Chittka. "We can do better, though, and minimise suffering."

I thought back to my close encounter with the fruit fly in the kitchen. Insect compound eyes are constructed such that a black dot called a pseudopupil can appear when you look at the eye head-on. This had the unsettling effect, when I peered at it with my lens, of making it seem like the fly was gazing intently into my eye. *Drosophila* has been the subject of countless experiments. As well as hitting the booze, males prevented from mating exhibit various responses, such as enhanced aggression, that scientists describe as "frustrative-like". This can't help but give you an insight into what it is like to be a fly.

"Knowing that about *Drosophila* changes, at some level, your appreciation of the kind of thing it is, and gives you access to it," says Bayne. "Many people would take very seriously the idea that insects are conscious."

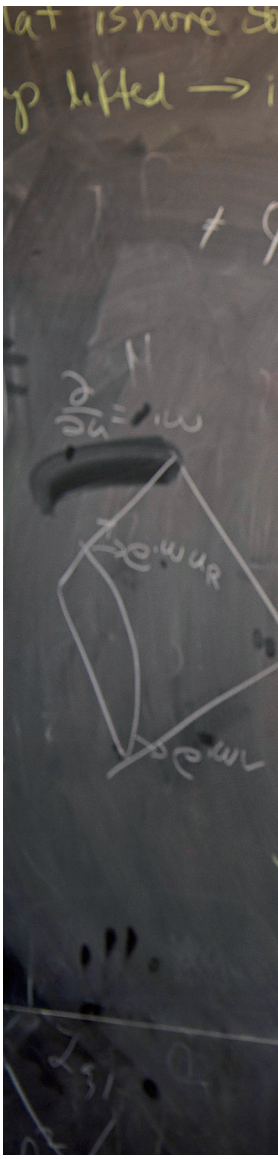
Billions of individual flies, maybe trillions, have been bred and investigated and mutated, with little or no regard for their welfare. This sends a shudder through me, and I hope it does you, too. Even with an awareness of the danger of anthropomorphising them – male fruit flies aren't like men in their taste for alcohol – it is hard to deny that there is something wonderful and unifying about what we are learning about the feelings and inner lives of our fellow creatures. ▮



Rowan Hooper is podcast editor at *New Scientist*. His latest book is *Togetherness*

"I don't take it very literally that I live in a hologram"

Is the universe we experience a projection of a simpler, lower-dimensional reality? Physicist **Sabrina Pasterski** tells Miriam Frankel about her mind-bending idea that could finally unify gravity and quantum theory



IT IS a windy day in London when I meet physicist Sabrina Pasterski on the sidelines of a conference – which turns out to be a problem. We had agreed to chat in a tent, but the canvas is flapping so loudly that we can barely hear each other. In the end, we retreat to a nearby church hall.

But then again, maybe this ad-hoc venue is strangely fitting. As a choir sings tunefully about heaven a few doors down, Pasterski tells me that her work is all about the celestial sphere – and has something in common with the Christian concept of the Holy Trinity, the idea that God is three persons in one.

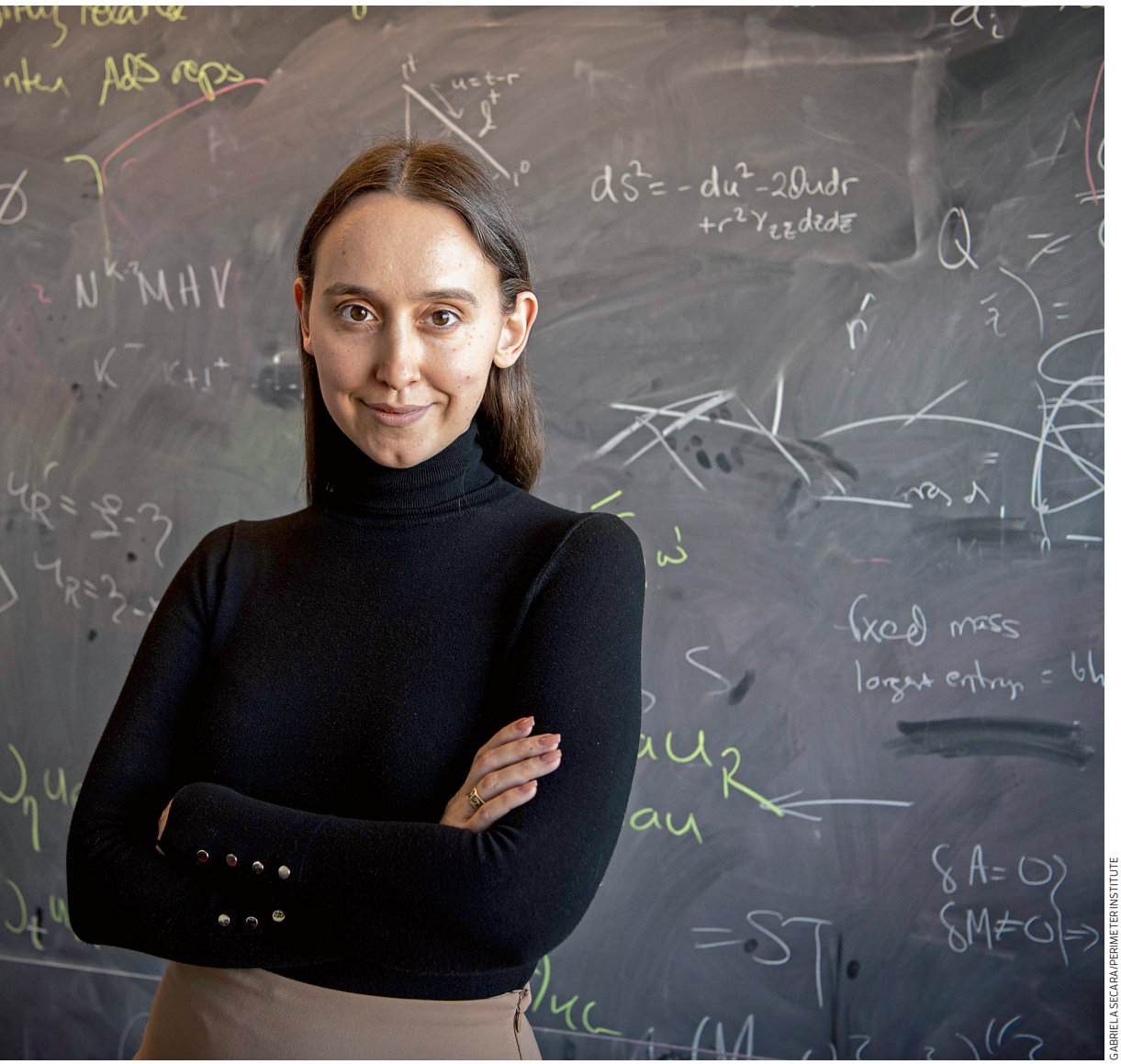
"Duality is almost like the Trinity," Pasterski tells me, referring to one of the principles at the core of her work. "I'm not religious, but I was raised Catholic. It's the sense that there can be different manifestations of something equivalent."

It isn't the introduction I expected to Pasterski's research, a subtle and complex idea known as celestial holography, which seeks to show how two separate descriptions in physics can be equivalent. But given that she is often called "the next Einstein" in the press in reference to her fierce intellect, I am excited to try to wrap my mind around her work, regardless of the venue.

It helps to start with the two key pillars of physics. On the one hand, there is general relativity, Albert Einstein's theory of gravity, the key ingredient of which is a smoothly curving fabric of space-time. On the other, quantum theory wonderfully explains the world of particles and envisages reality as not smooth at all, but instead coming in chunks with discrete amounts of energy. Suffice it to say that both are fundamentally incompatible.

The dearest wish of many a physicist would be to find a way to unify the two, and so produce a theory of quantum gravity. That is what Juan Maldacena was attempting back in 1997 when he proposed an exciting kind of duality.

Imagine a three-dimensional cylinder of space-time with a two-dimensional surface. Maldacena constructed a model like this where, inside the volume of the cylinder, you have a description of space, time, particles, gravity – the lot – but the surface



GABRIELA SECARA/PERIMETER INSTITUTE

is purely quantum. But here was the crucial point: he showed that the two descriptions of the model – the surface and the internal volume – were equivalent. They were a duality, two inter-translatable descriptions of the same thing. Put another way, it suggested that the universe was like a hologram: that the reality we live in could merely be a projection of a simpler, lower-dimensional foundation.

Celestial holography

All very exciting. The only trouble was that Maldacena's idea – which came to be known as the AdS/CFT correspondence – worked for only a specific type of curved space-time. And that isn't the same as the "flat" kind we really live in. Inevitably, physicists have wondered if the trick could be made to work for the real universe. It has been devilishly hard to pull off, but that is what celestial holography promises.

Meeting Pasterski, it is obvious she has a formidable brain. She speaks so quickly, it's as if time is running out. As she speaks, she gesticulates, energy levels sky-high as sharp gel nails scratch the air between us. My impression is that she processes information faster than the average person. I begin by asking how she feels about being labelled the next Einstein? "It's bullshit," she says, smiling. "I don't think I deserve it, first of all. The positive I try to turn it into now is that hype gets you a platform."

This energy appears to have driven her since she was a child. At a young age, she told her parents she wanted a flying broomstick; in response, they got her flying lessons. At 12, she began to build her own plane from a kit, and by 16, she could fly it. She dreamed of working for Blue Origin, Virgin Galactic or SpaceX, viewing the founders of those companies as heroes. As a young adult, her version of rebellion was to then turn against this idea – "you're basically just helping them build their thing" – and decide to major not in aerospace engineering, but in physics at the Massachusetts Institute of Technology instead.

I wonder if these tech founders are still her heroes? She will always appreciate Jeff Bezos, she says. He encouraged her as a child, penning a "nice letter". But when it comes to Elon Musk, she is more circumspect, going back and ›



CURLY_PHOTO/GETTY IMAGES

The core idea behind celestial holography is that there is an equivalence between the world we experience and the "shadow" it casts on a two-dimensional surface

> "Duality is almost like the Holy Trinity. It's the sense that there can be different manifestations of something equivalent"

forth. "A lot more people have seen [his] flaws, and yet he has done a lot of cool stuff," she says. But the fact that "someone like him can do all that cool shit", she says, raises the question, "Why can't we?"

Pasterski began to lay some of the mathematical groundwork for celestial holography during her PhD with Andrew Strominger at Harvard University in around 2018, but she now works at the Perimeter Institute in Ontario, Canada. Pasterski's hypothesis starts with particle collisions. She imagines the debris spraying off in all directions and that each piece of quantum shrapnel can be marked as a point on a sphere infinitely far away, along with information such as energy. Pasterski thinks of this sphere as being essentially like the night sky. "You see the stars, you think of them as being infinitely far away, like a sphere around you," she says. "That 2D sphere is the celestial sphere."

Instead of wrestling with the mess in the middle, celestial holography reconstructs the entire universe from the pattern written around the edge. You can think of it like a new, improved version of Maldacena's idea, except with a sphere that, this time, corresponds to the real space we live in. At least, almost. "I also cheat," admits Pasterski. We know that real space is expanding ever-faster, but hers isn't.

Over the past few years, Pasterski has been developing ways to translate between the boundary of the sphere and real space. Initially, the focus was on modelling how single particles behave, but she and Justin Kulp at Stony Brook University in New York have recently taken the big step of showing how to do this for multiple particles.

She has also been exploring the concept of entanglement, the mysterious quantum process in which two particles can be connected so that if you measure one, you can immediately infer something about its partner – even if they are very far apart. In AdS/CFT, physicists have shown that entanglement between quantum particles at the boundary can directly produce the fuller dimensional world we experience. In celestial holography, things are more complicated. "That's really well understood in AdS/CFT," says Pasterski. "It's harder to generalise to flat space."

One reason it's so tricky is that it is hard to keep the boundary part of celestial holography free of gravity – it isn't a neat wall of a box or a cylinder like it is in Maldacena's theory, it is a sphere infinitely far away. This makes the mathematics messier. But Pasterski and her colleagues have made a start in working it out, in particular, the connection between the entanglement present on the boundary of the sphere and the geometry of flat space-time. In the models they studied, the flat-space region was associated with reduced entanglement in the boundary compared with what you get when you use AdS/CFT.

Pasterski refers to the list of constraints, rules and equations she has developed as a "grammar" for celestial holography. While work on the dictionary translating the four-dimensional physics into a two-dimensional boundary description is progressing rapidly, there are still things missing.

Ideas collide

It is heady stuff and I am keen to know if any of this is testable. Potential theories of quantum gravity are notoriously difficult to subject to experiment, sometimes requiring particle colliders so powerful they simply cannot be built. However, Pasterski has thought of other possible ways to probe celestial holography.

Although the hypothesis typically deals with particle collisions, it is more general than that. "It could be that the collision is black holes," says Pasterski. When black holes collide, they give rise to ripples in space-time

called gravitational waves. Scientists believe that when these waves pass through regions of the cosmos, they leave behind small but permanent distortions in space-time.

Around a decade ago, Pasterski and her colleagues developed an extension to this idea known as the spin memory effect. This proposes that the distorted space-time also carries an imprint of the gravitational wave's angular momentum or rotation. This, in turn, can be directly translated to one of Pasterski's main hypotheses for how things work on the boundary, which potentially gives a link between something in our 4D universe and celestial holography. Excitingly, space-based detectors such as the gravitational wave observatory LISA, expected to be launched within a decade, could find evidence of the spin memory effect.

Another possibility is the Large Hadron Collider (LHC) at the CERN particle physics laboratory near Geneva, Switzerland. The trick here is to treat the LHC's detectors, such as CMS, as a holographic sphere. "The kind of fun thing about our framework is that we can talk about [a boundary at] infinity being literally the CMS detector or it can be like LISA," she says. "But you have to adjust because the geometry of the detector isn't exactly like a sphere." This means physicists can pore over collider data to try to discern the patterns her celestial grammar proposes. For example, it suggests there should be a geometric pattern in how energy is distributed during particle collisions.

> "If there are two equal universes, which one is the real one, the most fundamental?"

One thing I have always wondered about physicists who work on holography is whether they really believe it. The maths may work, but how seriously should we take the idea? "I study the mathematics that underlies these different theories that we have," says Pasterski. "So, I don't take it very literally that I live in a hologram – but I think that it actually is quite powerful to ask that question."

Indeed, if there are two equal universes, which one is the real one, the most fundamental? If it is the celestial boundary, does that mean gravity and the 3D space we so clearly experience are just an illusion? Pasterski isn't too worried about which is the real deal. "The way that we set up [the celestial holography research] programme, I think it's very much still the one that we're in," she says. "But I think in a world where we'd be able to fully understand this dual description, then they would be equally good... they would be equivalent."

When we arrived at the church earlier, I wasn't sure if Pasterski's cerebral intensity was going to make her an intimidating interviewee. She is certainly on another level to me, and as we leave the church hall, she keeps chatting with the same speed and energy, despite having flown in from Canada that morning. It was a relief, however, to also find her warm, relaxed and open.

Earlier on, I had become flustered trying to book a taxi for us on my phone. My signal was poor, nothing was happening, and at one point I looked at her pleadingly, wondering if she could dream up a technological solution with her powerful brain. But she just smiled and offered to book it on her phone instead. So, is she really the next Einstein? Time will tell. But I certainly warmed to her. ▮



COURTESY OF SABRINA PASTERSKI

Sabrina Pasterski built her own aeroplane as a teenager



Miriam Frankel is a science journalist, author and editor

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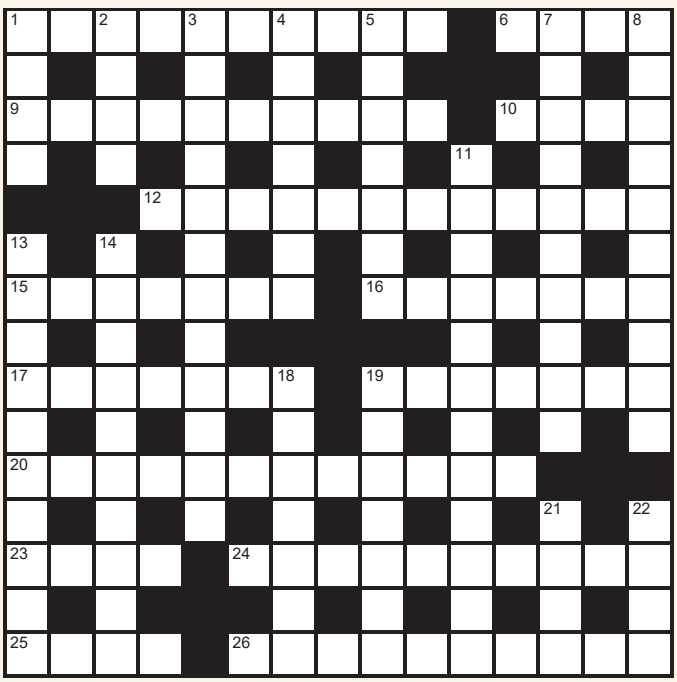
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Alzheimer's Society
It will take a society to beat dementia

Quick crossword #220 *Set by Richard Smyth*



Scribble zone

Cryptic crossword next week

ACROSS

1 Soft gap in the skull of an infant (10)
6 Yellowjacket, for example (4)
9 State of ongoing-ness (10)
10 Bring water to 100°C (212°F), for example (4)
12 John ___, English geneticist (7,5)
15 Rare but dangerous bacterial infection (7)
16 Right-angled (1-6)
17 Disorder; cause to become mentally unstable (7)
19 Upper jaw bone (7)
20 Unit of time roughly equal to 2.25 million centuries (8,4)
23 As well (as) (4)
24 Basic excretory organ also known as the pronephros (10)
25 Swirl in fluid (4)
26 Swelling around a joint (10)

DOWN

1 Item of information (4)
2 3^2 (4)
3 Electronic puppetry (12)
4 Celestial phenomenon observed twice a year (7)
5 Width-wise (7)
7 Basic nuclear reactor (6,4)
8 Having many sides (10)
11 Suffocation (12)
13 Water bear (10)
14 Made germ-free (10)
18 Incidence of an acute medical condition (7)
19 Plant in the chamomile tribe (7)
21 Litre or metre, say (4)
22 Organs of sight (4)

Quick quiz #376
set by Chelsea Whyte

1 A ship that sank in the Early Bronze Age may be the world's oldest shipwreck. Near which country's shores was it found?

2 Babies who are formula fed are more prone to infections, but the addition of what kind of supplement has been shown to slash the risk of catching respiratory viruses?

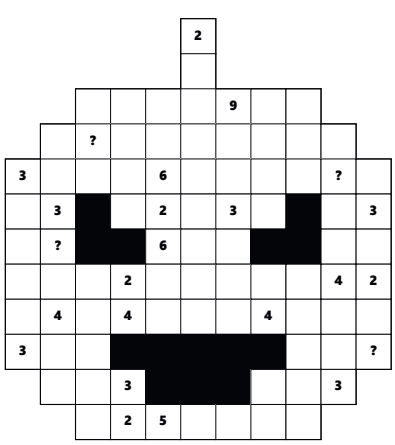
3 Scientists voted to abolish the practice of adding what unit of time to clocks to make them sync with Earth's rotation?

4 Japan's Martian Moons eXploration craft launched on 20 October and is headed towards Phobos. When will it arrive at Mars?

5 Cells that cross the placenta from a mother and enter the developing brain in utero have been found in some people in which decade of life?

Block Universe
created by Puzzlr

The goal is to divide the grid into non-overlapping rectangles. Each rectangle must contain exactly one number, and have an area equal to that number. For example, a 6 should have a rectangle covering 6 squares.



Answers to this week's puzzles on page 47

Our games are now playable online
newscientist.com/games

Cats v dogs

Humans have domesticated both cats and dogs. Why do dogs generally follow instructions, whereas cats largely ignore them?

Caroline Peters
Wokingham, Berkshire, UK
Wolves are pack animals. Therefore, as they were domesticated, human owners took on the role of the pack leader. The dogs would naturally obey commands given by the surrogate pack leader – hence the term "master" for the owner of a dog.

Domestic cats, on the other hand, evolved from a wild species that was naturally solitary. Such animals would therefore be used to making their own decisions. It is possible to train cats to respond to human instructions, but this has to be done in a way that is advantageous to the cat in order for it to want to comply.

The current trend for "adventure cats" is a case in point – if the cat enjoys trips out with its owners, it will quickly learn to follow the instructions that lead to this reward.

We taught our own cat (who was acquired as a rescue at age 11) to respond to a hand held up like a stop sign so that she would not immediately jump onto people who don't like cats. She very quickly understood what was required by this gesture. She also learned that the sound of the bell from one of her toys was a command to heel and would come in immediately if this was shaken, whether or not a food reward was given on her return. We even had one cat who had been taught to play fetch just like a dog.

"Cats moved into areas around human grain stores during the Neolithic agricultural revolution, attracted by rodents"

As with all domestic animals, the key to success in training is to be absolutely consistent in the message that you're trying to convey. All human members of the household must expect the same result from the same message and, especially when dealing with cats, the animal must see the benefit in obeying the command.

Pam Lunn
Kenilworth, Warwickshire, UK
It may be a category error to suggest that we have domesticated cats.

Cats moved into areas around human grain stores during and after the Neolithic agricultural revolution. The concentration of rodents drawn to grain stores proved a convenient attraction for cats. The "domestic" cat genome has changed very little since then: they retain their wild characteristics.

There may be an argument for saying that cats have domesticated us, exploiting us for our willingness to feed and pamper them.

The law in the UK says that cats have the right to roam, and their owners cannot be held liable for trespassing or property damage they cause.

This is in contrast to the legal position of dogs, whose owners remain liable for any injury or damage caused by them.

Simon McLeish
Lechlade, Gloucestershire, UK
Domestic dogs and cats have both been companions to humans for a long time, and they have both adapted to live with us.



SHUTTERSTOCK/WILLIAM LUQUE

This week's new questions

Hatching a plan **What is the advantage of eggs over live births?** *Brian Shipman, Maidenhead, Berkshire, UK*

Out there **If aliens with technology similar to ours lived on a planet orbiting Proxima Centauri (our next-nearest star), would we be able to see unmistakable signs of a technological civilisation? Of life?** *Chris Greenlaw, Vancouver, Canada*

What is the benefit of laying an egg rather than giving birth to live young?

The two animals are descended from very different ancestors and, accordingly, their behaviour is very different. Genetic testing indicates that the closest relative of domestic cats is the African wildcat (*Felis silvestris lybica*), while dogs are most closely related to wolves (*Canis lupus*) – so close, in fact, that domestic dogs are classified as a subspecies of the wolf, not a separate species.

Their behaviour is very different. Wolves themselves are pack animals, with a distinct hierarchy. Their place governs their behaviour and, to them, a human is a dominant member of the pack in a way that no domestic cat would recognise. For millennia, dogs descended from wolves have been bred by humans to enhance traits such as trainability.

Having said that, with patience, it is possible to train domestic cats to carry out taught actions, but it generally needs more work and time than it does with dogs.

Peter Meehan
London, UK*
I used to walk down a quiet lane and my pet cat enjoyed strolling along the other side of a hedge, jumping back to me when it suited him. A cat hears instructions, but will make the decision to act on things more interesting to them.

**Editor's note: We would like to point out that Peter's actual address is in Catford.*

Neil Sutcliffe
Glossop, Derbyshire, UK
There is an error in the initial suppositions: humans have indeed domesticated dogs, but cats have domesticated humans, hence the reversed master-servant relationship.

Kevin Craig
Arvada, Colorado, US
Clearly the questioner has never owned a greyhound!

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Tom Gauld
for New Scientist



Hot or cold

Why can't we cool water as quickly as we can heat it? (continued)

Graham Smith
Melbourne, Australia
The rate of heat transfer to, or from, water is determined by three variables. The first factor is the difference in temperature between the heating source and the water. The second factor is called the heat transfer coefficient. The third is the contact area between the water and the medium that is doing the heating or cooling.

Heating is generally accomplished by an electrical element, or some form of flame. The heating source can be hundreds of degrees hotter than the water. In contrast, cooling is generally accomplished with a liquid refrigerant or with ambient air, both of which are usually less than a few tens of degrees cooler than the water.

The heat transfer coefficient (HTC) is a measure of the conduction and convection that is occurring in the particular physical system. Water isn't a very good conductor, but it can be a very good convector, because water density changes with temperature, which sets up currents that carry heat away from the heating surface. The convection occurring with boiling water results in an extremely high HTC, because the turbulence carries more of the heat away, and because the steam transfers huge amounts of latent heat. Therefore, the observation of faster heating is due to a combination of greater temperature difference and a higher HTC.

"Water isn't a very good conductor, but it can be a very good convector, because water density changes with temperature"

However, in industrial cooling towers or your home evaporative cooler, the water surface area can be increased enormously by the water being broken into small drops and being in contact with air. The HTC is also high because the evaporated water carries away the latent heat. In this case, it is quicker to cool than to heat.

Kevin Hesketh
Preston, Lancashire, UK
We can engineer systems that cool water as quickly as we can heat it. Think of the coolant system for a car. The coolant is pumped into the coolant channels in the engine and is rapidly heated up by the engine block. Then it passes into the radiator, which has multiple thin channels where it is cooled by air flow.

When the system reaches its running temperature, it reaches an equilibrium temperature governed by the thermostat. The heating time is the time the coolant spends in the engine block coolant channels, and the cooling time is the time the coolant is in the radiator. These don't necessarily match, but they could be engineered to do so by resizing the radiator channels. ▮

Answers

Quick quiz #376

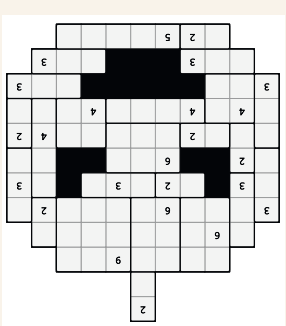
1 Turkey
2 Probiotics
3 Leap second
4 August 2027
5 Eighties

Quick crossword #220

ACROSS 1 Fontanelle, **6** Wasp, **9** Continuity, **10** Boil, **12** Maynard Smith, **15** Anthrax, **16** L-shaped, **17** Derange, **19** Maxilla, **20** Galactic year, **23** Also, **24** Forekidney, **25** Eddy, **26** Tendinitis

DOWN 1 Fact, **2** Nine, **3** Animatronics, **4** Equinox, **5** Lateral, **7** Atomic pile, **8** Polyhedral, **11** Asphyxiation, **13** Tardigrade, **14** Sterilised, **18** Episode, **19** Mayweed, **21** Unit, **22** Eyes

Block Universe



Observe this listing

Feedback has, belatedly in life, stumbled upon a new life interest: wildly aspirational property choices. We previously highlighted the Farnborough Centrifuge, a piece of aviation and space-flight history now up for sale as a home for someone with £750,000 to burn. The Centrifuge was still available the last time we checked. Now, chief subeditor Kelsey Hayes has identified an even more expensive domicile up for sale, which has been highlighted by the news site *London Centric*. Compared with this, she notes, the Farnborough Centrifuge "now seems like a bargain".

When Feedback opened the tab for the listing, it announced at the top: "Four bedroom detached house for sale". While this is technically true, it does not quite capture the scale of the property in question.

What is up for sale is the King's Observatory in Old Deer Park, London. It is a former astronomical observatory, since converted into a private home. It was built on the orders of King George III (as in *The Madness of*) in the 1760s, so that he and his wife Queen Charlotte (as in *Bridgerton*) could observe the 1769 transit of Venus. At the time, this was a major scientific endeavour, because it offered a way to determine the distance from Earth to the sun. Evidently the royals wanted to share the excitement.

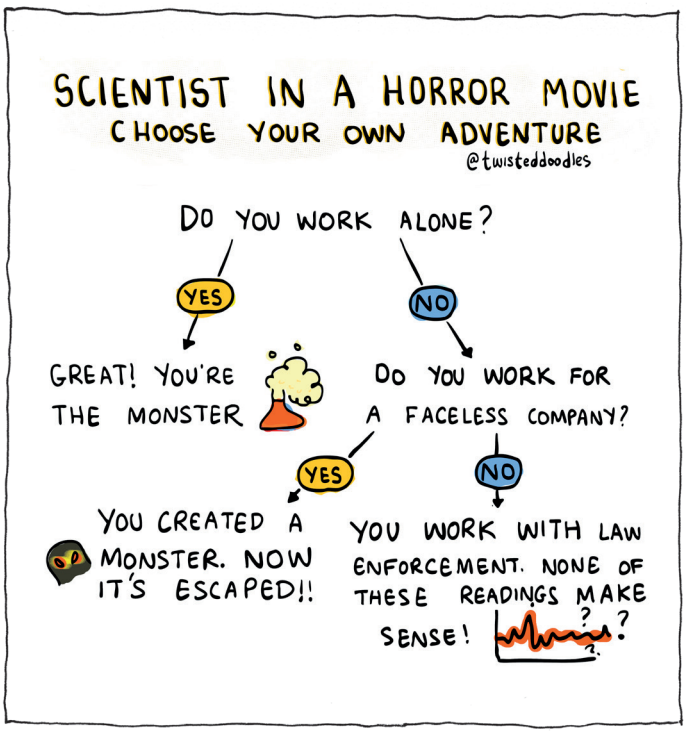
Careful examination of the listing reveals that the observatory is still operational: one of the photos shows an antique wood and brass telescope housed inside a cupola. Kelsey notes with bemusement that the estate agents do not seem to regard this as a major selling point: "it's the last photo in the slideshow".

In the decades after the transit, the observatory was used for an array of scientific tasks, including measuring atmospheric electricity and verifying the accuracy of instruments such as clocks. In the 1980s, it became offices, and in the 21st century, a private home. The listing describes it as having not a garden, but "grounds", and a drive that can accommodate the adjective "sweeping". Grecian carp are mentioned.

At this point, Feedback had heard enough. We were poised to book a viewing when we noticed the asking price: £18 million. We find ourselves a tad short. We could try for a mortgage, but we fear that by definition it would be sub-prime.

London Centric did highlight one potential disadvantage of purchasing the King's Observatory: "You do, however, have to live in the middle of a golf course." Readers and their spouses will have their own views as to whether this is a plus or a minus.

Twisteddoodles *for New Scientist*



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Dust to dust

We continue our efforts to compile the most niche science-themed tourist attractions from around the world. In this we have been aided by Brian Reffin Smith, who alerts us to "an exceptional wonder": the Museum of Dust.

The museum is the creation of artist and author Sally Kindberg. It's a little cabinet, blue on the outside and red inside. It's divided into eight compartments: two across, four down. Each houses an array of little bottles of dust.

But not just any dust. Sally has gathered samples from around the world. There is dust from the Great Wall of China and from the wrapping of an ancient Egyptian mummy. Another sample comes from yet another museum, the self-explanatory House of Automata. Do not look at photos of the items on display at the House of Automata unless you want to be inspired to write a *M3GAN*-style horror movie.

Sometimes people send Sally dust, which must surely cause a brief frisson of alarm when she opens the envelope. She has dust from the TARDIS from *Doctor Who*, sent to her in 2013 by a friend who worked on the show. She also has a sample of dust from the 2007 *Celebrity Big Brother* house, but has not yet revealed how she obtained it.

Readers eager to see the Museum of Dust need to know it has no permanent home: instead you have to attend one of Sally's workshops or talks. Just try not to sneeze.

Not in a name

Occasionally Feedback likes to throw a spanner in the works. In that spirit, we will highlight some examples of what we might call anti-nominative determinism: that is, people whose names are the opposite of what we might expect given their jobs.

In Queropalca, a remote district of Peru, a recent mayoral election was won by a candidate named Hitler Mussolini Simeon Flores. That name contains two waving red flags, but, in fact, Hitler Mussolini is a member of the Ahora Nación party, which is on the centre-left.

This sort of thing seems to happen quite a lot in South America. For instance, between 2017 and 2021, the president of Ecuador was one Lenín Moreno. Elected as a social democrat, he pivoted to right-wing economic policies – none of which, one feels, the original Lenin would have approved of.

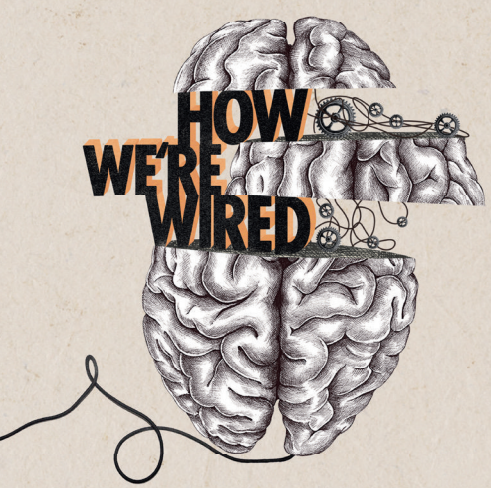
Likewise, reader Hillary Shaw wrote in to highlight another example of inappropriate naming: the 19th-century poet William Jeffrey Prowse. This one took Feedback a moment to understand because we associate the surname Prowse with the actor who embodied Darth Vader, whereas Hillary simply wanted us to read it without the "w".

Meanwhile, in Australia, Bonita Ely was alarmed to discover that her next cancer check-up was with a "Dr Kilian". ▮

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