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A SURPRISING TWIST ON COLD FUSION

WHICH ANIMAL LANGUAGE WILL WE CRACK FIRST?

A NEW HUMAN SPECIES?

Why the Neanderthals might not have been our closest relatives after all

REVERSING CANCER

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Christopher Ward

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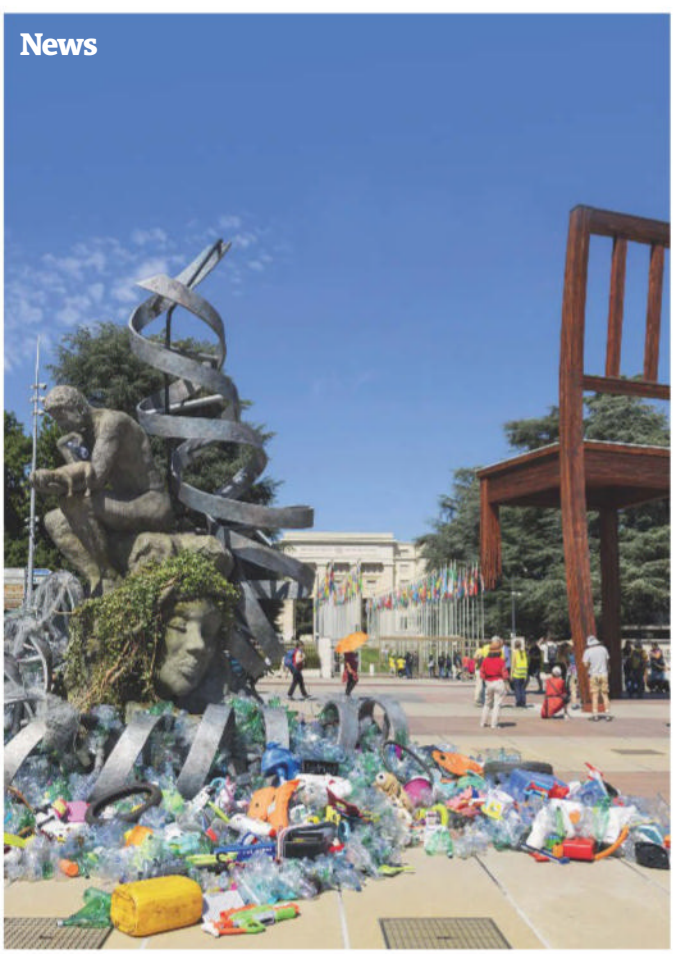

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Shaking the family tree

The idea that Denisovans were their own species means a rethink of our origins

TODAY we are alone. But just a few hundred thousand years ago, our ancestors shared the world with at least five other ancient human species, including diminutive hobbits and burly Neanderthals.

It may now be time to add to that list. As we report on page 30, there are growing calls to give species status to a group of ancient humans known as the Denisovans.

This is hardly a rushed decision, given that the first Denisovan fossils were identified 15 years ago. Ancient DNA extracted from these remains revealed that they belonged to humans with a discrete evolutionary history. But it also suggested that these mysterious ancient people had interbred with our own ancestors, leaving many researchers reluctant to consider them a separate species.

However, some definitions of a species allow for interbreeding, as long as the species involved maintain a defined appearance. The problem was that we didn't yet know what Denisovans looked like. But earlier this year, we learned that an unusually thickset ancient skull, unearthed in China, is associated with Denisovan DNA. With the confirmation that the Denisovans were distinct in appearance, it is easier to argue that they should be given a formal species name.

"It is possible that the Denisovans could help us work out why we were the last humans standing"

Biologists' desire to divide nature up into species is sometimes dismissed as mere stamp collecting, where the aim is to categorise organisms rather than truly understand them. But in this case, at least, there is value to the exercise. Anatomical evidence from the Denisovan fossils points to the intriguing possibility that these enigmatic humans were very closely related to our species – perhaps, in fact, more closely related than any other. That suggests we might gain a particularly clear insight into the early behavioural development of *Homo sapiens* by comparing them with the Denisovans.

At some point, our ancestors learned new behaviours that helped them outcompete all other human species. It is just possible that the Denisovans could help us work out how we came to be the last humans standing. ▮

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ADVERTORIAL

Grape expectations: The science fuelling the UK's wine revolution

The UK's wine sector is experiencing remarkable growth, and it is not just due to a warming climate. A revolution driven by science and technology is transforming British vineyards and wineries, boosting both the quality and scale of production.

According to experts at Plumpton College, the national centre for wine research, the industry's focus has shifted. "At first it was a drive to prove we could make really good wine here," explains Samantha Linter, Head of the Wine Department. "Now it's a drive to see how we can make that better and more efficiently and more environmentally friendly".

This has spurred a demand for greater scientific expertise. Plumpton is pioneering research from grape to glass. One project involves adapting a tractor with UV-C lights, based on research showing that radiating a vineyard at night can prevent fungal diseases and reduce the need for chemical sprays. The college has also launched a five-year "smart vineyard" project, embedding hundreds of sensors to gather data on everything from soil moisture and disease risk to weather patterns. The aim is to understand what drives success and help more UK producers achieve consistently high yields.

This scientific approach is creating new career paths. Plumpton's courses attract not only school leavers but also career-changers, including doctors and lawyers, who are keen to apply scientific principles in a new field.

Looking ahead, the vision is for a more sustainable industry with disease-resistant grape varieties and greater technological integration. "What I'd really like to see is some sort of innovation coming out of the UK... that's going to make big changes in the wine industry worldwide," says lecturer Dr James Clapham. With jobs in the sector projected to rise from around 8,400 to 30,000 by 2040, the future for British wine appears to be firmly rooted in scientific discovery.

You can find out more by visiting the Future of Food and Agriculture stand at New Scientist Live 2025. For more details go to: live.newscientist.com

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Archaeology

The ancient city under the sea

After thousands of years submerged in the Mediterranean, this sunken statue was returned to the surface on 21 August. Thought to be from the ancient Egyptian city of Canopus, it was one of several artefacts pulled from the water at Abu Qir Bay in Alexandria last week by the Egyptian Ministry of Tourism and Antiquities. Once an important trading site, Canopus sank due to earthquakes and rising sea levels.

KHALED DESOUKI/AFP VIA GETTY IMAGES

Physics

An unlikely boost for nuclear fusion

By revising the discredited idea of "cold fusion" from the 1980s, a new experiment may aid efforts to achieve practical fusion power, finds **Alex Wilkins**

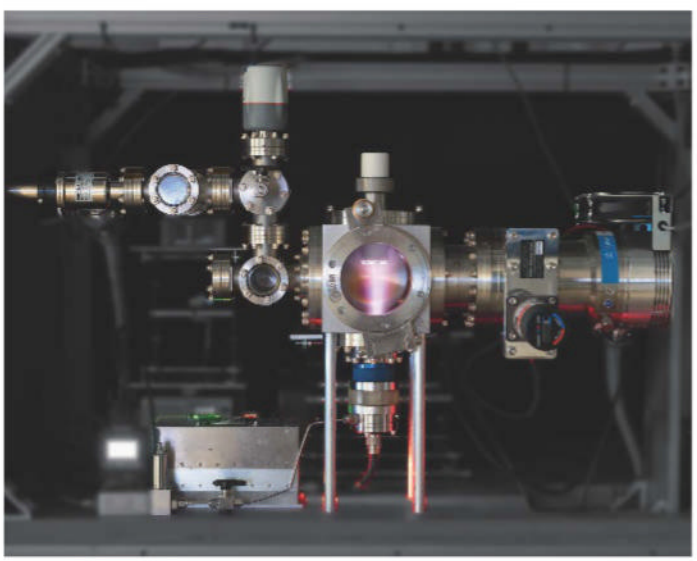
COLD fusion, one of the most notorious blunders in science, is making a return – of sorts. Scientists have resurrected an experiment that was once claimed to show room-temperature nuclear fusion.

Nuclear fusion is a process in which atomic nuclei are forced together at extreme temperatures and pressures, merging them and releasing energy as a result. While this takes place naturally within stars like our sun, replicating the process on Earth has proved incredibly difficult, and despite plans for a commercial fusion reactor first being proposed in the 1950s, we have yet to build one that can reliably produce more energy than it consumes.

In 1989, two chemists at the University of Utah, Stanley Pons and Martin Fleischmann, claimed to have demonstrated nuclear fusion occurring at room temperature in a tabletop experiment, which consisted of a rod of palladium submerged in water infused with neutron-rich deuterium and zapped with an electrical current. This process appeared to produce spikes of excess heat beyond what was predicted from simple chemical reactions, which Pons and Fleischmann took as a signal that nuclear fusion was occurring at a significant rate.

"Cold fusion was dismissed because it could not be reproduced. What we have built is reproducible"

The experiment, which quickly earned the name cold fusion, drew intense interest, as it showed an easier path to cheap, clean energy production than conventional hot fusion. But with multiple researchers failing to replicate the excess heat observations, the idea was dead by the end of that year.



BERLINGUETTE GROUP, UBC

The Thunderbird reactor is inspired by an experiment from 1989

Now, Curtis Berlinguette at the University of British Columbia in Canada and his colleagues have built a tabletop particle accelerator inspired by, but fundamentally different from, this original work.

"Cold fusion was dismissed in 1989 because the claims could not be reproduced. What we have built is a reproducible experiment that others can validate," says Berlinguette.

Like the original cold fusion experiment, the researchers used deuterium – a form of hydrogen with a neutron in its nucleus – and palladium. The reactor, called Thunderbird, consists of a high-energy beam of deuterium nuclei, or deuterons, that are fired into a palladium electrode. The palladium starts absorbing these deuterons, which begin to fuse with more incoming deuterons from the beam, producing neutrons. The rate of neutron production increased during the first 30 minutes of the experiment before levelling out, a sign that the palladium became saturated with deuterons.

To boost the rate of fusion further, the researchers then switched on an electrochemical device filled with deuterium oxide, also known as heavy water. An electric current splits this into deuterium and oxygen, with the former absorbed into the electrode and increasing the number of deuterons in the palladium further, driving the fusion rate up. "What we really drew from the 1989 experiment is this notion of using electrochemistry to load up an electrode with hydrogen fuel," says Berlinguette.

Superconductor hope

The team found that this increased the number of neutrons produced, equivalent to an increased fusion rate of around 15 per cent (*Nature*, doi.org/g9xnxv). However, this would be enough to produce only a billionth of a watt, while the device itself requires 15 W to run. "We are orders of magnitude off of being able to power your home or building with one of these reactors," says Berlinguette.

Though the experiment is inspired by the 1989 work, Thunderbird's nuclear fusion comes mainly from the powerful deuteron beam, rather than the electrochemistry originally claimed in Pons and Fleischmann's work, says Anthony Kucernak at Imperial College London. It is also a "hot" version of fusion, he says – the energy of the deuterons in the beam is equivalent to hundreds of millions of degrees kelvin, the temperature at which regular fusion occurs.

A 15 per cent increase in deuterium in the palladium target is also relatively modest, says Kucernak, but it would be interesting to see whether this can be increased by using different metals in the electrode, he says.

Berlinguette says recent unpublished work from one of his colleagues found that just changing the shape of the electrode can increase the fusion rate by four orders of magnitude – though this is still well below usable levels.

Even if they can't reach higher fusion rates, Berlinguette hopes that their electrochemical technique of increasing deuterium in a metal could have other uses, such as making so-called high-temperature superconductors, ones that don't require really cold conditions. Many promising superconducting materials, which have zero electrical resistance and could transform the world's electrical and energy systems, are metals that contain large amounts of hydrogen. Making these compounds requires vast pressures and energy-intensive processes, but the electrochemical cell used in the Thunderbird reactor could do this with far less energy, says Berlinguette. ▮

Health

Lacing food with fat-trapping microbeads could help us lose weight

Grace Wade

FEEDING rats edible microbeads designed to absorb fat helps them lose weight. One day the beads could be used in our food and drink to prevent or treat obesity.

While new, highly-effective weight-loss drugs like Wegovy and Zepbound have hit the market, their hefty price tag and numerous side effects mean other weight-loss interventions are still needed.

To that end, Yue Wu at Sichuan University in China and her colleagues developed edible microbeads that trap fat before it is absorbed by the body. They created the beads from vitamin E and compounds found in green tea, then coated them with alginate, a type of seaweed fibre. All of these components are food-grade ingredients approved by the US Food and Drug Administration.

Once ingested into the stomach, the protective alginate layer expands, allowing partially-digested fats in the gut to enter the interior of the beads, where they bind to the compounds within. The beads – along with the trapped fat – are then excreted during bowel movements.

The team tested the beads in eight rats fed a diet of 60 per cent fat. After 30 days, the rats lost about 17 per cent of their body weight, on average. In comparison, a separate group of eight rats fed the same high-fat diet without the beads didn't lose weight, and neither did another bead-free group kept on a diet of 10 per cent fat. The rats treated with the microbeads also had less fat tissue and liver damage than the others.

The researchers also tested faeces from rats fed the microbeads. Their waste contained roughly as much fat as that of a fourth group of rodents treated with orlistat – a weight-loss drug that prevents fat absorption. This indicates the microbeads blocked fat uptake in the animals' guts, like the drug does. Yet unlike orlistat, the beads didn't cause any gastrointestinal side effects.

"One of the reasons why [orlistat] still isn't very popular is because it makes it much more difficult to control bowel movements," says Sander Kersten at Cornell University in New York. These edible microbeads could, therefore, be an appealing alternative – though they still have to be tested in humans.

"We want to develop something that works with how people normally eat and live"

A clinical trial involving 26 people is already under way. "We anticipate that preliminary data may become available within the next year," said Wu in a press release from a meeting of the American Chemical Society, where she presented these results on 21 August.

One concern is the microbeads may interfere with the absorption of fat-soluble vitamins, says Kersten. It also isn't clear whether people will find them appealing. Both these issues ultimately led to the demise of a similar approach, he says: a synthetic fat the body can't digest, called olestra, was added to some US food products in the late 1990s and early 2000s. But the product was discontinued due to low sales.

The researchers foresee adding the flavourless beads, which can be shaped into balls the size of tapioca or boba, to desserts and bubble teas. "We want to develop something that works with how people normally eat and live," said Wu. ▮

Environment

Lighter-coloured cars could mean cooler city streets

THE colour of a car can make a discernible difference in the surrounding air temperature, as dark cars absorb and emit more heat than lighter vehicles. The collective impact in a city could influence urban heat island effects.

"You know when you walk past a parked car on a hot day and feel the heat radiating off it?" says Márcia Matias at the University of Lisbon in Portugal. "That's real!"

Matias and her team measured the air temperature around one black and one white car parked outside for more than 5 hours under a clear, sunny sky with temperatures of 36°C (97°F). Their measurements showed the black car raised the local air temperature by as much as 3.8°C compared with the asphalt. Meanwhile, the white car had much smaller impacts on air temperature (*City and Environment Interactions*, doi.org/p3mb).

OLENA POLKOVNYKOVA/ALAMY

The colour of your car has an impact on urban heat

The reason for the differences is white vehicle paint reflects between 75 and 85 per cent of sunlight, whereas black paint absorbs the most, reflecting just 5 to 10 per cent. A car's thin metal skin can also heat up quickly under sunlight, unlike even very dark asphalt that is thicker and warms more slowly.

The researchers calculated repainting parked cars from dark to lighter colours could create cooler surfaces and lower near-surface air temperatures on sunny, low wind days. Using the city of Lisbon as an example, the team found the change could effectively raise street-level reflectance of incoming sunlight from just 20 per cent to nearly 40 per cent in areas where parked cars cover more than 10 per cent of the road. ▮

For more on heat effects of infrastructure, turn to page 46

Jeremy Hsu

Neuroscience

The brain doesn't actually reorganise itself after a limb amputation

Luke Taylor

THE human brain may not be as capable of rewiring following an amputation as we thought.

A part of the brain called the somatosensory cortex receives and processes sensory information from across the body, such as touch and temperature. Some studies suggest the areas of the cortex are mapped to different parts of the body, so a different bit will light up if you burn your hand or your toe, for instance.

"This idea that the brain is capable of reorganising – that the cortex can do a switcheroo – is incorrect"

It has also been suggested that the somatosensory cortex reorganises itself in the case of an amputation or severed nerve.

But Tamar Makin at the University of Cambridge and her colleagues have compared the brain activity of people before and after an amputation – and found it doesn't actually change.

The researchers used MRI to scan the brains of three people before their arms were amputated for medical reasons. During the scans, they were asked to purse their lips and tap their fingers.

When the team repeated this three and six months post-amputation and asked the participants to try moving the fingers they no longer had, their brain signals remained the same (*Nature Neuroscience*, doi.org/p3gr).

Two of the participants were also followed up at 18 months and five years, respectively, post-amputation, with neither showing any significant change to their brain signals from before.

The researchers validated their findings by first training an AI model to recognise which pre-amputation brain scans were linked to the participants moving each finger. When they returned post-amputation and imagined wiggling each finger in a random order, the model could identify from brain activity which finger they were trying to move.

TAMAR MAKIN/HUNTER SCHONE

Study participants were asked to imagine moving fingers they no longer had

In another part of the experiment, the team measured the participants' somatosensory cortex activity as they moved their lips and tried to move their fingers post-amputation. This was also done for 26 people whose arms were amputated an average of 23 years ago, and the researchers found the activity was comparable.

"This study confirms in a definitive way that this idea that the brain is capable of remapping, rewiring or reorganising – that the cortex can simply do a switcheroo – is incorrect," says John Krakauer at Johns Hopkins University in Maryland.

The researchers argue the findings could change the treatment of phantom limb pain, a common condition among people who have undergone an amputation where they still perceive pain or discomfort in an arm or leg that is no longer there. ■

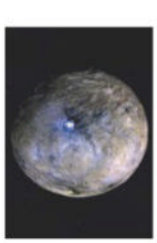
Space

Ceres may once have had the conditions to sustain life

IT MAY look cold and dead today, but around a billion years after the dwarf planet Ceres was formed, it might have had a warm interior that made it habitable.

Sam Courville at Arizona State University says he can't speculate on whether life ever arose on Ceres – but had this happened, the dwarf planet's past environment may have enabled it to survive.

Previous research has indicated there could be water ice and organic molecules on Ceres, which point towards the possibility of life. But in this study, the researchers focused on what these alien life forms would have eaten. They considered microbes like those that live in hydrothermal vents in Earth's oceans and extract energy directly from chemical molecules, rather than from consuming other organisms. Could similar microbes have survived in ancient Ceres's oceans?



NASA/JPL

Ceres's potential to support life might be replicated elsewhere

The team modelled Ceres's past on a computer, finding that when it was between half a billion and 2 billion years old, pores close to its hot core could have released fluids that then mixed with the colder water in its oceans. That process could have delivered the chemical "food" that microbes would have needed (*Science Advances*, doi.org/g9xph9).

If we want to find evidence of past or current life in our solar system, says Amanda Hendrix at the Planetary Science Institute, we should look to worlds like Ceres that have – or once had – oceans.

Strikingly, the type of microbial life support that the team identified could also have occurred on other Ceres-sized icy objects. It may mean that more of them than we expected could have been habitable.

"If Ceres was habitable in the past, then probably there are tens of asteroids and moons that were also habitable in the past. And if you can keep them hot, maybe [they are] still habitable today," says team member Joe O'Rourke, also at Arizona State University.

Habitability thus might be "a natural consequence of putting the right ingredients together, which seem to be the common ingredients in the solar system", says Courville. ■

Karmela Padavic-Callaghan

How to tackle environmental issues when the world can't agree

The requirement for unanimity hampers talks on plastic pollution and climate change – there are better ways to make progress, says **Madeleine Cuff**

ON 14 August, exhausted UN delegates filed into a windowless plenary hall, after hours of debate and little sleep, to watch their hopes of a global treaty to tackle plastic pollution evaporate.

The talks, which ran for two weeks in Geneva, Switzerland, were the second attempt to thrash out an international deal to stem the tide of this form of pollution. But at the eleventh hour, they fell apart, with countries divided on whether the treaty should include targets to reduce plastic production at source as well as measures to boost recycling rates.

Oil-producing states – which will come to rely on the plastics sector for revenue as demand for petrol and diesel wanes – opposed attempts to curb production.

Any treaty needed unanimous support to pass, and with nations refusing to budge from their "red lines", the talks collapsed.

Sound familiar? Tortuous negotiations, circular debates and total breakdowns in discussions are nothing new at environmental summits. Even when agreements are struck, they rarely do more than state the obvious.

Much of the problem lies in the requirement for unanimous consensus, says Robert Falkner at the London School of Economics, which has dogged UN climate and biodiversity negotiations since their inception. In practice, it means hundreds of nations, each with wildly different economic and political circumstances, must agree for any progress to be made.

"The consensus rule in international environmental negotiations has always been the Achilles heel of the UN environment process," he says.

In light of the latest crisis in Geneva, there is increasing despair over the diplomatic process for environmental issues. "Why would we, on environmental problems, consider ourselves to be confined only to multilateralism and consensus-based agreement among 190-plus countries? It doesn't make any sense at all," says Simon Sharpe, a former British diplomat and author of *Five Times Faster: Rethinking the science, economics, and diplomacy of climate change*.

"The consensus rule in environmental negotiations has always been the Achilles heel"

Increasingly, activists and strategists are casting about for a new approach. For Sharpe, who helped to organise the COP26 climate summit in Glasgow, UK, in 2021, this should include influential countries gathering together to accelerate decarbonisation on a sector-by-sector basis – with a focus on action, not targets. "If you want to bring about change, you have to do something," he says.

Eirik Lindebjerg at campaign group WWF Norway has much the same idea. "If 100 countries agreed on a harmonised measure like phasing out fossil cars, that would still have a massive climate impact even if there were countries that weren't a part of it," he says. "There's a strong, substantial argument, in my view, for breaking with the consensus thinking".

It is an approach inspired by the notion that the world is on the cusp of a series of positive "tipping points", where a nudge in the right direction can trigger different elements of the economy to rapidly decarbonise.

Tim Lenton at the University of Exeter, UK, author of the upcoming book *Positive Tipping Points: How to fix the climate crisis*, agrees that collaboration between smaller groups of nations could be a more effective way to accelerate the arrival of positive tipping points than relying on multilateral, consensus-based negotiation.

FABRICE COFFRINI/AFP VIA GETTY IMAGES

After weeks of debate there was no consensus on a plastics treaty

Signs of hope

"The whole point of a tipping point is a minority can ultimately tip the majority," he says. "So it makes no sense to hamstring yourself with trying to get everybody to agree on everything before anyone does anything."

Such an approach depends on having nations with economies powerful enough to drive forward a tipping point on board. With Donald Trump at the helm of the US, that is far from a guarantee.

Nevertheless, there are signs that this thinking is catching on in diplomatic circles. Privately, the Brazilian hosts of the upcoming COP30 climate summit are discussing the need for a restructuring of COPs, with a potential role for a new UN Climate Change Council that would be able to force through decisions under majority voting. Meanwhile, many in COP circles are taking China's increasing engagement on climate issues as a sign that it may take the lead in coordinating on certain issues, such as electric vehicles.

There is no denying that environmental summits have proved critical in pushing nations to agree on common strategies for tackling environmental problems. But consensus-based negotiations can only move as fast as the slowest actor in the room. With the world facing an escalating crisis spanning climate, biodiversity and pollution, it may be time to cut them loose. ▮

Health

Lesser-known food allergens pose a big risk

Christa Lesté-Lasserre

IMAGEBROKER/HILKE MAUNDER/ALAMY

Some people have serious allergic reactions to sheep milk

AROUND 1 in 7 cases of life-threatening allergic reactions seem to be caused by foods not typically labelled as potential allergens on a product's packaging.

Food allergies are becoming more common, but many official allergen lists have not been updated in years. For instance, the European Union's mandatory labelling of foods list is based on data from 2011.

To understand the lesser-known triggers, Dominique Sabouraud-Leclerc at Centre Hospitalier Universitaire de Reims in France and her colleagues analysed 2999 cases of food-induced anaphylaxis – a life-threatening reaction – voluntarily reported by doctors to the Allergy-Vigilance Network, which collects data from French-speaking countries, between 2002 and 2023.

They looked at emerging food allergens, which they defined as any foods not on the European mandatory labelling list, but which were individually responsible for at least 1 per cent of cases.

The team found goat or sheep milk and buckwheat triggered 2.8 and 2.4 per cent of cases, respectively. These were followed by peas and lentils, alpha-gal – a sugar that can trigger an allergy to red meat and other mammalian products – pine nuts and kiwifruit, which each set off between 1 and 2 per cent of incidences. Apples and beehive products like edible pollen, honey and royal jelly caused 1 per cent of cases.

Overall, emerging food allergies were responsible for 413 – about 14 per cent – of the reported cases (*Clinical & Experimental Allergy*, doi.org/p3gs).

Goat and sheep cheese provoked particularly dangerous reactions, especially in young boys, causing two deaths. Recurrent reactions and hidden exposure – such as in a sauce or as a thickener – were most common with goat or sheep milks and cheeses, followed by peas and lentils, buckwheat and pine nuts.

The team has suggested these four food types be added to the list of mandatory warning labels in the EU, which states the presence of these ingredients must be emphasised, for instance, by being written in bold on the packaging. ▮

Quantum physics

First steps towards a secure quantum internet

Karmela Padavic-Callaghan

THE US military has launched an initiative to determine how quantum devices and particles could augment traditional communication networks – like those that make up the internet – with more security.

Quantum networks that share information via particles' quantum states are extremely secure. For instance, messages carried by these states cannot be surreptitiously copied. Because of this, a number of quantum communication networks have already been built around the world.

But a fully quantum internet has been hindered because we don't know how to build some of the devices crucial for making it work. Instead of waiting for all of the outstanding questions to be answered, the US Defense Advanced Research Projects Agency (DARPA) has started a programme to identify the near-term benefits of making existing communication networks more quantum.

Above all, the agency's aim is to identify quantum additions that will be practical and useful in the near future, says Allyson

"Quantum networks will automatically have to be integrated with classical networks"

O'Brien, programme manager of DARPA's Quantum-Augmented Network (QuANET) programme.

In August, the QuANET team came together for a hackathon that culminated in a concrete demonstration: light put into a special quantum state was used to transmit images such as the DARPA logo and a simple graphic of a cat. At its best, this early test of a quantum-augmented network achieved bit rates high enough to stream high-definition video.

O'Brien says the quantum states from this demonstration are one example of a range of quantumness that the QuANET programme is exploring. Researchers are also working on "hyperentanglement", where several properties of light would be simultaneously linked via the inextricable bond of quantum entanglement. Preliminary mathematical models suggest hyperentanglement can help encode more secure information into fewer light signals, cutting down on the resources the quantum network would need.

On the other end of the spectrum, the team is exploring making light in its network not fully quantum but quantum-like. This involves endowing the light with some properties of quantum states without forcing a full fundamental change in its physical character.

QuANET researchers are also developing a quantum network interface card, which could be plugged into communication devices to allow them to transmit and receive quantum signals.

"Quantum networks are not going to solve everything," says Joseph Lukens at Purdue University in Indiana. They only excel at some tasks, and the most efficient way to run them will still include some traditional networking devices. "The future is that quantum networks will automatically have to be integrated with classical networks," says Lukens.

In his view, this makes programmes like QuANET valuable – despite questions about how to augment the internet infrastructure we already have. ▮

Space

Is Planet Y hiding past Neptune?

An Earth-sized object, distinct from the hypothesised Planet Nine, might lurk in the outer solar system

Jonathan O'Callaghan

SOMEWHERE at the edge of the solar system a new world about the size of Earth might be circling the sun, dubbed Planet Y.

Astronomers have long proposed that there might be hidden planets beyond the Kuiper belt, a region of icy objects that is home to Pluto. Some of the more famous suggestions include Planet X, a hypothesised world about seven times the mass of Earth orbiting around 50 times the Earth-sun distance – now mostly debunked – and Planet Nine, which would be 10 times the mass of Earth and at least 300 times farther from the sun than our planet and which remains a promising possibility.

Amir Siraj at Princeton University and his colleagues now propose another world, which they have dubbed Planet Y to make it distinct from the other candidates, based on a warping effect observed on the orbits of some Kuiper belt objects (arXiv, doi.org/p3gz). "If that warp is real, the simplest explanation is an undiscovered inclined planet," says Siraj.

The planet, if it exists, would have a mass between that of Mercury and Earth, and orbit at about 100 to 200 times the Earth-sun distance. It would be causing the orbits of some Kuiper belt objects to be slightly inclined out of the flat plane of the solar system, like a ripple in a lake, by about 15 degrees, with the gravity of the planet causing them to move above and below the orbital plane of most other objects.

"If the warping we see in the Kuiper belt is real, the simplest explanation is an undiscovered planet"

"Our signal is modest, but credible," says Siraj, with about a "2 to 4 per cent chance of being a fluke – early Planet Nine hints quoted similar fluke probabilities".

The warped plane hinting at Planet Y's existence is distinct from the reasoning behind the possible presence of Planet Nine, thought to be a giant world gravitationally tugging objects towards it – so both could be real. "The signature is different," says Siraj.

Jonti Horner at the University of Southern Queensland in Australia says it is "plausible" that there might be unseen worlds such as Planet Y hidden in the outer solar system. "It plays into the fact that we simply don't know what's out there. It's only in the last couple of decades that we've really started to explore the space beyond Neptune," he says, save for Pluto, which was discovered in 1930.

Worlds such as this would probably have been scattered from the inner solar system into the outer part early on, rather than forming directly out there, where material is sparser. "Scattering seems more likely," says Horner.

Our knowledge of the outer solar system is expected to dramatically shift over the next decade as the Vera C. Rubin Observatory conducts a 10-year survey of the sky. If there is a Planet Y, or a Planet Nine or other candidate planets, Rubin might be able to directly observe them.

"Rubin will rapidly expand the catalogue of well-measured trans-Neptunian objects," says Siraj. If Planet Y does exist, Rubin might well detect it "within the survey's first few years", he says, or at least find further evidence for the warping effect. ▮

Environment

Super-cool cement could stop buildings trapping heat inside

CEMENT that can cool itself by reflecting light on the outside and releasing heat from its surface could help buildings stay comfortable without needing air conditioning.

Normal cement tends to absorb infrared radiation from the sun and store it as heat, which can increase the temperature inside cement buildings as well as that of the surrounding air.

Fengyin Du, then at Southeast University in Nanjing, China, and her colleagues decided to address this by creating a cement in which tiny reflective crystals of a mineral called ettringite collect on the surface.

The team's cement emits infrared light from its surface, rather than storing it, and so loses heat quickly. "It works like a mirror and a radiator, so it can reflect sunlight away and send heat out into the sky, so a building can stay cooler without any air conditioning or electricity," says Du.

To make it, the researchers first produce tiny pellets from common minerals like limestone and gypsum. These are ground to dust and mixed with water before being poured into a silicone mould covered in small holes. Air bubbles passing through the holes create slight depressions in the cement's surface, where the reflective ettringite crystals can then grow, while an aluminium-rich gel in the set cement lets infrared light pass through the material.

This process is easily scalable, says Du, and the cement is also $5 per tonne cheaper than regular Portland cement because it can be produced at lower temperatures.

CAMIMAGE/ALAMY

Normal cement absorbs more infrared light and stores it as heat

Du and her team tested how their cement kept cool on a hot roof at Purdue University in Indiana, which jointly hosted Du's PhD project, finding that the surface temperature was 5.4°C (9.7°F) lower than the air and 26°C (47°F) lower than the Portland cement (*Science Advances*, doi.org/p3gm).

"It's a useful material," says Oscar Brousse at University College London. "You increase the reflective capacity as well as increasing the emissivity, so any energy that is captured or conducted to the material is emitted efficiently back."

However, measuring only the surface temperature of the material doesn't tell us how it will perform in the real world, says Brousse. "It doesn't mean that because the surface is 5°C lower, that the air temperature will be 5°C lower around it. The effect locally may be greatly limited." ▮

Alex Wilkins

Climate change

Earth's carbon sinks are waning due to climate feedback loops

Michael Le Page

DAVID SWANSON/AFP VIA GETTY IMAGES

Wildfires, like the ones in California this year, affect the planet's carbon sinks

CLIMATE change is increasingly affecting the ability of Earth's natural carbon sinks to soak up excess carbon dioxide, and this means more of this greenhouse gas emitted by human activity is staying in the atmosphere, leading to further warming.

These feedback effects are responsible for about 15 per cent of the increase in CO_2 levels since 1960, according to Pierre Friedlingstein at the University of Exeter in the UK.

The land and oceans have been acting as carbon sinks, soaking up nearly half of all the excess CO_2 humans have been pumping out. For instance, higher CO_2 can boost plant growth, meaning more CO_2 is taken up by vegetation. But as the world warms, extreme heat, droughts and wildfires can increasingly counteract this CO_2 fertilisation effect.

Friedlingstein is involved in the Global Carbon Project, which is trying to work out exactly how much CO_2 is being emitted, how much is absorbed by various sources and how this is changing over time. He and his team had previously used climate models to estimate that the land sink would be taking up 27 per cent more CO_2 were it not for feedbacks such as droughts.

30%

Land carbon sink reduction as a result of climate feedbacks like more drought and wildfires

15%

Amount of atmospheric CO_2 rise since 1960 due to such effects

Their latest estimate now puts it at 30 per cent, Friedlingstein told the Exeter Climate Conference in July. Meanwhile, the ocean sink would be taking up 6 per cent more CO_2 were it not for feedbacks, he said.

Put together, the land and oceans would be taking up 15 per cent more CO_2. Since the level of CO_2 in the atmosphere has risen by around 100 parts per million (ppm) since 1960, 15 ppm is due to feedback effects hitting the sinks. "The sink is not collapsing, but it is slowly [coming] down," said Friedlingstein.

The sinks have still grown in absolute terms, just not as much as they would have done otherwise, says David Armstrong McKay at the University of Sussex in the UK.

"It's broadly in line with expectations, but still not great news that it's a bit more than we thought," says McKay. "The more warming there is, the harder it gets for the land sink to keep pace with rising CO_2, as the CO_2 fertilisation effect on vegetation growth is increasingly limited by extreme events like the recent El Niño-enhanced droughts."

The big question is what happens next. There has been much concern about studies suggesting the land sink has hardly taken up any net CO_2 in the past two years because of warming-fuelled droughts and fires.

That has led to suggestions that there could be a sudden, massive decline in the relative capacity of the land sink, rather than the slow decline most climate scientists expect.

But Friedlingstein said these short-term events are "blips" that aren't necessarily the best guide to the future, as the land sink can vary a lot from year to year. "The long term is what we should be looking at," he said. ▮

Solar system

Uranus's newest moon could be the first of many more

Matthew Sparkes

URANUS now has 29 known moons, after the discovery of a small, dim satellite orbiting the planet.

The new moon was discovered by a team led by Maryame El Moutamid at Southwest Research Institute in Colorado, using 10 long-exposure infrared images taken by NASA's James Webb Space Telescope (JWST) on 2 February this year.

The moon currently has the provisional name S/2025 U 1. But in time it will probably be named along the same lines as 27 of Uranus' moons: taking a character's name from one of Shakespeare's plays. This convention dates back to the discovery of the planet's first two moons, Titania and Oberon, in 1787.

Mark Showalter at the SETI Institute, who was part of the research team, says spotting a moon so small and dim was a difficult task. "It's a tiny object right next to a very, very bright object. It's like staring into the headlight of a car and trying to look at a fly," he says.

El Moutamid says the sharpness of Uranus's rings indicates there are likely to be more moons, yet undiscovered, that helped with the rings' formation. Some of these may be found by JWST, but there could be a rash discovered by the proposed Uranus Orbiter and Probe mission in 2044 if it goes ahead.

S/2025 U 1 is estimated to be around 10 kilometres in diameter, meaning it is too small to have been seen by the cameras aboard the Voyager 2 probe. Voyager 2 launched in 1977 and passed by Uranus in 1986, coming as close as 81,500 kilometres. It remains the closest pass by Uranus by a spacecraft from Earth.

The new moon is at the edge of Uranus's inner rings, located around 56,250 kilometres from its centre in the planet's equatorial plane. This places it between the orbits of the moons Ophelia and Bianca. ▮

Health

A bespoke treatment for depression

An implanted device, likened to a pacemaker, selectively targets different areas of the brain

Carissa Wong

A MAN who had severe depression for more than three decades appears to have gone into remission, thanks to a brain "pacemaker" that selectively activates different brain networks.

Treatment resistance is common with depression; this is most commonly defined as seeing little improvement after taking at least two types of antidepressants. In such cases, zapping the brain with weak electrical pulses, like electroconvulsive therapy (ECT), may help, but can also fail to provide relief. Damien Fair at the University of Minnesota says this is because it targets the same spot in everyone's brain, yet every brain is different.

Fair and his colleagues have developed a more personalised approach for a 44-year-old man who was first hospitalised with depression at 13, and had tried 20 treatments with no lasting impact.

They scanned his brain for 40 minutes, using MRI to map out the borders of four brain-activity networks linked to depression. This revealed that his salience network, which helps process stimuli, was four times larger than typical. This may have contributed to his symptoms, says Fair.

"When they stimulated the brain-activity network involved in rumination, the man shed tears of joy"

Next, they surgically implanted four clusters of electrodes across these borders, inserting them through two small holes drilled into his skull. Three days later, the researchers sent weak electrical pulses through external wires attached to the electrodes, stimulating each of the four brain networks in isolation.

When they stimulated the first network – the default mode network, which is involved in introspection and rumination – the man shed tears of joy.

The team then attached the electrode wires to two small batteries implanted just beneath the skin around his collarbone, allowing him to experience these benefits outside of a hospital. This acts as a "brain pacemaker", says Fair, stimulating various networks of the brain for 1 minute, every 5 minutes, throughout the day.

Over the following six months, the man used an app wirelessly connected to the pacemaker to switch between various brain stimulation patterns, designed by the team, every few days. He also recorded his symptoms every day. Analysing this data every month, the team continued to optimise the stimulation until six months post-surgery.

By seven weeks post-surgery, the man stopped reporting having suicidal thoughts. By nine months, he had gone into remission, defined according to the Hamilton depression rating scale (PsyArXiv, doi.org/p3bp). This improvement remained for more than two and a half years, except for a brief period when his symptoms slightly worsened after catching covid-19.

A randomised controlled trial, where people with depression are randomly assigned to receive the stimulation or a placebo, is needed to verify this approach, says Mario Juruena at King's College London. The team hopes to do this within the next two years, says Fair. ▮

Need a listening ear? UK Samaritans: 116123; US 988 Suicide & Crisis Lifeline: 988.

Physics

Flower-like origami patterns unfold in one smooth motion

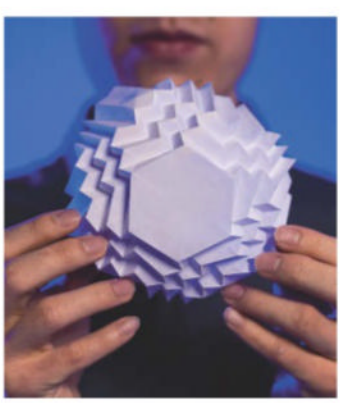
ORIGAMI shapes that unfold like flower petals could be used to design more effective structures in space, such as telescopes or solar panels.

Origami structures, based on the Japanese paper-folding art, are used by engineers because they can be stored compactly but then opened up into much larger shapes. However, these origami patterns can't always be easily packed away and are often complex to unfold, where one failed step can prevent the entire structure from deploying.

Now, Larry Howell at Brigham Young University in Utah and his colleagues have found a new family of origami shapes they call bloom patterns that unfold in one smooth motion to create a bowl-like structure, resembling a flower. "We're able to make new things that have never been done before, but then, at the same time, we're creating these beautiful shapes," says Howell.

Although a few instances of bloom patterns were previously known to origami enthusiasts and researchers, Howell and his team realised they belonged to a larger class of shapes with common features: a polygon centre surrounded by identical, symmetric creases that unfolds in one smooth motion from a flat, thin disc to a much larger, curved, three-dimensional shape.

After classifying different variants of bloom pattern and coming up with a mathematical explanation for how they worked, the researchers built functioning versions using materials of different thickness, like plastic or thick acrylic panels, and showed that each shape always unfolded reliably (*Proceedings of the Royal Society A*, doi.org/p3bh).



AARON CORNIA/BYU

New shapes called bloom patterns can create bowl-like structures

Being able to unfold in one go could be an advantage for space structures because it reduces the chances of a misfold ruining the entire procedure, says Michael Bartlett at Virginia Tech. "Everything has to go right. If there's a weak link in the chain, the whole thing fails," he says. "When I watch these [bloom patterns] unfold, you can see that it doesn't necessarily have to do one thing after another for it to reach its maximum deployment."

Space telescopes are often forced to use relatively flat mirrors for their observations, but the bloom patterns' curved shapes could be used to deploy dishes more like some Earth-based telescopes, which produce more accurate images, says Howell. ▮

Alex Wilkins

Physics

A new way to measure electricity

What previously required two separate quantum devices could now be done with one

Karmela Padavic-Callaghan

A SINGLE quantum device could define all three units we use to understand electricity.

When you measure electricity, you need to find the flow's current in amperes, its resistance in ohms and its voltage in volts. But before even getting started, researchers must agree on the size of each of these units. So far, this has required two separate quantum devices. Unlike classical devices, they relate the units to fundamental physics constants, but using two often landed researchers with the costly and complicated task of visiting separate laboratories.

Now, Jason Underwood at the National Institute of Standards and Technology (NIST) in Maryland and his colleagues have shown how we could instead characterise these units using a single device. "The idea of integrating those two quantum standards was always sort of a holy grail," he says. "It's been a long time coming. Like Sisyphus, we just kept pushing the rock up the hill."

This integration was challenging because both devices rely on fragile quantum phenomena that can only be observed at very low temperatures – so low they must be operated in special fridges called cryostats. Traditionally, one device also required a magnetic field that disrupted the operation of the other.

"It's been a long time coming. Like Sisyphus, we just kept pushing the rock up the hill"

The new "one box" method sidesteps this issue by using a novel material that can perform its quantum tricks without the magnetic field, so two quantum systems that previously had to be kept separate can operate in the same cryostat. The team used it to obtain amperes, ohms and volts with uncertainties as small as a few millionths of each unit (*Nature Electronics*, doi.org/p27b).

Before researchers can use the combined device in practice, however, its accuracy must be increased further. For now, it is limited by how the two systems and their wiring heat each other up when they are put side-by-side. Plus, work is ongoing to perfect the still "juvenile" quantum material that enables the two systems to work together, says Linsey Rodenbach at Stanford University.

Though he sees the project as an unqualified success, Underwood says another thing that prevented the team from reaching even higher accuracies were the poor conditions at NIST, which is funded by the US government. He noted the institution's "crumbling infrastructure", as described in a 2023 study that found multiple NIST buildings are deteriorating. NIST declined to comment.

Susmit Kumar at the Norwegian Metrology Service says the new device is an "impressive engineering achievement" that could make quantum electrical standards more cost-effective and easier to access for scientists and technology developers across the world. He is part of the QuAHMET consortium, which is also using novel materials to develop an easier-to-use device for determining the ohm.

"The international system of units is a common language that all scientists and engineers use. You want to make that as useful as possible," says Richard Davis, who is retired from the International Bureau of Weights and Measures. He says efforts to unify different devices that are currently in use are bound to accelerate going forward. ▮

Entomology

Artificial superfood for bees boosts colony reproduction

AN ENGINEERED supplement that provides essential nutrients for bees results in colonies producing many more larvae, suggesting it could help tackle the global decline in honeybees.

Bees need to eat pollen from a range of flowers to get the nutrients they need, including essential lipids called sterols. But due to climate change and industrial agriculture, the environments they live in often lack the floral diversity they need to survive.

"We need more bees to do pollination for crops, and there is less food for them," says Geraldine Wright at the University of Oxford.

SHUTTERSTOCK/MOHD NOOR ROMADHON

Bees don't have access to as much pollen due to climate change and industrial agriculture

To address this, beekeepers are increasingly feeding bees artificial pollen substitutes. But commercial supplements – usually made of protein flour, sugars and oils – lack the right sterol compounds, making them nutritionally incomplete.

Using CRISPR gene editing, Wright and her colleagues engineered the yeast *Yarrowia lipolytica* to produce a precise mix of six key sterols that bees need. The yeast was incorporated into diets fed to bee colonies during three-month feeding trials in enclosed glasshouses.

By the end of the study, colonies fed with sterol-enriched yeast had reared up to 15 times more larvae to the stage of viable pupae, compared with colonies that received a typical commercial bee feed.

Colonies fed the sterol-enriched diet were able to keep producing eggs and larvae right up to the end of the 90-day period, while colonies on sterol-deficient diets had largely stopped brood production before the end of the study (*Nature*, doi.org/p3f2).

"Our technology allows beekeepers to feed bees in the absence of pollen," says Wright. "When incorporated into a pollen substitute that's been optimised for all other nutrients, the bees will be healthier and produce stronger, longer-lasting colonies."

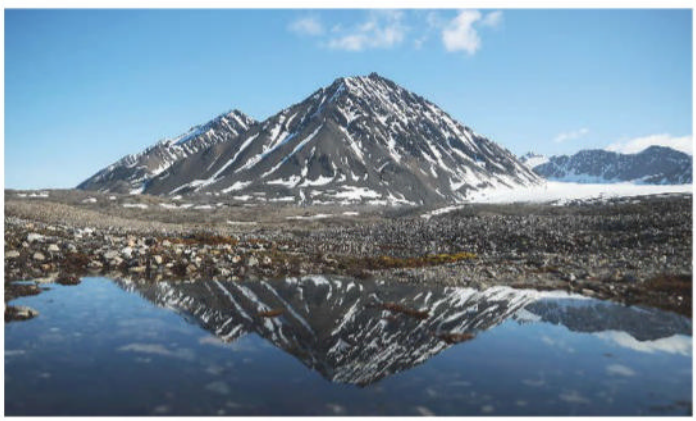
The yeast could also be used to engineer essential nutrients for other farmed insects, which are increasingly important food sources for humans and livestock, says Wright. ▮

Graeme Green

Climate change

Arctic heat causes huge Svalbard ice loss

Michael Le Page



XINHUA/SHUTTERSTOCK

The Arctic archipelago of Svalbard lost around 62 gigatonnes of ice last summer

DURING the summer of 2024, six weeks of extreme heat led to a record-obliterating amount of ice melting on the islands of Svalbard in the Arctic. By the end of the summer, 1 per cent of all the land ice on the archipelago had been lost – enough to raise the global average sea level by 0.16 millimetres.

"It was not just a marginal record. The melt was almost twice as high as in the previous record," says Thomas Schuler at the University of Oslo in Norway.

More than half of Svalbard is covered in ice. Winter snowfall adds to the ice, while the flow of glaciers into the sea and surface melting during summer leads to ice loss.

Schuler's team has been using a combination of on-site measurements, satellite data and computer modelling to estimate how the total mass of ice on the archipelago is changing.

Since 1991, less than 10 gigatonnes of ice has melted during each summer, on average. But four of the past five years have set new records for summer ice loss. Altogether, the team estimates that around 62 gigatonnes of ice were lost last summer, almost entirely due to surface melting rather than ice flow into the sea.

Schuler and his colleagues also measured the land rising in response to ice loss by a record 16 mm at one site during the summer of 2024, which is consistent with their estimate for the ice loss (*PNAS*, doi.org/p27k).

The exceptional melting was due to record air temperatures, with a mean August temperature of 11°C (52°F), compared with around 7°C (45°F) in recent decades. This extreme event was, in turn, the result of warmer seas and a persistent weather pattern that brought warm southerly winds, on top of big jumps in global warming.

While this kind of extreme summer heat is unusual at present, climate models suggest it will become common as the planet continues warming. Even in a low-emissions scenario, more than half the summers between now and 2100 could exceed this level.

Schuler's team hasn't yet estimated how much ice will be lost in the future in various emissions scenarios. Winter snowfall is expected to rise as the atmosphere becomes moister, but not by enough to compensate for much greater summer melting. ▮

Health

Covid-19 may make women's arteries stiffer

Luke Taylor

CATCHING covid-19 seems to accelerate the ageing of blood vessels, but perhaps only among women.

The infection has previously been linked to cardiovascular complications, like heart disease, but how it has this effect isn't entirely clear. To learn more, Rosa Maria Bruno at the Université Paris Cité in France and her team recruited 2390 people, aged 50 on average, from 16 countries – including the UK and the US – between September 2020 and February 2022.

Some of them had tested positive for SARS-CoV-2, the virus that causes covid-19, or had antibodies against it despite not being vaccinated, a sign that they had been infected. The others had only ever tested negative for the virus and had no signs of prior infection.

The health of their arteries was assessed by measuring how fast a pressure wave passed between the carotid artery in their neck and the femoral arteries in their legs. This is a measure of artery stiffness, which increases naturally with age, with less flexible arteries raising the risk of heart disease.

"There is something measurable in the blood vessels that corresponds to long covid"

The researchers found that among the women in the study, a known SARS-CoV-2 infection was linked to stiffer arteries (*European Heart Journal*, doi.org/g9xb25). This also seemed to increase with the severity of their infection. For instance, women who were hospitalised with covid-19 had a vascular age around five years older than their uninfected counterparts, rising to 7.5 years among those admitted to intensive care.

The researchers controlled for other factors that can influence artery stiffness, such as smoking and obesity.

But none of these effects occurred among the men. Previous research suggests that women react more strongly to infections than men and are less able to dial down their immune response, which could lead to damaging inflammation. Bruno says she was expecting to see some difference between the sexes, but not this much.

The findings could shed some light on long covid, which seems more common among women. At a six-month follow-up, the stiffness of the women's arteries had improved slightly, but was still particularly high among those with lingering covid-19-related complications. "Here we have demonstrated there is something measurable in the blood vessels that corresponds to the symptoms of long-covid patients," says Bruno.

It is possible that some of the people in the uninfected group may have unknowingly had a mild infection, affecting the validity of the results.

Nevertheless, Vassilios Vassiliou at the University of East Anglia in the UK says this could help identify people with long covid. "The study is the first large international multicentre investigation to demonstrate that covid-19 is associated with accelerated vascular ageing," he says. "The findings may also contribute to a better mechanistic understanding of post-covid-19 syndrome, potentially paving the way for targeted pharmacological interventions." ▮

Environment

Rare weather pattern may explain why 2023 was so hot

Madeleine Cuff

AN UNUSUAL "triple dip" La Niña weather pattern that suppressed ocean temperatures in the Pacific for three years may have primed the planet for the dramatic surge in heat experienced in 2023.

While global temperatures had been expected to increase around this time, due in part to greenhouse gas emissions and warm surface waters in the Pacific, they weren't anticipated to peak until early 2024. As it was, record-breaking heat emerged from September 2023, months ahead of schedule.

Julius Mex at the University of Leipzig in Germany and his colleagues set out to explore what exactly happened in late 2023 to trigger the onset of this extraordinary heat.

"What we're trying to explain is why the change in temperature in [northern hemisphere] fall was so extreme," he says.

The researchers used datasets that combine historical weather observations with climate models to investigate circulation, temperature, cloud cover, radiation and precipitation in the Pacific during 2022 and 2023.

KEVIN CARTER/GETTY IMAGES

Changes in the Pacific Ocean could have driven rising temperatures

A dramatic shift

They conclude that the background state of the Pacific, which unusually had been stuck in cooler La Niña conditions since 2020, was a key factor. That suppressed ocean heat and encouraged the development of low-lying clouds, helping to reflect more of the sun's radiation back into space.

When the El Niño weather pattern finally emerged in 2023, the swing from La Niña to El Niño was so dramatic that it produced unusual effects on air circulation and rainfall over the western Pacific, allowing the ocean to release even more heat than anticipated into the atmosphere.

In parallel, the shift to El Niño also triggered a sudden and dramatic fall in cloud coverage in the eastern Pacific, allowing Earth to absorb much more radiative heat (*Research Square*, doi.org/p27h). "This is something that can drive the annual temperature change," says Mex.

Karsten Haustein, also at the University of Leipzig, wasn't involved in the work but says he broadly agrees with the analysis. "If you have a triple dip La Niña, then you are not allowing the ocean to release heat," he says. "So you build up heat deeper in the ocean basin, and eventually it has to come out."

Mex says the findings are in line with research published in recent months suggesting the disappearance of ocean cloud cover was a key driver of the rapid jump in temperatures beginning in 2023. "I think it's a perfect fit," he says.

Richard Allan at the University of Reading in the UK says the work improves understanding of how cloud cover changed in the Pacific during 2022 and 2023. But he stresses that human-caused climate change, alongside cuts to planet-cooling aerosol pollution, were also major factors in reducing ocean cloud cover and driving warming.

> "Heat builds up deeper in the ocean basin and eventually it has to come out"

"The size of the global temperature rise in 2023 was only possible due to the rising overall heating of the planet caused by rising greenhouse gases, but also reducing and dimming clouds related to the warming and also declining aerosol particle pollution," says Allan. ▮

Health

Radio-wave treatment passes the smell test

Matthew Sparkes

BEAMING powerful radio waves directly into a person's head seems to improve their sense of smell – at least temporarily.

Ageing, trauma and some neurological conditions can all affect the olfactory nerve, which enables smell, reducing or even eliminating the sense entirely.

"Unlike other medical fields where therapeutic devices have advanced rapidly, treatment in this area has remained relatively traditional," says Yongwoo Jang at Hanyang University in South Korea.

Jang and his colleagues wanted to directly stimulate the olfactory system, but because it lies deep inside the human head, they were unable to use electrical stimulation, so instead turned to radio waves.

The scientists first recruited 28 people with no smell issues. For 5 minutes, these participants were exposed to 15 watts of power, emitted from a 5-centimetre-square antenna attached to a mount located 10 cm from their head. "The stimulation itself is not directly perceived by the patient," says Jang. However, if it continues for some time, they may experience a mild warming sensation at the site of the stimulation, he says.

Sense of smell was assessed via the commonly used Sniffin' Sticks smell-threshold test. This involved the participants trying to detect the presence of the alcohol n-butanol, produced in the fermentation of sugars, at varying dilutions.

The researchers found that the participants scored significantly better after the radio-wave treatment than they did before, with this improvement lasting for around a week (*APL Bioengineering*, doi.org/g9xhdp). People with smell issues may need recurring treatment, says Jang.

The researchers are now preparing to test the approach on people with olfactory problems. ▮

Artificial intelligence

AI model can predict solar flares

Knowing the sun's future appearance may alert us to impending space storms

Jeremy Hsu

NASA and IBM have trained an artificial intelligence model that can forecast what the sun will look like hours into the future – even predicting the appearance of solar flares that may warn of dangerous space weather for Earth.

"I love to think of this model as an AI telescope where you can look at the sun and you can understand the moods," says Juan Bernabé-Moreno at IBM Research Europe.

The sun's moods matter because outbursts of solar activity can bombard Earth with high-energy particles, X-rays and extreme ultraviolet radiation. These can disrupt GPS and communications satellites, and potentially harm astronauts and even people on commercial airlines. Solar flares can be followed by coronal mass ejections, which may disrupt Earth's own magnetic field and create geomagnetic storms capable of knocking out power grids.

Bernabé-Moreno and his colleagues at IBM and NASA trained an AI model called Surya, after the Sanskrit word for sun, on nine years of data from NASA's Solar Dynamics Observatory. The satellite captures ultra-high-resolution images of the sun in 13 different wavelengths. The AI model learned to identify patterns in the visual data and generate images of what the sun would look like from the observatory's point of view in the future.

When tested on historical solar flare data, the model predicted the occurrence of a solar flare within the next day with 16 per cent better accuracy than a standard machine learning model. It could also generate the visual image of a flare the observatory would see up to 2 hours in the future.

"The power of AI is that it has the ability to learn the physics in a more roundabout way – it kind of develops an intuition for how the physics works," says Lisa Upton at Southwest Research Institute in Colorado.

"I love to think of this model as an AI telescope where you can look at the sun and understand the moods"

Upton says she is especially interested in whether the Surya model can help predict solar activity on the far side of the sun and at the poles, where NASA's scientific instruments can't make direct observations. Surya does not explicitly attempt to model the far side of the sun, but it has still proved successful in predicting how the sun will look several hours in the future, when part of the far side has rotated into view, says Bernabé-Moreno.

But it is unclear whether the AI model can address existing challenges in predicting exactly how solar activity may impact Earth, says Bernard Jackson at the University of California, San Diego. That is because there is currently no way to directly observe the magnetic field configurations between the sun and Earth, which is what determines the paths of the high-energy particles travelling outward from our star.

Bernabé-Moreno says the model is currently intended for scientists, but future integrations with other AI systems that can harness Surya's capabilities to answer basic questions about future solar activity might make it more accessible to power grid operators or satellite constellation owners as part of an early warning system. ▮

Microbiology

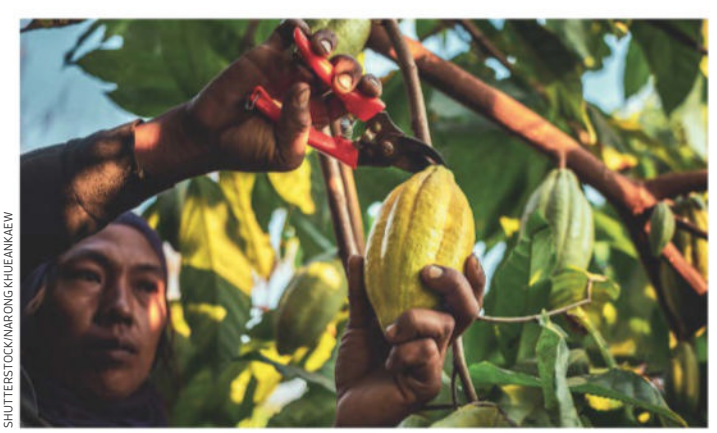
The tiny secrets behind chocolate's finest flavours

WE COULD soon taste new kinds of chocolate after the discovery of fungi and bacteria that produce fruity and caramel notes from cocoa beans.

Chocolate is typically made by fermenting cocoa beans from the fruit of cacao trees, drying them, roasting them and then grinding them up into a paste that is separated into cocoa butter and cocoa solids. These are then mixed with other ingredients to produce dark, milk or white chocolate.

During the fermentation step, microbes that come from the surrounding environment digest parts of the cocoa fruit and produce various molecules that contribute to chocolate's flavour. In most cases, this yields dark, woody flavours, says David Salt at the University of Nottingham, UK. But finer chocolate also has fruity flavours, he says.

To find out which microbes may produce such flavours, Salt and his colleagues collected samples of fermenting beans from cocoa farms in Colombia. By analysing genetic material in the samples, they identified five bacteria and four fungi that were consistently found in batches of beans that produced fine-flavoured chocolate (*Nature Microbiology*, doi.org/p27q).



SHUTTERSTOCK/NARONG KHUEANKAEW

The fruit of cacao trees is affected by microbes in the surrounding environment

The team then took cocoa beans that were sterilised to carry no other microbes and used the nine microbes to ferment them, before grinding the beans into a liquid, known as a cocoa liquor. A handful of chocolate-tasting experts assessed the liquor and found it had various fruity notes that weren't present in liquors made from beans without these microbes.

Salt says that adding these microbes to fermentation mixtures could help cocoa growers improve the flavour of their product.

However, the set of microbes that produces fine flavours may differ in cocoa farms beyond Colombia, where the climate may alter which ones thrive. Further studies are needed to explore this, says Salt. ▮

Carissa Wong

~~DISCARD~~

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Views

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Faking it

Why do we love fake lips, but hate fake meat? This inconsistent attitude has implications for sustainability, says **Sophie Attwood**

IN A twist of modern consumer psychology, we are now comfortable injecting synthetic substances into our faces, yet bristle at the thought of putting them in our mouths.

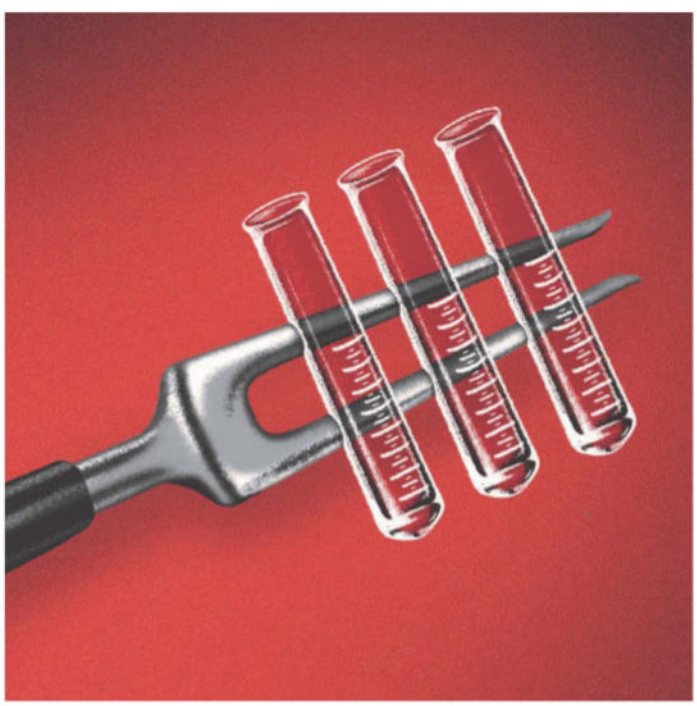
The cosmetics industry is booming. Dermal fillers and wrinkle-smoothing neurotoxins have become routine maintenance, with the injectables market set to more than double by 2030.

Jewellery, meanwhile, has undergone its own synthetic revolution. Lab-grown diamonds, once dismissed as tacky, now claim a growing market share, pushing natural gem sales into decline. Luxury consumers, it seems, are fine with "fake" as long as their sparkle is real.

But while we embrace synthetics when it comes to beauty, we continue to draw the line at our lunch. Alternative proteins, from plant-based fake meat to cultivated meat, struggle for public acceptance despite clear benefits: far lower greenhouse gas emissions, no animal welfare issues and potential reductions in antibiotic resistance.

One explanation for this is our peculiar reverence for "natural" as shorthand for purity, authenticity and safety. This preference is known as the "naturalness bias" in psychology and it underlies why we recoil from "synthetic meat" even when it is arguably less risky than industrial farming.

This preference isn't irrational so much as archaic. For early humans, avoiding unfamiliar foods was a survival tool, as a strong disgust response protected us against ingesting contaminated food. But our instincts haven't kept pace with innovation and what is now considered the "natural" choice may be the one carrying significant risk, from hormone-laced beef to the heavy environmental toll of animal agriculture.



ELAINE KNOX

Food, unlike gems or cosmetics, continues to trigger a visceral reaction, and this poses a real problem. If we are to meet the protein needs of a global population approaching 10 billion by mid-century, food innovation isn't a choice, but a necessity. Livestock farming's land, water and emissions footprint is unsustainable at scale. Cultivated meat and precision fermentation – bioengineering microbes like yeast to produce protein – are viable alternatives, but consumer scepticism, fuelled by outdated, naturalistic fallacies, is slowing their adoption.

This resistance isn't about taste or health. Blind taste tests show plant-based proteins can match meat's sensory profile, often with equal or better nutrition. Nor is it strictly economic: costs for alternative proteins, especially plant-based ones, are falling. The real obstacle is psychological – our fear of technology and the new.

One way forward is transparency: explaining alternative protein production processes to consumers and linking these to familiar ones like cheese-making or beer-brewing. Framing alternative proteins as evolutions of tradition, not radical departures, can help build trust.

Equally, we must be willing to puncture the myth that meat, as it is consumed today, is somehow "natural". A typical supermarket pack of sausages is the result of a long process involving feed additives, pharmaceuticals, genetic selection and industrial slaughter. If we are squeamish about the word "synthetic", we might do well to consider what conventional meat production actually entails.

Our bias towards the natural once kept us alive. Now it may be preventing us from embracing the very technologies that are essential to our long-term food security, environmental stability and even public health. After all, if we have welcomed synthetics into the intimacies of our lives and our bodies as anti-ageing injections, lip filler and lab-grown diamonds, perhaps it is time to extend that pragmatism to our plates. ▮

Sophie Attwood is a behavioural science consultant at Behavior Global, UK

Future Chronicles

Seeing further By the 2070s, advances meant an optical telescope with an effective mirror size of 3000 km could be built on the moon. **Rowan Hooper** investigates

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

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

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

THE All-Seeing Eye, which came into operation in the 2070s, was by far the largest and most powerful optical instrument ever built. Comprising eight telescopes built across the entire lunar surface, each with a 100-metre-diameter mirror, the effective aperture of the full, composite telescope was the size of the entire surface of the moon, enabling an unprecedented imaging ability.

For the first time, we could see the fabled "first light" – the birth of the first stars in the universe. We could also see surface features of exoplanets many light years away.

Several proposals had been made in the 2020s for ambitious, next-generation telescopes, but the capacity for large space-based projects wasn't then in place. By the 2050s, however, transport to the moon had become routine and affordable, and construction on the lunar surface was well under way.

This was when an old 2020 proposal for what was called the Ultimately Large Telescope (ULT), with a 100-metre-diameter mirror, was dusted off and updated.

The ULT relied on a mirror made not of glass, but of liquid. Liquid was cheaper to transport to the moon and easier to construct and form into a perfectly reflective surface. In the lower gravity of the moon, it was possible to build a much larger mirror than on Earth or even in space, where anything larger than 10 m in diameter caused alignment headaches. The James Webb Space Telescope, which became operational in the 2020s, had a 6.5 m-diameter mirror.

On its own, a single ULT on the moon was powerful, but not quite powerful enough to resolve features and physical structures, such as buildings, on exoplanets. No matter: cunning astronomers had built the ULT with expansion in mind.

To increase its reach, a clever method used for radio telescopes, called very-long baseline interferometry (VLBI), was adapted for use in optical systems. VLBI had been used in 2017 by the Event Horizon Telescope collaboration to capture the first image of a supermassive black hole at the centre of our galaxy. The EHT worked by combining inputs from eight telescopes on Earth to increase the effective size of the telescope.

In 2025, scientists led by Zixin Huang at the Centre for Engineered Quantum Systems at Macquarie University in Australia worked out a way to use VLBI for optical telescopes. It took some years for technical, political and financial hurdles to be cleared, but serious plans to build a moon-sized optical telescope were drawn up in 2050 as the first 100 m-diameter telescope took shape in a crater on the lunar surface.

"The telescope on the lunar surface saw back 13 billion years and imaged high-mass, first-generation stars"

By 2075, seven more such telescopes had been constructed across the moon. Linked together, they formed a telescope with an effective mirror size of 3000 km.

In the mid-2020s, the James Webb had reached back in time to see the formation of the first galaxies. Now, the completed All-Seeing Eye revealed a near-mythical population of stars called population III. Stars are classified into various groups. Population I includes recent stars with an abundance of heavier elements, also known as high metal content, such as the sun in the Earth system. Population II stars are old and low in metal content, while population III stars are the first formed after the big bang, with low to no metal content. The big bang only created hydrogen and helium, and traces of lithium and beryllium; all the other, heavier elements needed stars to be forged. The All-Seeing Eye saw back 13 billion years and imaged high-mass, first-generation stars. One such giant early star, a blue gargantuan 100,000 times the mass of the sun, was named Zixin-1 after the astronomer who had done so much to develop optical VLBI.

The concept of a moon-sized telescope itself had gone by a number of names. Originally, in 2008, a team at the University of Arizona proposed the Lunar Liquid-Mirror Telescope, which became the Ultimately Large Telescope in 2020. The public, however, complained that the names of these and previous telescopes (the Extremely Large Telescope, the Thirty-Metre Telescope) were too boring. To avert the choice of Moony McMoonFace, the All-Seeing Eye was selected as the official name. The project became known by the unofficial nickname SAURON: super-accessible ultra resolution optical network.

The facility enabled the imaging of black holes in greater detail than ever before, but its primary aim was to discover whether humans are alone in the universe. The structures revealed on exoplanet Gliese 667Cc, about 22 light years from us, and some of the planets in the TRAPPIST-1 system, about 40 light years away, suggested alien civilisations had evolved in our cosmic backyard. The arguments that some had raised about the cost of building SAURON were never heard again. ▮

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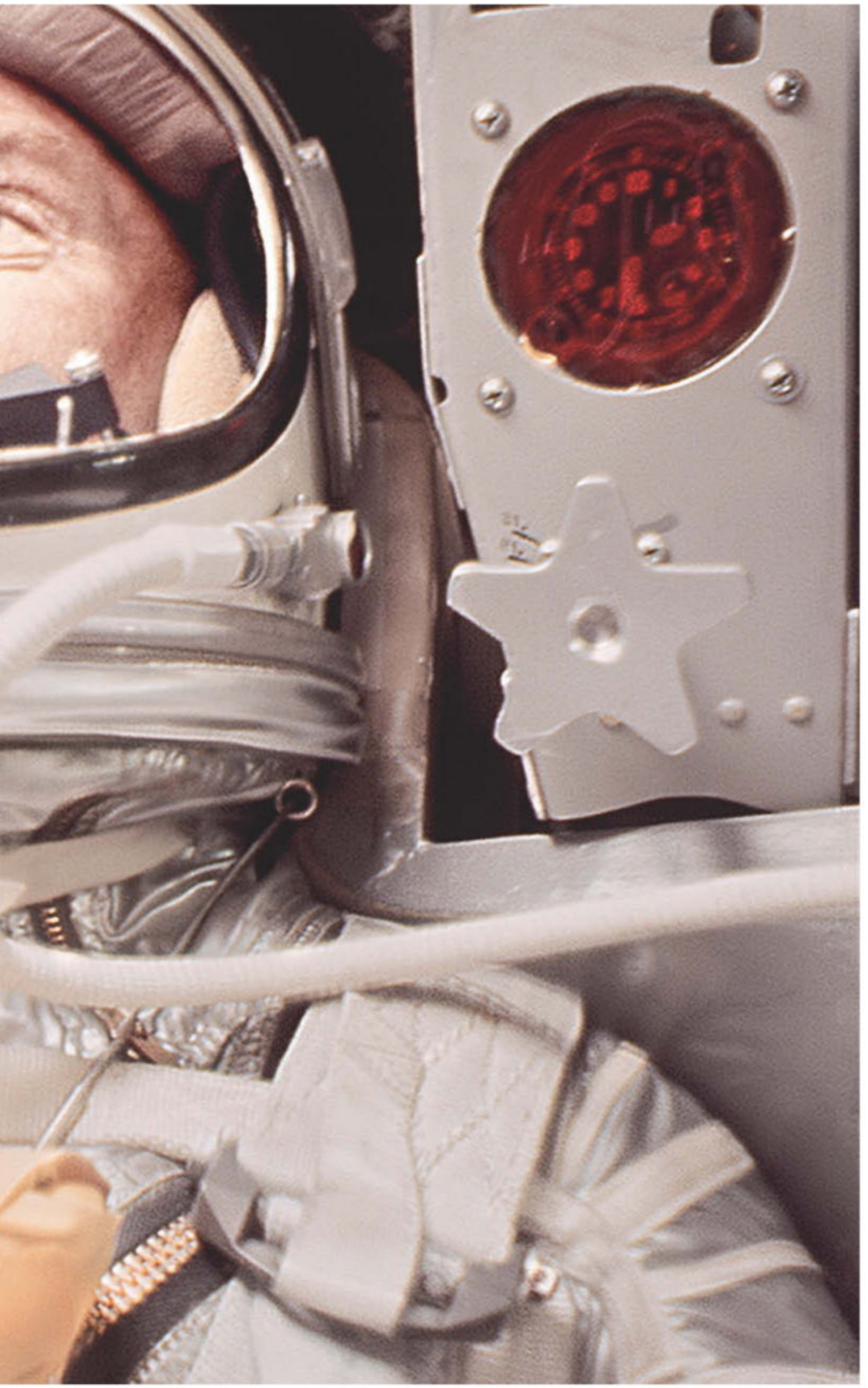


Up in the air

Andy Saunders
Particular Books

ON 20 February 1962, NASA astronaut John Glenn became the first American to orbit Earth, but there were signs of trouble. As Glenn's Friendship 7 spacecraft returned from its historic flight, a warning light indicated its heat shield had unlatched, risking complete incineration. This image (left) captures Glenn at the moment he reenters Earth's atmosphere, pieces of the burning spacecraft casting a fiery orange glow on his face.

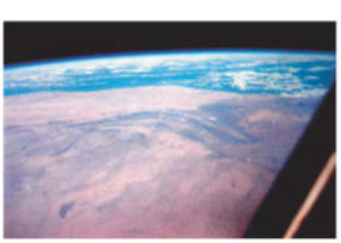
Fortunately, Glenn splashed down safely in the Atlantic Ocean minutes later. A faulty switch in the heat shield circuit was to blame for the alarm.

The image is featured in a new book, *Gemini and Mercury Remastered*, which celebrates these early NASA missions through masterfully restored photographs and film stills.

Another significant moment came earlier in the flight, when Glenn used a camera he had purchased from a shop near the launch site in Cape Canaveral, Florida, to snap the first photograph taken by a human in space (below). Later photos by astronauts showed Earth in unprecedented ways, and NASA realised the scientific and public value of such space photography.

Gemini and Mercury Remastered by Andy Saunders, who restored the NASA images himself, is out in the UK from 28 August.

David Stock



The ultimate takeover

Why did Christianity grow from an eastern Mediterranean sect to a religion followed by billions? **Michael Marshall** explores Alice Roberts's latest book

Book
Domination
Alice Roberts
Simon & Schuster

SAM PELLY/MILLENNIUM IMAGES, UK

Some two millennia on, Christianity is still a dominant religion

ALICE ROBERTS's latest book is something of a left turn. In her previous works *Crypt* and *Buried*, she fused expertise in osteoarchaeology – the study of preserved human bones – with more traditional historical approaches, such as the analysis of ancient texts. Technical science was interwoven with empathic and thoughtful discussions of the historical record as she aimed for, and often achieved, nuanced, three-dimensional portraits of past human lives and cultures.

In *Domination: The fall of the Roman Empire and the rise of Christianity* there is virtually no osteoarchaeology. The focus is much more on historical documents. That isn't a criticism – Roberts is a careful and curious reader of history – but it just might take some fans by surprise.

Roberts's topic here is the rise of Christianity from humble eastern Mediterranean sect to a religion with billions of adherents. How and why did it become dominant, when most faded away?

At the centre of the narrative is the Roman Empire. When Christianity emerged, the empire controlled almost all the lands around the Mediterranean, from Britain all the way to Syria. The Romans had many gods, but Christianity gradually became more popular. There are several obvious turning points. One was when Constantine I, who ruled from AD 306 to 337, decriminalised Christianity (and supposedly converted, but Roberts points out gaps in the evidence on that front). Another came when Theodosius I, who reigned from AD 379 to 395, made Christianity the state religion.

Roberts is sceptical about traditional explanations for this: that the ideas of Christianity were especially appealing, say, or that its followers were more dedicated. Such claims, she argues, are little more than Christian propaganda.

"The eternal truth is not theological: gods come and go, temples rise and fall – but business is always business"

Instead, Roberts says the real secret to Christianity's success is how swiftly it penetrated the upper echelons of Roman society. Jesus may have hung out with lepers and sex workers, but the evangelists who followed in his wake targeted moneyed Romans, soldiers and the educated elite. This recruitment effort succeeded wildly. "Early adopters were to be found, not among the rural, or even the urban, poor of the Empire – but among the urban middle and upper classes," writes Roberts.

In the following decades and centuries, the church acquired a portfolio of moneymaking enterprises. As Roberts writes, "peel away the religious overlay and what you're left with is a huge, sophisticated system of interconnected businesses: welfare, health, legal, agribusiness, shipping, education".

The church also took on many state functions, especially charitable efforts directed at poverty. However, it did so in a way that looks distinctly cynical. "Christian charity," writes Roberts, "was never intended to solve the problem of poverty." Instead, it enabled the church to market itself to all levels of society: "The poor were to be told that they would reap rewards in heaven. The rich were to be told that the only way they'd get to heaven was by donating to the Church."

This was a system built on steep social inequality. One can't help but compare it to modern billionaires' philanthropy.

Eventually, the entire Roman socioeconomic system was reorganised around the church, says Roberts. Elite, educated Romans pursued church careers, in part because they were lucrative.

When the Western Roman Empire collapsed, this elite aligned themselves with the new regimes but kept the system intact, and often retained their positions. "Whatever the rhetoric, whatever spiritual messages were being adduced, the entity as a whole is looking very much like Roman business, Roman society as usual," writes Roberts. "The eternal truth is not theological: gods come and go, temples rise and fall – but business is always business."

Domination is a little hard going at first: there are a great many names to keep track of, and the narrative jumps around in space and time. Everything shifts up a gear, however, once Roberts's argument comes into focus. The result is an incisive, provocative and sometimes polemical account of one of the most important organisations in human history. ▮

Michael Marshall is a writer based in Devon, UK

Compounding factors

The history of carbon dioxide's role in life on Earth combined with a call to climate action makes for compelling reading, finds **Chris Stokel-Walker**

Book

The Story of CO_2 Is the Story of Everything

Peter Brannen

Allen Lane

CARBON dioxide consumes our thoughts – and rightly so. Its emission from power plants, car exhausts and the burning of natural habitats is making our world warmer and warmer – a fact seriously exercising the minds of politicians and policy-makers who must address global warming.

CO_2, comprising one carbon atom joined to two oxygen atoms, facilitates life on Earth. But rising levels of CO_2 are now fuelling global warming, and helping threaten that life. This is the paradox examined by Peter Brannen in *The Story of CO_2 Is the Story of Everything: A planetary experiment*, a book that is both comprehensive and compelling.

Brannen is a science journalist who has previously written about Earth's past big five mass extinctions. This time, he has taken on a heroic task: trying to turn a subject (the carbon cycle, and CO_2's role as a vehicle driving it) that left many people disengaged at school into an engaging story of the entire history of our planet.

It would be easy to get bogged down in the periodic table, or to lose readers with dull tales of atmospheric currents or the like. But Brannen deftly weaves his narrative, bringing to life the story of CO_2 and its importance to all life forms. Worlds practically unimaginable to the reader because of their remoteness hundreds of millions of years ago are vividly described, such as "Snowball Earth", the 56-million-year phase in which the world was "imprisoned in ice sheets".

We learn, as we did at school, that wood is carbon. But Brannen goes further, adding that so, too, are "the psychedelics in mushrooms; the spice in peppers; the caffeine in coffee". Many authors might stop there, but Brannen goes on: carbon is "your eyeballs; the petals of a bougainvillea… the baleen, blubber, and brain of a blue whale… the scum on your bathtub; the mane of a lion".

These rhetorical flourishes could easily collapse under their own weight, but Brannen argues their case earnestly and elegantly. The biggest compliment I can pay this book is that it regularly evokes a kind of child-like wonder – and does so for a subject that is so completely woven into our everyday life that we take it for granted.

But this is no book for children. Alongside the history of our planet, our people and the plants and animals with which we interact (and those that have long since gone extinct), Brannen uses historical insights to make a call for action now, to wean ourselves off fossil fuels

Our actions in adding CO_2 to the atmosphere are eerily similar to those that resulted in the last mass extinction, he writes throughout the book, becoming ever more persuasive as he reaches his conclusion. "We can't capture and bury our way out of this mess," he says, arguing against carbon capture and storage as a penitent measure to offset our current way of living. "In summary, we're in deep shit," he writes.

Doing nothing and assuming that everything will work out, that money-making enterprises will see sense and stop their old ways of working when they wake up to the issues it causes the planet, is just plain misguided, he argues.

This is an attitude that prevails "in some climate circles", he says, but it ought to be corrected. "Maintaining our current path will lead toward certain climate catastrophe, so whatever the odds of our success to alter this trajectory, there is only one way to find out, and we might as well give it our best shot," he writes.

Those decision-makers who can shift the direction of our societies away from fossil fuels would do well to start by reading this book. ▮

Brannen argues that actions like carbon capture aren't enough to mitigate humans' emissions

FLORIAN GAERTNER/PHOTOTHEK VIA GETTY IMAGES

Chris Stokel-Walker is a technology writer based in Newcastle, UK

New Scientist *recommends*

Bethan Ackerley
Subeditor
London

There I was, idly researching cetaceans on the company dime, when I came across **Songs of the Humpback Whale**. Released 55 years ago this month, this album of whale songs remains the bestselling environmental recording of all time, inspiring everyone from Pete Seeger to Kate Bush. I had to see what the fuss was about.

The five-track album was full of keening, alien songs as magical as they would have been in 1970. My favourite is *Three Whale Trip*: full of spine-tingling undulations, it feels both very intimate and otherworldly.

The album was compiled by Roger Payne, a bioacoustician and biologist who co-discovered whale song among humpback whales (for more on animal language, see our story on page 36). It gave a voice to animals hunted for their meat and blubber, and helped fuel the Save the Whales movement.

At just 35 minutes long, the album is a quick listen, but it lingers. Give it a go as you drift off to sleep – and fill your head with ocean dreams.

CAPITOL RECORDS

Love letters from Earth

Clues to our planet's dramatic past are in the layers of rocks we might overlook. A great guide shows why they deserve our attention, says **James Dinneen**

Book
Strata
Laura Poppick
W.W. Norton

PAUL ANDREASSEN/ALAMY

Rock strata, like these in Canada, can help us piece together the deep past

THE story of Earth is the story of change. The 4.5 billion years of this planet's history saw it transformed from a hellish world of magma oceans and poisonous air to a temperate, habitable home blanketed with a diverse array of life. That arc was itself punctuated with stops, starts and catastrophic reversals as the interlocking biogeochemical cycles of the Earth system played out their roles on the most epic stage imaginable.

That we know anything about this sweeping tale is mostly thanks to rocks. In particular, it is thanks to the sedimentary ones that preserve in their layers a legible order of events that shaped the surface. These are the strata, and the science of interpreting them is called stratigraphy.

In *Strata: Stories from deep time*, journalist Laura Poppick offers a paean to this subtle science of reading the rocks, and the lessons it can teach us about how the planet responds and recovers from periods of upheaval. "It is through these lines in stone that we can glimpse ancient iterations of this planet and gain context for the moment we're spinning through now," she writes.

There are many moments in our planet's past that could tell a story of transformation, but Poppick focuses on four episodes, some especially dramatic, some lesser known. The first explores the history of how the atmosphere filled with oxygen, from a series of "whiffs", as micro-organisms began to develop photosynthesis, to the Great Oxidation Event, which drove innumerable species to extinction about 2.4 billion years ago.

Debates about what triggered this event give way to the second section, about "Snowball Earth", a period around 720 million years ago when much of the planet is thought to have frozen over. Another segment explores the rise of mud, and how, with plants, it remade the continents. Then, finally, the dinosaur-dominated Mesozoic Era serves as a study in how the planet behaves in a hothouse climate due to volcanic outbursts pushing concentrations of carbon dioxide in the air several times higher than they are today.

"Sedimentary rocks preserve in their layers a legible order of events that shaped the surface of our world"

For each episode, Poppick profiles geologists working now to untangle the many unanswered questions about what happened when, and why. She also visits key sites where the strata underlying these stories of change are visible, from Newfoundland in Canada to the Australian outback, where she has worked as a field geologist.

The importance of paying attention to the rocks is a recurring theme. To the untrained eye, they can look mundane, writes Poppick, but "to the trained eye, they contain physical and chemical clues, or proxies, that reveal in remarkable detail how the planet looked and felt at the time the rocks formed". At another point she quotes a geologist as saying: "You can't appreciate what's special, without appreciating what's boring."

This book is an admirable effort to make stratigraphy not boring. It doesn't always succeed, and Poppick's fragmented style meant I sometimes lost the plot.

The way she compares some transformations to human-caused changes today is also strained at times. For instance, Poppick compares the Mesozoic hothouse climate to warming driven by our emissions now, but that era was so much hotter that it isn't really all that apt to do so, even under the highest-emissions scenarios.

Another limitation comes from the unfinished quality of Earth Science itself. A few too many of the big questions Poppick sets up – the true trigger of Snowball Earth, for example – remain without satisfying answers, or are left to flutter as differences of opinion among partisan camps. I finished reading feeling uncertain about what we can say for sure. But maybe that is par for the course in geology. "Nothing is set in stone, because our understanding of the stones keep changing, as do the stones themselves," says Poppick.

That aside, the book does succeed in capturing the scale of the story the rocks hold. This works best when she helps us see how observations of "boring" rocks lead directly to insights about the major transformations in Earth's history. Such moments give us a glimpse into how a stratigrapher thinks when Poppick scrutinises otherwise forgettable outcrops, inviting us to see rocks we come across in a new light.

"Strata are, in certain ways, love letters left behind by an aging Earth," she writes. This book is full of reasons to read their secrets. ▮

Editor's pick

The path to domesticated wolves could be short

9 August, p 34

From Dave Aslin, Bargate, Derbyshire, UK

It is proposed that the exact process of the domestication of wolves by our species isn't clear, so here's my take on how it might have gone.

Any tribe consists not only of adults, but children too, and they have a propensity to like small, fluffy things. A young wolf cub adopted from the wild would be fascinating to them, and children would have time to play with it, habituating it.

Children are notorious for their pester power. ("If Johnny has a wolf cub, why can't I have one?") Multiple cubs may then grow up within a tribe. As cubs mature faster than children, they would then mate and cubs would be born entirely within that tribe. This, I argue, would quickly bring about wolves that knew of no other existence.

'Funerals' for animals, great and small

26 July, p 38

From Jon Hinwood, Melbourne, Australia

Why are many scientists sceptical that an animal (in this case, the hominin *Homo naledi)* could respond to the death of a fellow animal by special treatment of the body – burial – as proposed by Lee Berger? Like most pet owners, I have seen one animal mourn another by inspecting and even prodding the body, then carrying a toy or garment with the scent of the deceased pet for a few hours.

More dramatically, in an outer suburb of Sydney, I once observed a "funeral service" for a firetail finch that had flown into a large plate-glass window that was a few metres from dense bushland. Two dozen of these little birds examined the body, then formed a ring around it and slowly circulated, bobbing up and down. The whole performance, from the flock gathering to the inspecting and dancing, took about 10 minutes. If birds can do that, surely so could *H. naledi*.

Two more views on talk of species de-extinction

9 August, p 7

From John Woodgate, Rayleigh, Essex, UK

I look at de-extinction this way: people interested in wildlife regret extinctions, especially human-caused ones. They would like to atone. Attempts have already been made to produce, for example, aurochs-like cattle just by selective breeding. If de-extinction results in creatures that resemble extinct species and can live and thrive in the present, there is no harm done. Such animals may differ less from the extinct species, in terms of expressed genes, than one breed of dog differs from another.

From Gillian Peall, Macclesfield, Cheshire, UK

What are people going to do with animals that are de-extincted? They obviously aren't going to dump such valuable specimens in wild, unbounded habitats. No, they will be confined, possibly in a zoo, where they will be gawped at – sorry, marvelled at – by endless streams of humans. They will be poked, prodded, measured and thoroughly studied by scientists, until they lie down and die. Would you do this to your dog?

To some very large numbers, and beyond

9 August, p 28

From Paul Whiteley, Bittaford, Devon, UK

Visualising 1×10^{90} as the number of particles in the universe was seen as a sort of upper limit for all practical purposes for numbers. Why bother with infinity?

I think we are capable of visualising much bigger numbers, but do they have a place in reality? Imagine a 4000-by-4000-pixel monochrome screen with 256 brightness levels. Cycle through every combination of every pixel and brightness level and the result appears to be 1.37×10^{514}. Most combinations would be noise, but the output would also contain every possible image of everything that exists or could exist that could be represented at this resolution.

Now imagine a civilisation that could examine every combination for meaning. Why? Because the secrets of the universe will be hidden among the images. I don't have a problem grasping this. The information level of the universe is perhaps a more useful very big number than a measly 1×10^{90}.

From Richard Kay, Coventry, UK

1×10^{90} seems very small compared with the useful numbers used to generate cryptography keys. Given that such numbers are routinely involved in calculations with practical real-world applications, physical reality is no constraint to going full steam ahead further towards infinity.

Are gift-bearing orcas more like playful dogs?

12 July, p 19

From Christine Wolak, Huntersville, North Carolina, US

Maybe orcas were indeed being altruistic and bringing us gifts. Some cats leave mice, birds or gophers on their owners' doorsteps, which sounds like a gift of food. But a dog (or cat) dropping something at your feet may be asking you to play fetch. What's more, the story explains that the orcas played with the prey before presenting it to the humans, and that they lingered for a moment after doing so.

I would love to see a follow-up where the gift is accepted, then tossed gently away. Does the orca chase it? If so, does it encourage more gifting (bringing it back again) or less (due to the gift being unappreciated and "throwaway")?

Rocks made of garbage, what a legacy!

19 July, p 24

From Helmut Krueger, Haar, Germany

Now we have realised that we messed up Earth by changing the climate and overpopulating the planet, we cling to the thought that we have left some traces that will tell future alien visitors or intelligent cockroaches about us: we created the Anthropocene, even if it is just radioactive waste, microplastics and rocks formed from garbage. What a legacy!

Yes, human milk is great, but formula has its place

9 August, p 10

From Sam Edge, Ringwood, Hampshire, UK

While I am aware that breastfeeding has many benefits, as highlighted in your story, I am a living testament to the alternative. I was entirely bottle-fed as a baby, my mother having had quite enough after feeding my three siblings, especially in the climate in Singapore where I was weaned. Sixty years on, I am in good health.

Perfect read while waiting for a bowel movement

9 August, p 38

From Jon Arch, Welwyn Garden City, Hertfordshire, UK

Keeping the latest *New Scientist* in my toilet/loo/john helps my constipation. There is no better way to relax while waiting for my bowels to spring into action. ▮

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How tomorrow's technologies are changing the battlespace

The future of warfare is being forged in labs, at tech companies and on battlefields. These changes, and the emerging technologies driving them, are set to profoundly influence military thinking, industrial strategy and society more broadly, say experts

"OUR role is to think the unthinkable," says Peter Stockel, head of mission partner engagement at the UK government's Defence Science and Technology Laboratory (Dstl). Technology has always changed the character of warfare in unprecedented ways, but those tasked with keeping their nations secure against aggression by state and non-state actors must anticipate the influence of a broad range of technologies emerging now. "This is a time of hugely accelerated development," Stockel says.

Just how the battlespace will change and the way this will influence industry and society more broadly is not well understood. So earlier this year, New Scientist CoLab, sponsored by BAE Systems, brought together leading thinkers from industry, military research and academia to discuss the technologies driving change and explore the possible futures that might emerge.

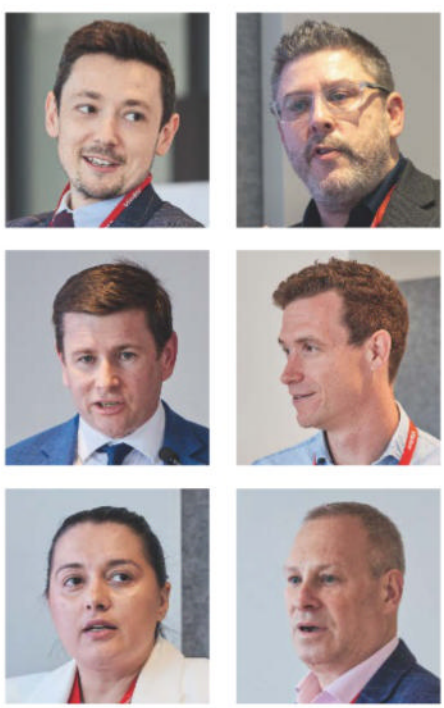
Quantum advantage

One of the most talked-about advances are so-called "quantum" technologies that take advantage of the unusual properties of the smallest kinds of matter, such as atoms, electrons and photons of light. "It gives you new capabilities," says Ryan Hanley, General Manager of Infleqtion UK, which is now bringing advanced atom-based quantum technologies to market.

Infleqtion and other companies are already building these capabilities into useful technologies, such as quantum cryptography systems that allow perfectly secure communication; and gravitational field monitors that detect tanks, aircraft and even troops by the way they alter Earth's gravitational field.

Another promising quantum tool is exquisitely precise atomic accelerometers, ruggedised and miniaturised for the battlefield, that act as robust and accurate navigation tools. These systems cannot be jammed, unlike GPS which is a growing problem for military and civilian operations.

The technology experts from industry, academia and military research



Clockwise from top left:

Ryan Hanley
Infleqtion UK
Nick Colosimo
BAE Systems
Mike Speirs
Faculty AI
Peter Stockel
Defence Science and Technology Laboratory
Simona Soare
Lancaster University
Nick Beecroft
BAE Systems

Another area of innovation is the way information is processed. Information resources are now being analysed and exploited more efficiently with artificial intelligence (AI). This has proved crucial to Ukrainian forces who have combined AI with crowdsourced data and mapping software to create digital warfare tools with air defence and military intelligence abilities. "This is creating a profusion of new capabilities," says Nick Beecroft, International Cybersecurity Lead at BAE Systems Digital Intelligence.

Robot transformation

Beecroft has been observing these developments on the ground in Ukraine and is impressed at how quickly engineers have learned to harness cutting edge digital technologies. One of the most recent AI-based developments, known as Avengers, has radically scaled-up target identification. "It offers the equivalent of a significant team of military intelligence analysts in a plug-in app," Beecroft says.

Progress in robotics and automation is also transforming the battlespace. "Most of the magic happens where the technologies overlap," says Nick Colosimo, head of Group Science & Technology at BAE Systems.

One example is highly accurate sensors combined with smaller, cheaper, energy-efficient processors that run AI systems, which analyse the data being gathered. Add in cheap, powerful actuators that drive machinery such as propellers for drones, and you have a powerful foundation for long-range intelligence gathering. Then there's the emerging techniques such as neuromorphic computing that aims to copy the efficiency of biological systems. "The growth of all of these things together means it's easier than ever to build useful and effective robots," Colosimo says.

BATTLESPACE AI IS NOW A VITAL RESOURCE

Artificial intelligence (AI) is everywhere, but how can we best put it to work? Shrewd deployment will be crucial in future conflicts, according to Mike Speirs, a senior leader at applied AI company Faculty AI.

"The 20th century was the age of industrial warfare: tanks, planes, aircraft carriers and so on," he says. Now, data-gathering is as important as firepower. "The 21st century is the age of cognitive warfare where strategic advantage comes from superior sensing, understanding and adapting. It's about algorithms and the speed of decision-making."

In other words, wars are won by those who understand the battlespace better and faster, and AI will be a crucial advantage. Speirs sees a range of areas where AI will make a strategic difference. One is predictive logistics that forecast supply requirements. Then there is collaboration between human and machine intelligence, whether for weapon firing or for dealing with disinformation on social media. But perhaps most important will be working out the intent of potential adversaries. "These days there is simply too much information available for human analysts," he says.

"Ukrainian forces are combining AI with crowdsourced data and mapping software to create whole new digital warfare tools"

At the moment, battlespace robots look like standard military hardware: drones, self-driving supply trucks and autonomous underwater vehicles, for example. But it won't be long before they look and behave more like people, Colosimo reasons. That's because we'll eventually need robots that operate in our homes and factories using the same tools that we do. "It's easier to slot a humanoid robot into that world," he adds.

Tech convergence

All this will be enhanced by the convergences of technologies: quantum computers that use machine learning techniques, for instance. "It will allow you to perform unbelievably enormous complex problem-solving that was previously impossible," Colosimo says.

This progress is coming faster than anyone expected. Simona Soare, a senior lecturer in Strategy and Technology at Lancaster University, has analysed NATO's endeavours over the last few decades. She has identified an exponential increase in the complexity and functionality of software – including AI – over this time. "This pace is set to accelerate," Soare says.

Making the most of these emerging technologies will require a radical re-think about how military technologies are developed and delivered, Soare reckons. In some instances, it might make sense to scrap existing systems rather than find ways to improve them. "Sometimes it's easier to build a system from scratch than to work out what needs to be replaced in your existing system," she says. This strategy also makes serendipitous breakthroughs more likely. "Someone who has a blank slate can make progress in surprising ways," she adds.

Ensuring innovation is rapid enough to keep bad actors in check means changes in approach are needed now. "There's a lot riding on the way we choose to adopt our ability to innovate, and whether we can adopt at the pace of warfare," Stockel says.

To find out more visit: baesystems.com

Welcome to the family

Could Denisovans, rather than Neanderthals, be our closest ancient relatives? **Colin Barras** looks at what this would mean for our family tree

PAO-HAN CHEN

ONE of the biggest mysteries in human evolution has just been solved. In 2010, a groundbreaking genetic analysis revealed that east Asia was once home to a previously unknown group of enigmatic ancient humans. We knew them as the Denisovans, but until very recently, we had no idea what they looked like.

That has now changed thanks to a 146,000-year-old skull unearthed in Harbin, China, in mysterious circumstances more than 90 years ago. In June, we learned that it carries Denisovan DNA in the ancient gunk attached to the surface of a tooth, suggesting that the cranium belonged to this ancient relative of modern humans. The discovery shows that these hominins had an unusual combination of features: their faces were similar to ours, but they had thick brow ridges and lacked our tall foreheads.

This finding closes one chapter of the Denisovan story. But another has just begun – and it looks set to bring even bigger revelations. For one thing, we can expect a new name for this extinct hominin, with at least two rival proposals for what it should be. There will also be a battle over how to accommodate the Denisovans in our family tree, particularly given the suggestion that they are more closely related to living people than any other ancient human – potentially ousting the Neanderthals from their position as our sister species.

That controversial idea has big implications in the ongoing search for Ancestor X, the population that gave rise to modern humans. It will also prompt a scramble to learn more about Denisovan lives and behaviour – because it is only by studying our closest cousins that we can really understand how we differ from the other humans that once walked the planet.

The story of the Denisovans, in terms of our recognition of them, begins just a decade and a half ago. They have been a puzzle since their unconventional discovery in 2010. Unlike other ancient humans, all of which are defined by the physical features of their skeletons, these hominins were originally defined solely on the basis of unusual DNA signatures in a tooth and tiny finger bone – both now thought to be between 51,000 and 84,000 years old – found in Denisova cave in Siberia, Russia. That DNA turned out to come from a human lineage that was related to, but distinct from, the Neanderthals.

Bence Viola at the University of Toronto, Canada, who was a member of the team that made the discovery, says the researchers considered placing the fossils in a new species: *Homo altaiensis*. They ultimately decided not to, in part because the DNA showed that ancestors of living humans had interbred with the mysterious lineage. We now know that there were several episodes of this interbreeding, and that some human populations – particularly in the islands of South-East Asia and Oceania – inherited between 4 and 6 per cent of their DNA from Denisovans.

"Species names are problematic when you're looking at populations that are so closely related," he says. The team opted instead to give the lineage an informal name – the Denisovans – which some researchers view as merely a population within our species, *Homo sapiens*.

What's in a name?

There isn't universal agreement that this was the correct decision, however. Species can be defined in dozens of ways, many of which allow for a limited degree of interbreeding with other species. This means, for instance, that many researchers argue that Neanderthals deserve to be considered as a distinct species – *Homo neanderthalensis* – despite evidence that they interbred with modern humans. In a study published last year, Andra Meneganzin at KU Leuven, Belgium, and Chris Stringer at the Natural History Museum, London, advocated for this position because the Neanderthals developed a unique set of physical features and exploited resources in a distinct way.

With such ideas in mind, Christopher Bae at the University of Hawai'i at Mānoa recalls being intrigued by the fact that the original Denisovan tooth and a handful of others from Denisova cave were strikingly large. They strongly reminded him of teeth associated with ancient human remains that had been unearthed in China during the 20th century. "I said that it was only a matter of time before the Denisovans were given a Chinese species name," he says.

The trouble was, says Bae, that no existing names were available there. Researchers in China had traditionally opted for a simple, linear picture of human evolution and so chose to label any human fossils from the past 200,000 years as either *H. sapiens* or – if the fossil had a primitive appearance – archaic *H. sapiens*.

Today, most researchers in China think our evolutionary tree is more complicated. As such, when Xijun Ni at the Chinese Academy of Sciences in Beijing and his colleagues ›

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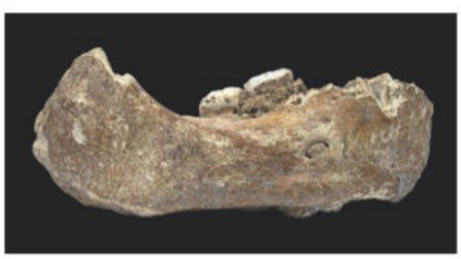


DONGJU ZHANG, LANZHOU UNIVERSITY

A skull discovered in Harbin, China, (above) and a mandible bone found in Baishiya Karst cave on the Tibetan plateau (left) both belonged to Denisovans

examined the Harbin skull and concluded it didn't belong to a Neanderthal or a modern human, they were comfortable with placing it in a new species. In 2021, they named this species *Homo longi*, derived from a Chinese term meaning "dragon".

A few years later, in 2023, Bae attended a scientific meeting in Novi Sad, Serbia, to discuss the human evolutionary tree. "We basically agreed that *H. longi* is OK," he says.

So, with news earlier this year that the Harbin skull contains Denisovan proteins and there is Denisovan mitochondrial DNA in the tartar adhering to its single tooth, a strong case can be made for saying the Denisovans and *H. longi* are one and the same. But Bae doesn't see it that way.

For a few years, he has suspected that *H. longi* wasn't the only ancient human wandering around east Asia in the Stone Age. In particular, he points to fragments of hominin skulls from Xujiayao and Xuchang in north China that are between 100,000 and 200,000 years old. He says they would have accommodated truly enormous brains with a volume of 1700 to 1800 cubic centimetres – much larger than the 1350 cc of the average living human.

Last year, he and his colleague Xiujie Wu at the Chinese Academy of Sciences placed these fossils and some others in a new species named *Homo juluensis*, which Bae is convinced is where the Denisovans really belong.

"You just have to look at the molars," says Bae. The unusually large teeth from Denisova cave are, he says, virtually indistinguishable from the teeth associated with the fossils he and Wu placed in *H. juluensis*. And while he accepts that the Harbin skull carries Denisovan-like DNA and protein signatures, he suspects that, if DNA can be extracted from some of the *H. juluensis* fossils, they will provide an even closer genetic match with the remains from Denisova cave.

As things stand, then, there are now three potential ways to think about the Denisovans. The research community may begin to refer to them as *H. longi* or as *H. juluensis* – or a decision may be made to continue using the informal term Denisovan on the assumption that they really belong in *H. sapiens*. Currently, there is no consensus, but one is needed, says Bae. "You have to give them some kind of name because otherwise it's really difficult to have a conversation about the variation and the evolutionary history of these human groups."

Names are particularly important in light of new research. In an as-yet-unpublished study, Ni and Stringer have teamed up, together with other colleagues, and used anatomical information from dozens of ancient fossils to reconstruct the evolutionary relationships among species in our human genus. The results led to a radical redrawing of our family tree (see "Shaking the tree", right).

Traditionally, the Neanderthals have been viewed as the closest ancient humans to living people. But Ni and Stringer's team concluded that Denisovans are more closely related to us than the Neanderthals are. According to their analysis, the Denisovans and modern humans last shared a common ancestor about 1.32 million years ago. The Neanderthals branched away from our evolutionary line earlier, around 1.38 million years ago.

Ni and Stringer won't discuss their conclusions until the work is accepted for publication in a scientific journal, but many researchers consider them to be controversial, given they clash with the DNA evidence. Not only does that DNA evidence suggest that Neanderthals and Denisovans are equally closely related to living humans, it also implies that the divergence between the Neanderthal-Denisovan line and our own occurred between 500,000 and 700,000 years ago – far more recently than Ni and Stringer's team found.

"It's very clear from the genetic data that a major split between the lineages leading to modern humans on the one hand, and Denisovans/Neanderthals on the other, occurred within the last 500-700,000 years," says David Reich at Harvard University.

That being said, Aylwyn Scally at the University of Cambridge says such divergence estimates depend to some extent on the methods used to analyse the genetic data. José María Bermúdez de Castro at the National Human Evolution Research

Centre (CENIEH) in Spain also thinks there is wiggle room on the divergence date. "The last common ancestor may be up to 1 million years old," he says.

Conventionally, it is believed that this Ancestor X was located somewhere in Africa. But if Denisovans – a group that seems to have been largely confined to east Asia – emerged from the Ancestor X population too, an African location might seem less likely.

Some researchers are already willing to entertain the idea that Ancestor X lived in Eurasia rather than in Africa. In a 2022 study, Bermúdez de Castro and María Martinón-Torres at CENIEH argued that south-west Asia might make more sense, particularly the Levantine region bordering the eastern Mediterranean Sea. "It's the umbilical cord linking Africa to Eurasia," says Bermúdez de Castro.

Ancestor X might even have existed further east. In their yet-to-be-published study, Ni and Stringer's team took a fresh look at two complete, but slightly squashed, ancient human skulls found in Yunxian, central China, about 35 years ago. They used software to create an undistorted model of one of the skulls, and realised that its anatomy was almost exactly in line with that expected of Ancestor X. For instance, it has features of our modern human face coupled with a more primitive-looking braincase that originally housed a brain of roughly 1140 cubic centimetres – smaller than that of the average living human.

> **"There will be a battle over how to place Denisovans in our family tree"**

Moreover, its age – about 0.9 to 1.1 million years old – is roughly in line with the researchers' estimate for when our last common ancestor with ancient humans roamed the world. As such, they reached a striking conclusion: this Yunxian skull came from a human very closely related to Ancestor X. What other researchers make of such a bold suggestion, however, remains to be seen.

Inside Denisovan lives

With these ideas swirling around the research community, it has never been more important to understand the lives of the Denisovans. This is because assessing how much of a behavioural overlap there was between these ancient humans and our modern human ancestors could provide vital information about our own behavioural evolution.

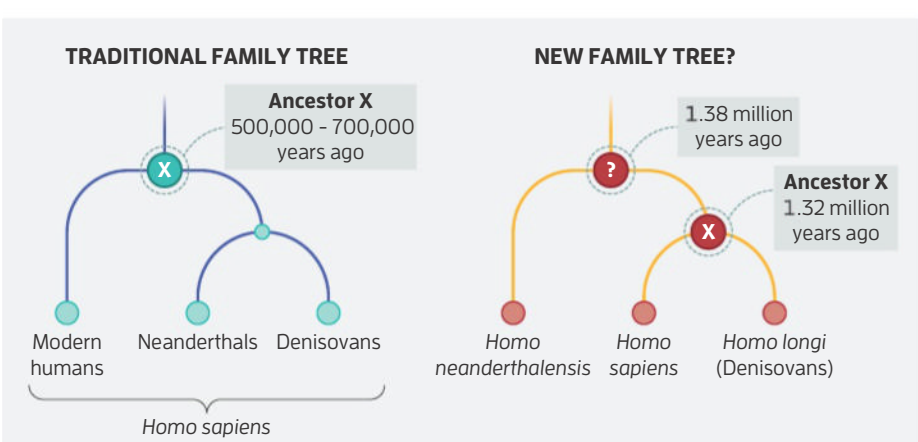
But it is difficult to conclude much about Denisovan behaviour without excavating sites that they occupied. We have known since 2010 that Denisova cave is one such location, but ancient DNA indicates that Neanderthals and modern humans also occupied the cave at various times during the Stone Age. This complicates things when it comes to interpreting the artefacts unearthed there, which include plenty of stone tools, bone needles for sewing and even ancient jewellery, such as an ivory tiara and a bracelet of polished green rock. Simply put, we don't know which Stone Age humans made those artefacts.

Other sites, however, are beginning to offer some insights into Denisovan lives. In 2022, for instance, a research team reported the discovery of a tooth with a Denisovan-like appearance in Tam Ngu Hao 2 – dubbed Cobra cave – in Laos. It suggested that some Denisovans adapted to humid tropical conditions quite unlike those found around Denisova cave – although such a conclusion was tentative given that it wasn't possible to extract Denisovan-specific DNA or proteins from the tooth.

But it is Baishiya Karst cave on the Tibetan plateau that is emerging as perhaps the most important Denisovan archaeological site. A study published last year concluded there is DNA evidence that the Denisovans – and ›

Shaking the tree

According to the traditional picture (below left), Neanderthals, Denisovans and modern humans are all sub-populations of *Homo sapiens*, with Neanderthals and Denisovans being most closely related. In a new interpretation (below right), *Homo longi* (a possible new name for Denisovans) and *H. sapiens* are the closest sister species



PAO-HAN CHEN

"It is likely that Denisovans wore clothing to protect themselves from the cold"

no other humans – sporadically occupied the cave between 160,000 and 60,000 years ago.

Excavations have yet to unearth anything as striking as the Denisova cave jewellery, but they are still revealing important information about the Denisovans. Perhaps most interesting is the fact that they occupied the cave at all given the extreme environment in which it is located. "It's cold throughout the year," says Dongju Zhang at Lanzhou University, China. "Snow covers the whole area in the wintertime, and you need a thick jacket even in July or August."

Unsurprisingly, then, Zhang and her colleagues have found evidence that the Denisovans made fires inside the cave. It is also likely that they wore clothing to further protect themselves from the elements, with evidence that they skinned animals including the bharal (*Pseudois nayaur*), also known as the blue sheep. "We think they took the skins to cover their bodies and keep themselves warm," says Zhang.

Adding to the challenges the Denisovans faced is that the site is 3200 metres above sea level. "I was at the cave last year for a scientific workshop and the lack of oxygen is shocking – I got a horrible headache," says Viola. Astonishingly, there are now hints that the Denisovans took to even higher altitudes: in as-yet-unpublished work, Zhang and her colleagues have found evidence of an ancient archaeological site on the Tibetan plateau at about 3700 metres above sea level.

Finding food on the plateau can be difficult because prey is thin on the ground. This may explain why Zhang and her colleagues discovered that the Denisovans at Baishiya Karst cave hunted a wide range of animals, including large mammals like the bharal and snow leopards as well as rodents such as marmots, and even birds. "It seems they had to use all the animal resources available to them," says Zhang. To do so, the Denisovans must have developed a range of hunting strategies, because each of their prey species had a unique suite of behaviours.

Collectively, these discoveries paint a picture of the Denisovans as remarkably adaptable. Indeed, some archaeologists have commented that their behavioural flexibility is strikingly reminiscent of modern humans.

But even as we are finding echoes of ourselves in the Denisovans, we are also identifying subtle ways in which we differed from them.

For instance, the stable isotopes in fossil teeth – which can reveal information about the variety of plants and animals an individual ate – suggest that modern humans adapted to hunt and forage in the rainforests of south and South-East Asia tens of thousands of years ago. But a 2023 analysis of the suspected Denisovan tooth from Cobra cave in Laos indicates that our ancient cousins lacked the tools and skill set to do so: they seem to have hunted only on nearby savannahs, says Mike Morley at Flinders University in Australia.

Vast territory

Archaeological discoveries in the years ahead should help us more precisely define the similarities and differences between the Denisovans and modern humans. The odds of making such discoveries received a boost earlier this year. After analysing ancient proteins inside a jawbone dredged up off the west coast of Taiwan, a research team concluded that the bone came from a male Denisovan – providing the strongest fossil evidence yet that the Denisovans really did occupy a vast territory. "The geographic range for Denisovans was likely huge," says Morley. "Just think how much more there must be to find." ▮

JOHN BAVARO FINE ART/SCIENCE PHOTO LIBRARY

A reconstruction of a girl based on a bone fragment found in Denisova cave in Siberia

Colin Barras is a science writer based in Ann Arbor, Michigan

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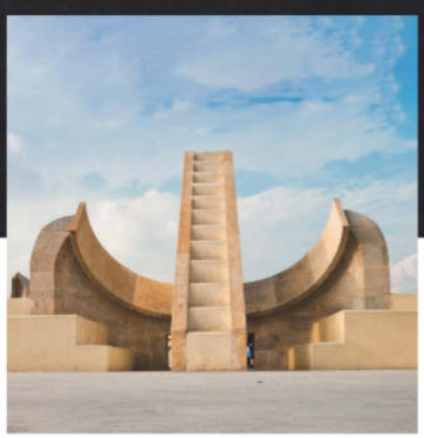

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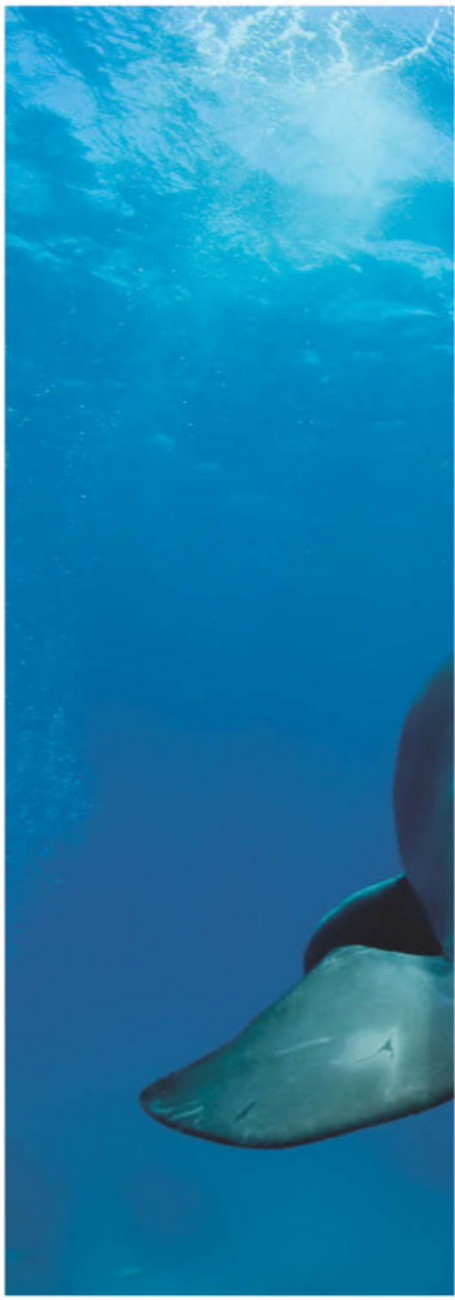
Talk to me!

With the help of artificial intelligence, we are edging closer to deciphering animals' speech. But who will we speak to first, asks **Chris Simms**



Dolphins may have a whistle for "What was that?"

STEPHEN FRINK/GETTY IMAGES, SHUTTERSTOCK

SOPHIE COHEN-BODÉNÈS knew she was onto something when she saw the cuttlefish extend two arms upwards while twisting its six others together. It was making what she calls the "up" sign – and, intriguingly, it was throwing this shape in response to a video of another cuttlefish making similar movements. This was the first hint that these marine animals, which are cousins of octopuses, may communicate with a kind of sign language.

For decades, researchers have studiously avoided claiming that any animal other than humans has language. That is now changing, thanks to artificial intelligence's ability to spot patterns in huge datasets of animal noises and actions.

Research efforts have been boosted further by the new Coller Dolittle Challenge, which tasks the scientific community with developing an algorithm to communicate with non-human organisms, or at least understand what they are saying. This year's winner got $100,000 to fund their work, just pipping Cohen-Bodénès at the post. The challenge, established by Tel Aviv University in Israel and venture capitalist Jeremy Coller's philanthropic foundation, is also offering a $10 million bounty to the first team to crack the puzzle of interspecies communication.

As researchers rush to publish their results, cuttlefish are just one surprising example of animals that are more loquacious than we had thought. The wealth of new findings is raising hopes that, like the fictional Dr Dolittle, we may one day be able to talk with animals. But it also throws up big questions about what language is, why it is so hard to ascribe to non-human species, and what it will mean if we do finally work out what other animals are saying.

If you have pets, no doubt you communicate with them – you know, for example, if they are hungry or want a walk. But that isn't the same as language. The human communication system consists of a vocabulary of words and the grammatical rules for using them. It uses sounds learned from others, rather than being innate, that are divided into semantic categories such as nouns and verbs, which change to describe what happened in the past or will occur in the future. It also has a syntax that governs how the words are organised into sentences. All this allows us to create new words and combine them to make sentences that have never existed before. We can even discuss hypothetical things outside our own

"Dolphin communication goes way beyond name-calling"

space and time, such as absent people and distant targets.

It is an impressive list, and even if another animal had a communication system anywhere close to ours, it isn't clear how we would go about demonstrating that. Some animal researchers suspect that our obsession with our own way of communicating holds us back from understanding the capabilities of other species. It is a sentiment shared by Coller. "We've arrogantly convinced ourselves that we are the only living things worth listening to," he said earlier this year at the inaugural awards ceremony of the annual Coller Dolittle prize.

Common cuttlefish (*Sepia officinalis*) certainly have very little in common with us. Nevertheless, Cohen-Bodénès at Washington University in Saint Louis and Peter Neri at the Italian Institute of Technology in Genoa discovered that they wave their arms to create four distinctive signs, which the pair have dubbed "up", "side", "roll" and "crown". Using a computer algorithm designed to analyse videos of cuttlefish interactions, they found that when one animal sees another signing, it responds with one of the four signs. Cuttlefish will even do this if they just detect vibrations in the water generated by another's sign.

Exactly what these movements mean is still unclear, but Cohen-Bodénès thinks that "crown" – which is a bit like when you put the fingertips of both hands together to make a pyramid shape – is used to express unease that something has changed. In further experiments, cuttlefish have backed away when doing the crown sign and have turned their bodies orange or sometimes black, behaviours Cohen-Bodénès thinks are associated with aversion. As communication goes, this might not sound very impressive, but it is surprising, given that cuttlefish are a solitary, evolutionarily ancient species.

A second team shortlisted for the Coller Dolittle prize was a group at the Max Planck Institute for Biological Intelligence in Germany, which is looking at nightingales (*Luscinia megarhynchos*). These birds produce songs comprising whistles with a wide range of frequencies, and the researchers discovered that they can instantaneously adjust their pitch to imitate that used by another ›

individual. Such flexibility is an important aspect of human speech, but it had never before been seen in a non-human animal.

David Omer at the Hebrew University of Jerusalem and his colleagues were also shortlisted for discovering a first in animal communication. They found that marmosets, which live in tight-knit family groups, use unique name-like "phee" calls for each other. They are the first non-human primates known to do this, although recent research suggests elephants also use arbitrary sounds as names and dolphins have signature whistles to identify themselves.

SHUTTERSTOCK/MADELEIN WOLFAARDT

ARCO/TUNS/IMAGEBROKER.COM GMBH/ALAMY

Above: Cuttlefish appear to use a form of sign language. Right: The brains of budgerigars map vocalisations in much the same way that our brains do. Far right: Orangutans seem to alter their calls when talking about past events.

Dolphin gossip

Dolphin communication goes way beyond name-calling, though, as Laela Sayigh at the Woods Hole Oceanographic Institution in Massachusetts and her colleagues found in research that won the Coller Dolittle prize. They have been studying a pod of some 170 wild bottlenose dolphins (*Tursiops truncatus*) living in Sarasota Bay, Florida, spanning six generations. Using AI to detect repeating features in recordings made over many years, they have so far identified 22 non-signature whistles made by multiple dolphins. The most widespread is produced by more than 35 animals and used when they see or hear something unexpected or unfamiliar. It is as if they are saying, "What was that?", says Sayigh.

Another whistle is quite jarring and seems to be a warning. On its own, this isn't groundbreaking: some other animals, including vervet monkeys, have specific warning calls for different predators. But dolphin communication starts to look pretty impressive when you consider these non-signature whistles in combination with the fact that they use their signature whistles to bond, are exceptional vocal learners and adopt a higher pitch when communicating with their young, much as we often do when we talk to babies. Yet-to-be-published findings even hint at dolphins using the signature whistle of an animal that isn't present. "It would be really cool to think that they're talking about that dolphin," says Sayigh.

These four teams are far from unique in using AI to try to crack the puzzle of animal communication. The approach has been especially successful for studying whales. Earlier this year, for example, it helped reveal that humpback whale songs have statistical patterns in their structure that are similar to those seen in human language.

And in June, David Gruber – founder of Project CETI, a non-profit organisation dedicated to listening to sperm whales – linguist Gašper Beguš at the University of California, Berkeley, and their colleagues used AI to demonstrate that sperm whale clicks resemble human vowels acoustically. Project CETI researchers had previously discovered 156 click patterns, which they say make up the whales' "phonetic alphabet", and shown that the animals adjust the tempo of their patterns of clicks during exchanges with each other. Such synchronisation has been seen in many animals, including plain-tailed wrens and gibbons, says Luke Rendell at the University of St Andrews, UK, but his own research indicates that sperm whales use it for social coordination and bonding.

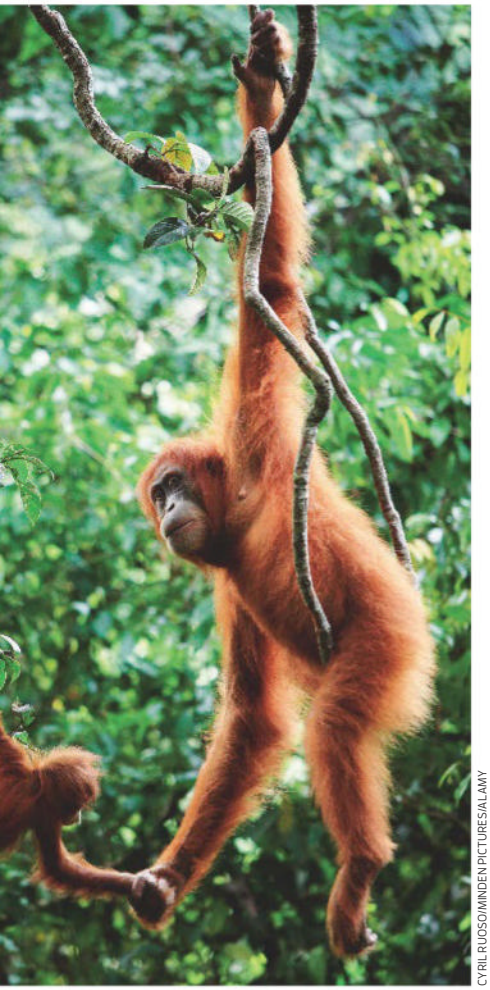
"AI allows us to really scale up experiments. It allows us to process data much faster," says Frants Jensen at Aarhus University, Denmark, who works with Sayigh. "That really is a phenomenal game changer."

Nevertheless, it isn't a panacea. The approach sounds simple: accrue a massive number of communications, run them through AI to find the patterns, then sit back and indulge your inner Dolittle. However, it doesn't always work. AI does a good job if you train it on part of a set of recordings and then test it on the rest, says Rendell, but give it data with slightly different acoustic characteristics and it often fails.

Even when it does find patterns in huge datasets, that is just the beginning. "It's now our role as scientists to examine these features and to make sure they mean something to the animal," says Yossi Yovel, also at Tel Aviv University, who chairs the Coller Dolittle Challenge.

Essentially, this comes down to knowing the context in which an animal made a noise. That isn't always easy. For example, whales spend most of their lives below the surface, making it difficult to gather information on them.

Orangutans, too, can present an interesting challenge, says Adriano Lameira at the University of Warwick, UK. He and his colleagues discovered that these great apes have the capacity to communicate about past events when they found that mothers were delaying making alarm calls to their infants by up to 20 minutes after spotting a predator. Now, in work that is under peer review, they have found that orangutans alter



CYRIL RUOSO/MINDEN PICTURES/ALAMY

"We've arrogantly convinced ourselves that we are the only living things worth listening to"

the acoustics of their calls to allow the listener to infer how much time has passed since the event happened. This makes things difficult for a researcher trying to work out the context of a particular call. "Is it referring to the moment now or when the event was seen?" says Lameria. "We have no idea."

Shocking communication

Irene Pepperberg at Boston University in Massachusetts highlights a bigger problem: "If we just look at cracking vocal codes, we're going to miss out on other forms of communication," she says. Even subtle things can have a big effect. For example, Japanese tits (*Parus minor*) use different notes and note combinations to convey various messages, such as "danger" and "approach", but the order in which they sing these can change the overall meaning. Add in other methods by which some animals communicate – colour changes, scent releases, touch, facial expressions, even the electric shocks used by some fish – and it makes the task look decidedly tougher than just throwing everything at an AI.

Even if we can learn to decode different forms of communication, the question of whether any non-human species has language is still likely to be hotly debated. "I see language as multifaceted," says Rendell. "There are things that help it, like vocal learning. There are things you absolutely need, like a theory of mind – understanding that there is another agent out there with a different state of knowledge from yours and you can perhaps influence it to achieve a common goal. You also need a vocal system that's flexible enough, and the ability to remember the past and think about the future."

He thinks there are animals with some of these abilities, but humans are the only species that has them all. Gruber is more positive, though. "We wrote the definition of language and other animals will never be able to pass it, but if you see language as a continuum, then whales have it," he says.

Whales are certainly up there when it comes to the $10 million question of which species is likely to have its communications cracked first, not least because we have already recorded so many of their calls. For instance, there are decades' worth of data on the songs of humpback whales in the South Pacific Ocean and how the songs spread between populations, says Rendell. Another contender is the Sarasota dolphin project, he says. "It has a really good combination of long-term data and very precise data about specific animals in their population, so it's definitely in the top five in the world in terms of long-term studies."

Sayigh also has her fingers crossed for her dolphins, but she knows it will be a big challenge. For a start, dolphins make a whole suite of burst-pulse sounds, comprising rapid sequences of clicks, that she hasn't even begun to study. These are often used in concert with whistles and, in many cases, they seem to convey something like emotions. Potentially, a burst-pulse sound together with a dolphin's own signature whistle could mean something like "I'm really upset" or "I'm happy", she says.

Dolphins also use echolocation, which could add a whole other element to their communication if these calls are made in conjunction with specific changes in body movements – like those made by cuttlefish – which might perhaps be like us raising an eyebrow or winking. "It's becoming much clearer to me now that this is going to take a long time because they're very complicated," says Sayigh.

"Working with dolphins is very difficult," says Yovel. He thinks the first animal to have its communications fully decoded will be more amenable to study, perhaps a species of social bird that lives in groups and uses vocalisations to coordinate behaviour. "I would go to study jays. That's where I would put my bet," he says.

CINOBY/GETTY IMAGES

Elephants use arbitrary sounds as names for each other

Pepperberg, who became famous for her work with grey parrots, including the irrepressible Alex, also thinks birds have an edge. She points to recent research indicating that the brains of budgerigars, also known as parakeets in the US, contain a map of vocal sounds that bears a strong resemblance to the ones found in human brains. "Personally, I'm fascinated by the bird system because their vocal learning is so similar to ours," she says.

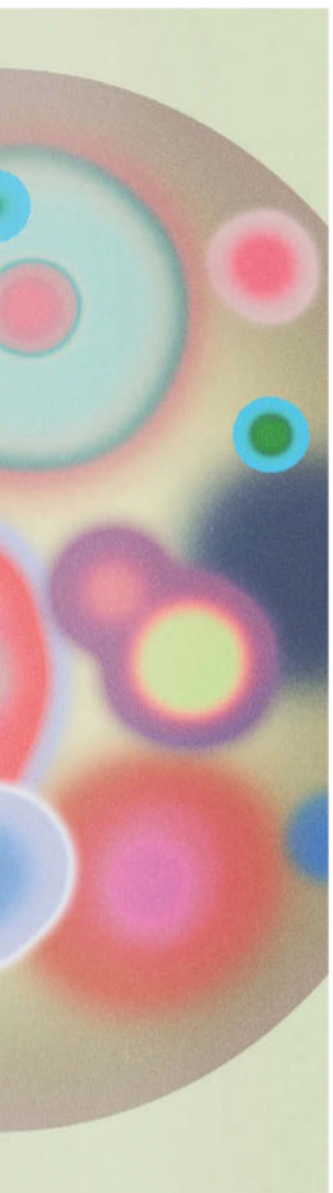
This isn't just a race to be first or to win a big prize, though. If we do manage to crack the communications of any other species – and many researchers believe this is just around the corner – it could open up whole new ways of seeing and understanding the world. Perhaps it will help us perceive what it is like to communicate with echoes. Or we might see new meanings in colours, as we did when we worked out that bee vision extends into the ultraviolet, allowing us to see what the world looks like from their perspective. More fundamentally, it could boost our respect for other species. "I think that anything we learn about animals makes us appreciate them more," says Yovel. "Study on communication probably drives many people to think: 'Oh wow, they're like us!'" ▮

Chris Simms is a science writer based in Somerset, UK

Rehabilitating cancer

Instead of killing every last tumour cell, we may be able to persuade them into becoming benign, finds **Claire Ainsworth**

IBRAHIM RAYINTAKATH



THE cells in Ling He's lab dish looked nothing like cancer cells. Which was odd, because they had been extracted from the tumours of people with an aggressive brain cancer called glioblastoma.

Glioblastoma cells can grow and spread rapidly, invading the brain with tentacle-like projections that push into surrounding tissue, suppressing the immune system as they do so. This makes the cancer hard to fully root out: it has a five-year survival rate of just 5 per cent.

But the cells in He's dish had changed. Many were now looking and behaving remarkably like neurons, while others seemed to have morphed into immune cells called microglia. This was because they had been treated with the aim not of killing them, but of persuading them to adopt a new identity. "I was really excited," says He.

Exciting as it is, He's research isn't an outlier. She and her colleagues are part of a growing group of scientists who, instead of looking for new ways to destroy cancer cells, are trying to leverage their natural plasticity to return them to a benign state. The results are promising: in addition to He's work – which was done in Frank Pajonk's lab at the University of California, Los Angeles – experiments have seen liver cancer cells ditch their malignant behaviour and human breast cancer cells reprogrammed into harmless fat cells.

These findings offer support for a bold new treatment principle starkly at odds with the conventional, guns-blazing approach. The war on cancer is now over half a century old, and around 10 million people worldwide still die from the condition each year. A truce can't come soon enough.

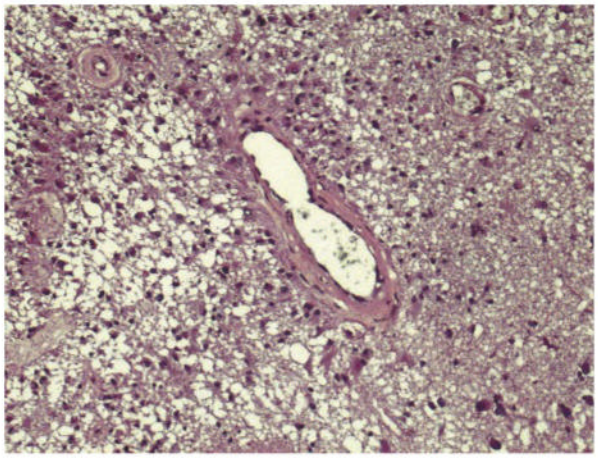
The idea that cancer might be malleable – or at least open to persuasion – isn't entirely new. More than 80 years ago, developmental biologists began pursuing the idea that cancer was fundamentally a disease of disrupted development, a breakdown of the social interactions of the cells that build or repair tissues, organs and bodies. And if it were, could that malignant development be reversed?

Early reports of cancers spontaneously regressing in patients and research showing cancer cells resuming benign behaviour in the lab suggested that it could. In 1959, for example, pathologist Barry Pierce and his team grafted embryonic tumour cells from a type of cancer called teratocarcinoma into adult mice. They discovered that the cancerous cells could differentiate into benign cell types that then contributed to healthy muscle tissue. In the mid-1970s, researchers injected the same kind of cancer cells into early mouse embryos and found they lost their cancerous nature, instead becoming part of the tissues and organs of the developing mice.

Researchers realised that the tissue environment in which cancer cells found themselves seemed to influence their behaviour, so they began looking for the mechanisms responsible. Pierce's team discovered that cancer could be retrained through exposure to embryonic environments in which closely related cell types were generated. "In this period, there were several researchers who understood that the processes that naturally drive embryo development can also drive a correct harmonisation of cancer cells," says Andrea Pensotti, who has worked on studies exploring cancer reversibility at Campus Bio-Medico University in Rome. It all suggested that, under the right influences, cancer could be rehabilitated into a law-abiding cellular citizen.

But it wasn't until the mid-1980s that two doctors applied this concept in the clinic. Zhen-Yi Wang and Zhu Chen drew inspiration from the Chinese philosopher Confucius to treat acute promyelocytic leukemia (APL), a type of blood cancer that, at the time, was usually fatal within a short period. Confucius advocated education rather than punishment to cure societal ills; if cancer is a breakdown of cellular society, Wang and Chen reasoned, then "educating" cancer cells might offer a better solution than killing them.

Research from the late 1970s had found that a derivative of vitamin A called retinoic acid could push immature APL cells to ›



PROF. J.L. KEMENY/SCIENCE PHOTO LIBRARY

Glioblastoma cancer cells (pictured) were coaxed into becoming non-cancerous types

differentiate into mature white blood cells in the lab, although its mechanism of action was unknown at the time. So, in 1985, Wang and Chen gave the drug, alongside chemotherapy, to a 5-year-old girl who was dying of treatment-resistant APL at Shanghai Children's Hospital. Within a month, the girl was in complete remission and has remained so for decades.

Further research showed that retinoic acid beneficially alters the shape of a protein involved in causing APL. The best results came from administering it along with an arsenic compound and conventional chemotherapy. This combination, still in use today, has turned APL into a highly curable condition.

The art of persuasion

But the treatment was an outlier. Other attempts to reverse cancer had success in laboratories yet proved difficult to translate into clinical applications. And the idea behind them, that cancer was a disruption of development, was being eclipsed by the somatic mutation theory, which posited that cancer results when multiple mutations pile up in a cell's genome. At the same time, chemotherapy drugs aimed at destroying cancer cells were yielding encouraging results, says Pensotti, although they came with problematic side effects.

"Cancer research has spent a lot of time trying to figure out how we can selectively kill cancer cells and very little time on understanding how our bodies naturally suppress cancer," says Boris Kholodenko, a systems biologist at University College Dublin in Ireland.

That approach, say some biologists and cancer researchers, isn't working, not least because cancer cells quickly evolve resistance to treatment aimed at wiping them out. "If you are trying to kill the cells, you have against you the most efficient weapon of all biological systems, and it's Darwinian selection of the cells which are resistant," says Jan Brábek, who is researching ways to retrain cancer at Charles University in Prague, the Czech Republic. "With the approaches which would rather educate or persuade cells than kill them, you avoid the strongest defence of cancer."

The key to retraining cancer is understanding how cells differentiate and acquire their specialised functions. Embryonic stem cells start out with the ability to form any kind of cell in the body, a feature called pluripotency. They draw on signals from their neighbours and environment to make a sequence of decisions that progressively restrict their ability to form different cell types.

In the 1940s, biologist Conrad Waddington created a metaphor to describe this process. Imagine a developing cell as a ball sitting at the top of a valley. As it rolls down, the valley splits into two new valleys, separated by a mountain. The ball picks one path and continues rolling until it meets another fork, where it must choose again, and so on. Eventually, the ball comes to rest at the bottom of this landscape, where it stays, committed to its specialisation. This ever-forking series of valleys represents the non-genetic forces – which Waddington dubbed "epigenetic" – that help cells translate their genetic information into their physical form by regulating gene expression.

Waddington's landscape implies that cells cannot scale the mountains between valleys nor retrace their steps once they reach the bottom. But our cells are more malleable than once thought. Under stress or during tissue repair, some adult cells can reverse to become a more immature cell type or even shapeshift directly from one mature type to another, a feature known as plasticity. And if you add just four proteins, known as Yamanaka factors, to adult cells in a lab dish, you can push them all the way back to pluripotency – the head of the valley – creating what are called induced pluripotent stem cells (iPSCs). If you then give these iPSCs the right signals, you can guide them back down the landscape towards the new cell type you desire.

The same is also true of cancer cells, which can be fully or partially reprogrammed to a pluripotent state and then transformed into benign cell types. In 2019, for example, a team at the University of Basel in Switzerland used a cocktail of drugs to prod breast cancer cells into a kind of plasticity seen both in cancer spread and normal wound healing, before directing them to become harmless fat cells.

Cancer cells can also reprogram themselves, either on their own or in response to treatment. Pajonk's lab, for example, has shown that radiotherapy, as well as killing glioblastoma cells and prolonging patient survival, also prompts some tumour cells to start producing Yamanaka factors. This pushes certain glioblastoma cells to become what are called cancer stem cells, which tend to be resistant to anti-cancer therapies and have the ability to regrow the tumour. These induced cancer stem cells, which have been seen in other cancers, are part of what makes glioblastoma so deadly.

"They can reprogram themselves and then differentiate to the other lineages," says He. "That's why it is very hard to treat this devastating disease."

To see whether they could use this reprogramming to prod the cells into a non-cancerous state, He and her colleagues turned to an intracellular signaling molecule called cyclic adenosine monophosphate (cAMP) that stem cell biologists use to push iPSCs to differentiate into neurons. They treated irradiated glioblastoma cells with cAMP and found that the cells started to differentiate into two types, neurons and microglia cells.

Unfortunately, cAMP isn't practical for use as a drug, so the team turned to forskolin, a molecule known to boost cAMP in cells. When

> "EDUCATING CANCER CELLS MIGHT OFFER A BETTER SOLUTION THAN KILLING THEM

Cancer treatments like chemotherapy focus on destroying cells

> YOU'RE CONSTANTLY BATTLING THIS EVOLUTIONARY BEAST THAT IS TRYING TO FIGURE OUT HOW TO SURVIVE

irradiated glioblastoma cells were treated with forskolin in a lab dish, they differentiated in a similar fashion to the cAMP-treated ones. He and her team then tested the same treatment combination in healthy mice injected with mouse glioblastoma cells. These mice survived about three times longer than untreated mice or those treated with radiation alone.

"We were very surprised to see the strong effect of the forskolin," says He. Many anti-cancer drugs that work in a lab dish fail to have an effect when tested in animals, she says, but not in this case. "We were thrilled to see that."

He and her colleagues are now investigating whether the cells remain differentiated permanently, as well as whether it is possible to boost the mice's survival rates by changing their dosage regimen. Taking the treatment to clinical trials, however, might prove tricky: forskolin is readily available as a health supplement, so can't be patented – meaning drug firms will be reluctant to take it forward, says He. Still, it is evidence that differentiation therapy could work for glioblastoma.

Directing cells themselves is one option. Another is tackling the abnormal environment surrounding a tumour that helps drive malignancy. These approaches are known as tumour reversion strategies. Rather than looking for bottom-up causes of cancer in genes, as the somatic theory suggests, they seek to explain the disease in terms of mechanisms cascading "top down" from higher levels of biological organisation, such as tissues, to lower-level ones, like cells.

"This is all the system, in its entirety, that is changing," says Mariano Bizzarri, Pensotti's colleague, now at Sapienza University in Rome.

Drawing on previous findings that embryonic environments can regulate malignancy in cancer, Bizzarri's team is testing extracts collected from fish embryos at various stages of development. The researchers have identified one particular kind of molecule, known as a microRNA, that seems to curtail malignancy in multiple ways.

Prediction machines

Ben Stanger, who researches pancreatic cancer at the University of Pennsylvania, is exploring the flipside of this mechanism: how a pancreatic tumour corrupts the surrounding tissue so it forms cell types that support and protect the tumour, and how this interacts with tumour genetics. Stanger cautions, however, that any treatments will have to contend with the forces driving cancer cells to overcome attempts to shackle their growth or survival. "You're constantly battling this evolutionary beast that is trying to figure out how to survive your selective pressure through whatever means, whether those are epigenetic or genetic," he says. Luckily, state-of-the-art computational biology is lending a hand.

In the decades since Waddington proposed his landscape, scientists have worked to better understand how cells interact with their environments and the molecular mechanisms by which they do so. Projects such as the Human Cell Atlas, for example, have revealed how the activation of specific genes and other molecules create cells' specialised forms and functions. But understanding how a cell's physical form and behaviour, be it normal or malignant, emerge from the interactions between these tens of thousands of parts remains a challenge. To do this, researchers have drawn on a branch of mathematics known as dynamical systems theory to model how networks of molecules create different cell types and states.

Kholodenko and his colleagues, for example, have built a computer model called cSTAR that lets them create "digital twins" of different cell types, including cancerous ones. By modelling the networks controlling these cell types, the researchers could predict how different drug combinations would influence them, as well as the effect this would have on the cell's position in Waddington's epigenetic landscape.

"We try to push a cell in a pathological valley over the mountain into the valley that corresponds to a physiological, normal development valley," says Kholodenko. The team tested cSTAR's predictions on neuroblastoma cancer cells in a lab dish and showed that the drug combinations it suggested forced them to differentiate into benign types. The model also lets us predict a cancer cell's pathways to evolving treatment resistance.

What cSTAR does is help researchers get to grips with the intricacies undergirding cancer. Cancer, we increasingly understand, isn't simply the product of genetic mutations or cellular development gone awry, but a combination of genetic and epigenetic factors at many levels of biological organisation. Untangling this complexity, says Kholodenko, is "the grand challenge".

"Once we have learned to seamlessly model across scales, from molecules to cells to tissues and organisms," he says, "we will be able to explain cancer on all levels."

Cancer is a crafty enemy, so bringing it to heel will require more than a single strategy. He's research, the treatment for APL and evidence from other scientists all suggest that differentiation therapies may need to be combined with conventional approaches such as surgery, chemotherapy and radiotherapy.

But after decades of fighting, perhaps it is time to hold at least some of our fire and explore the art of negotiation. ▮

THOMAS FREDBERG/SCIENCE PHOTO LIBRARY VIA REUTERS

Claire Ainsworth is a science journalist based in the UK

The back pages

Stargazing at home

Turning red

Sky watchers around the world are in for a treat. Get ready for a Harvest Blood Moon, says **Abigail Beall**

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

MY FEELINGS about the moon changed in the past year, when I gave birth on the day of not just a full moon, but a Harvest Moon.

For the first few months of my son's life, the passing of time felt very strange – there was little distinction between day and night. But the moon's almost-monthly cycle was there to remind me that the months were ticking on. Every time I saw a full moon, I knew another 29.5 days had passed by. It was a reminder that my son was around another month older.

It is now almost a year later, and the next full moon is going to be particularly special. On 7 September 2025, there will be a total lunar eclipse.

It will be visible to people in most of Europe, Asia, Africa and Australia, and parts of South America, too. From where I live, in the UK, the eclipse will begin when the moon is below the horizon, but about 20 minutes later, around 7:30pm, it will become visible and will stay that way until the eclipse finishes.

As I said, the moon orbits Earth every 29.5 days. During a full moon, our planet sits between the moon and the sun, so that the entirety of the moon's face reflects light back towards Earth.

But because the moon's orbit is slightly tilted compared with Earth's around the sun, the three bodies don't line up in one plane – a phenomenon known as syzygy – during every orbit.

When syzygy happens during a new moon, we get a solar eclipse. When syzygy occurs during a full moon, there is a total lunar eclipse.

JG PHOTOGRAPHY/ALAMY

When this happens, the moon moves into a shadow cast by Earth. This is why the moon is always visible during a lunar eclipse – it just appears darker and redder. The only light that still reaches the surface of the moon and is reflected back at us has passed through Earth's atmosphere, which scatters most of the wavelengths of light except the red ones.

To work out when to see the eclipse, and how much of it will be visible from where you live, you can use interactive eclipse maps. These will give you the best idea of how to view it.

Unlike a solar eclipse, you don't need any special protective equipment to view a lunar eclipse – just a clear sky. Once you know when to look, find the moon and watch it darken and redden (pictured). You might want to see how it looks through some binoculars. If you live in the UK, the moon will be low in the eastern horizon that night, so you will need to find a spot with a clear view to the east.

This specific event is known as a Harvest Blood Moon – "Harvest" because it is the full moon that occurs right before the autumn equinox, and "Blood" because of the moon's red colour during an eclipse.

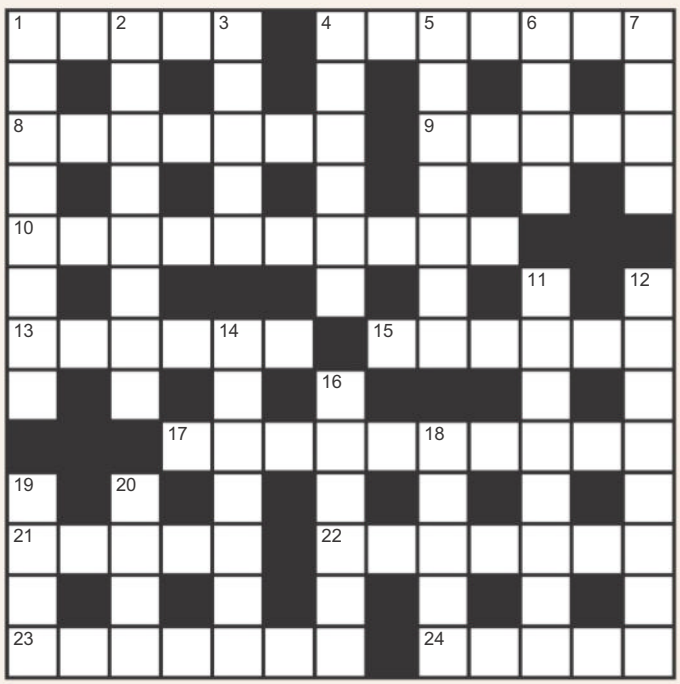
I am not sure if he is old enough to appreciate it yet, but I will be taking my son, born on a Harvest Moon, out to show him the total eclipse. ▮

Stargazing at home appears monthly

Next week
Mathematics of life

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

Cryptic crossword #169 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Black bee disrupts auction (5)
4 Praise second of two options after bit of fence-sitting (7)
8 New version visibly embarrassed host (7)
9 Line of light adorning fabric (5)
10 Twice taps nose of sea bream (5,5)
13 I bet UV breaks down medical conduit (2,4)
15 Amino acid base contains sulphur, iodine and nitrogen (6)
17 Paper-maker and I hopped on a Zoom about small division (10)
21 Reportedly level a group of plants (5)
22 Romantic outing involves playing Tango records (7)
23 Our group maintains narrow passage for fish (7)
24 Evenly divide volume in well (5)

DOWN

1 Preps for the theatre scene with Hamlet's catch and wicked deed (6,2)
2 Worried mudbath covering Olivia's left smear (8)
3 Tests small chopper in ascent (5)
4 Understand dad replacing hesitation with vacuous optimism (6)
5 Waste a cup (7)
6 Goodbye text framed by petty lover (4)
7 Foul-smelling class (4)
11 That man's implement collects pinch of soft, peaty earth (8)
12 Pair of newshounds write article, forgetting drug? (8)
14 Military unit ordered outside drilling structure (7)
16 Say a vow quietly atop outcrop (6)
18 Lighter craft finally included in airspeed measurement (5)
19 Several awls, 50 per cent reduced, iron inside (1,3)
20 Survey extreme north or south sonically (4)

Our puzzles are now solvable online
newscientist.com/games

Quick quiz #317
set by Corryn Wetzel

1 What is the term for a sharply defined transition zone between ecological communities?
2 What hormone triggers ovulation in humans?
3 An aerogel made from what substance can extract gold from e-waste?
4 What is the name given to the maximum number of stable relationships that a human can supposedly maintain?
5 What element is used in fireworks to create a bright red colour?

Answers on page 47

BrainTwister
set by Graham Smith
#88 Double base

In the grids below, the top row represents 0 and the bottom row represents 1. For each puzzle, choose one box from each column so that if the selected contents are read as an expression, it results in the same value as the corresponding binary number. For example:

0	(7)	+	9	×	(4)	1	(3)
1	6	(6)	-	(5)	1	/	6

7 6 - 5 4 / 3 = 58

0 1 1 1 0 1 0 = 58

Here are three more for you to try:

5	-	4	+	7
1	-	9	4	5

3	+	1	2	/	8
5	+	7	+	5	2

9	+	9	/	1	/	9
2	7	9	×	4	+	7

Solution next week

Cooling coat

How much difference would it make to global temperatures if the roofs of all the buildings on Earth were painted white?

Mike Follows
Sutton Coldfield, West Midlands, UK
When I answered a similar Last Word question 20 years ago, I expressed the hope that someone would eventually use a climate model to predict the effects of painting roofs white. Since then, there has been a good deal of research into the impact of cool roofs – painted white or with light colours to reflect sunlight – particularly in relation to the urban heat island (UHI) effect, where cities tend to be warmer than the surrounding countryside.

At first glance, cool roofs should increase Earth's albedo – the fraction of sunlight reflected from the surface. This ought to cool the planet, or at least counter some of the warming that has occurred since the industrial revolution. They should also reduce the need for air conditioning and the associated greenhouse gas emissions. However, some of those benefits are offset

"Cool roofs could have saved up to 249 lives during London's hot summer of 2018, according to a 2024 study"

by increased heating demands these roofs cause in winter or in places above roughly 40° latitude.

Cool roofs could have saved up to 249 lives during London's hot summer of 2018, according to a 2024 study. Widespread adoption might have reduced average city temperatures by 0.8°C, preventing nearly a third of the 786 heat-related deaths.

That said, a 2011 global climate model study by researchers at Stanford University in California found that, while the albedo effect of white roofs may lower global urban temperatures by 0.02°C, this could be at the expense of warming Earth overall by 0.07°C. The cool roofs enhanced convection, which increased rainfall downwind of cities. However, reduced cloud cover overall allowed more solar radiation to reach the surface – a positive feedback. It also led to greater solar absorption by airborne soot particles, which absorb both incoming and reflected sunlight.

Meanwhile, green roofs , which are planted with vegetation, are also gaining attention. These require sturdier structures and more materials to support the weight of soil and plants. Although they help cool urban areas during the day by absorbing solar energy, they release that heat at night, raising nighttime temperatures. Their overall effect on the UHI is thought to be neutral – but they do bring other advantages, such as improved biodiversity.

Nick Baker
Rowhedge, Essex, UK
Painting all roofs white wouldn't make much difference. This is mainly because the area of roof compared with the area of unbuilt land is very small. A second reason is that solar radiation delivers about half its energy as infrared and ultraviolet light, which is absorbed by most white paints.

But a white-painted roof would bring a large benefit to those living or working under it, particularly if the roof were badly insulated, such as a rusting sheet of corrugated iron. It is difficult to imagine a worse-performing solution in respect of overheating, and such roofs would benefit hugely from a coat of white paint.

Furthermore, in urban areas, where rooftops form a much higher proportion of the surface intercepted by solar radiation, there would also be a benefit, reducing the so-called heat island effect by several degrees.

Hillary Shaw
Newport, Shropshire, UK
Firstly, what counts as a "building"? A shed, a bus shelter, a pier? Would you also whiten car parks, umbrellas, boats, cars, clothing? What about the sides of buildings? In many areas the sun spends more time below 45 degrees elevation than above it. That could be harsh visually.

Secondly, the process would need a lot of paint to be produced, generating carbon dioxide. Then you have to transport the paint and the scaffolding needed to apply it. Thirdly, you would need to repeat the process every few years, as the paint would become dirty and less reflective. Fourthly, the economic resources for this process might crowd out other green investments.

Maybe just emit less, and consume less too.

JOHN ZADA/ALAMY

Do lefties make better piano players than those who are right-handed, or vice versa?

This week's new questions

Duly noted **Does left-handedness or right-handedness make for a better pianist?**
John Grant*, Caloundra, Queensland, Australia*

Staying warm **When getting dressed in the morning, I want to warm up as quickly as possible. Should I put on my trousers or my top first?** ***Tom Van Oss****, London, UK*

Story time

How does the experience of reading a good novel differ from listening to the same story on audiobook? Are different parts of the brain engaged?

Inés Antón Méndez
Madrid, Spain
There are definitely different parts of the brain engaged, at the very least, at the beginning of the process: reading engages the visual system for letter/word recognition and listening engages the auditory system for phoneme (speech sound) recognition. But I

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Tom Gauld
for New Scientist

suspect that the questioner means differences further down the line.

As *New Scientist* has reported (27 May 2023, p 51), there is some evidence that the processing depth of the two modalities can vary – with reading inducing a more analytical mode than listening.

There are many reasons why this may be the case. It could be that, reading being a relatively recent development in the history of humankind, it is more cognitively demanding, which could ultimately result in a deeper level of analysis than when the task is easier and can be achieved with shallower processing. The fact that one can multitask when listening, but not so much when reading, testifies to the different cognitive demands of the two modalities.

Once the information is extracted, however, it is likely to follow the same path. So, for material for which the analytical and instinctive paths don't deliver different results, how these results are then stored in memory or associate with other knowledge the reader/listener has is probably similar.

"There is one breed of cat that is able to come head first down a tree – the Norwegian forest cat. I have seen mine do it"

With one exception: when committing new information to memory, the what (the content) is processed independently from other ancillary information relating to contextual factors at play when obtaining information, such as where you obtained it, when, etc (which is called source memory). In our case, the "what" of what was read or heard will be accompanied by a different "how" depending on the modality.

Still, I am an avid consumer of both printed books and audiobooks and sometimes I can't remember whether a particular one was consumed through my eyes or my ears. This is because source memory is more labile and likely to be forgotten, leaving only the content or item memory.

Incidentally, I have the same thing with languages. I often can't remember whether I read (or heard) something in English or Spanish. So, language is also treated as source memory and not part of the "essential" content.

Going vertical

Why can squirrels run straight down trees? And could my cat do the same thing if it had to? (continued)

Margaret Muirhead
Canterbury, Kent, UK

Most cats can't come head first down a tree. There is one breed of domestic cat that can – the Norwegian forest cat. These have a stronger build and longer hind legs, which allows them to spread their weight and grip the tree bark with their claws. They also have longer and sharper claws than many other breeds, which helps them grip better too.

I have a Norwegian cross cat and her claws are lethal. I have seen her do it.

Answers

Quick quiz #317 *Answers*

1 Ecotone
2 Luteinising hormone
3 Old milk
4 Dunbar's number
5 Strontium

Quick crossword #190 *Answers*

ACROSS 1 Cicada, **4** Lapwings, **9** Alloy, **10** Black hole, **11** Wire, **12** Odds, **13** Pulse, **15** Cadmium, **16** Hide, **19** AIDS, **20** Tear gas, **23** Among, **24** If so, **25** Oral, **27** Open-ended, **28** Logic, **29** Apoplexy, **30** Neuron

DOWN 1 Chadwick, **2** Chloride, **3** Days, **5** Anaesthetised, **6** Wikipedian, **7** Noodle, **8** Sweden, **10** Body mass index, **14** Diving bell, **17** Agar-agar, **18** Psilocin, **21** Dakota, **22** Pomelo, **26** Blue

#87 Seating mix-up *Solution*

For three passengers, there is a 50 per cent chance of the final passenger getting their own seat. There are four possible arrangements (with probabilities of either one-third or one-sixth), and the ones where the final passenger gets their own seat add up to a probability of 50 per cent. After the second passenger has boarded, their assigned seat is definitely occupied (if it is unoccupied when they board, they sit in it). So there is zero probability of the final passenger sitting in the second passenger's seat. For 100 passengers, the same reasoning can be applied, so the final person must either be in the first person's seat or their own seat. Each is equally likely, so the last person has a 50 per cent chance of being in their own seat.

Computer versus dog

Sometimes Feedback gets an email with such a punchy opening line, we basically have to include it. Hence, we perked up when Elliot Baptist emailed to say: "I thought Feedback might like to know, if Feedback doesn't already, that a well-trained New Zealand dog has surpassed quantum computers."

Elliot was highlighting a preprint paper by two cryptographers, Peter Gutmann at the University of Auckland and Stephan Neuhaus at the Zurich University of Applied Sciences, on the Cryptology ePrint Archive. It is about the long-running effort to create a quantum computer that can factorise an extremely large number – that is to say, identifying two numbers that can be multiplied together to get the target number.

This is an important challenge because a lot of encryption methods rely on huge numbers that are difficult to factorise. If somebody ever builds a quantum computer that can factorise big numbers quickly, a lot of seemingly secure servers and transactions will suddenly become insecure. There have been some milestones towards this: in 2001, IBM built a computer that could factorise 15 (5x3, if you weren't sure), and in 2012 they upgraded to 21 (7x3). By 2019, a start-up called Zapata claimed it could factorise 1,099,551,473,989.

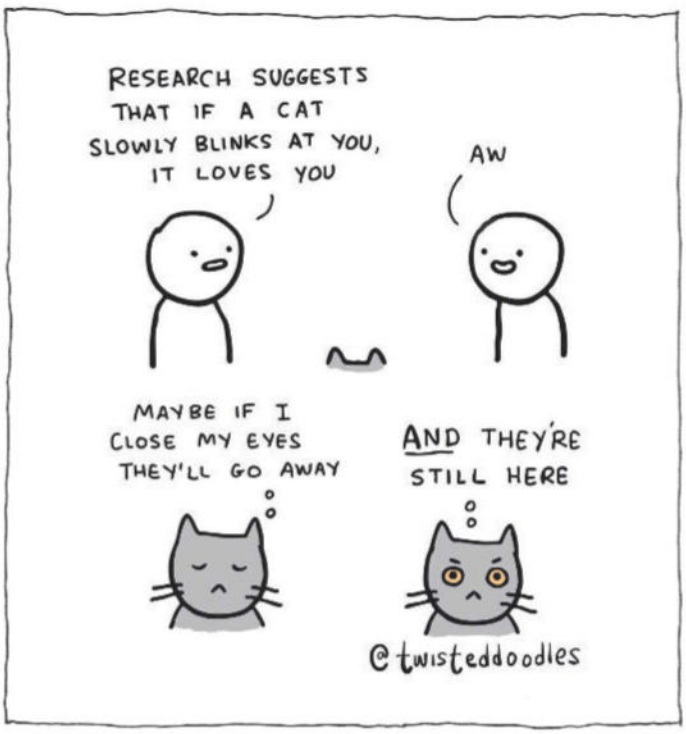
Gutmann and Neuhaus, however, are relaxed about the future of encryption. They argue that many of the quantum factorisations are sleights of hand. "Similar to stage magic, the exercise when responding to a new quantum factorisation announcement is not only to marvel at the trick but to try and figure out where the sleight-of-hand occurred," they write.

Which is why they decided to replicate the quantum factorisations using less advanced forms of technology: specifically, "an 8-bit home computer, an abacus, and a dog". The method using the home computer took them two pages to describe, so we will leave it as an exercise for the reader. The abacus method is simpler, although it does require one abacus with 616 columns for the bigger numbers.

Let us now proceed to the dog-based method. To replicate the original factorisations of 15 and 21, the researchers simply trained a dog to bark three times. "We verified this by taking a recently-calibrated reference dog, Scribble, depicted in Figure 6, and having him bark three times, thus simultaneously factorising both 15 and 21," they write. "This process wasn't as simple as it first appeared because Scribble is very well behaved and almost never barks. Having him perform the quantum factorisation required having his owner play with him with a ball in order to encourage him to bark."

Elliot says he is "not qualified to comment on the validity of the argument", and Feedback would like to add that we may be even less qualified. Any readers that actually understand quantum computing and encryption are invited to write in and explain what on Earth is going on. Feedback probably won't understand the answer, but we will run the explanations past one of Feedback's Felines and see what they meow.

Twisteddoodles *for New Scientist*



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Send it to feedback@newscientist.com
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Consideration of items sent in the post will be delayed

Robotic responses

Feedback's account of next year's "electrifying" Love and Sex With Robots conference, due to be held in Zhejiang, China, drew a few emails, some of which got through our filters.

Tim Stevenson pointed out that we had neglected to mention a key detail, which "would have been most revealing... the fee for attending". Feedback is nothing if not diligent, so we revisited the conference website and discovered that it costs $105.98 to "reserve a spot". We have a suspicion that actual tickets may retail for rather more, but we didn't want to register to find out.

Meanwhile, Pamela Manfield cut to the chase: "Any university or other government-funded organisation that pays to send anyone on its staff... should have their funding cut." Feedback doesn't disagree, but, on the other hand, Donald Trump's administration is cutting all the research funding anyway, so perhaps the point is moot.

Seasonal injuries

Nicole Rogowski writes in to highlight a study from 2023 that had somehow escaped our attention. She suggested it was an example of "no shit, Sherlock" – a study that goes to enormous lengths to demonstrate something obvious – but Feedback doesn't agree, because you could have forced us under extreme duress to spout obvious-sounding statements for 100 years and we would never have come up with this. The study is called "Penile fractures: the price of a merry Christmas", which, as Nicole says, "speaks for itself".

The researchers explored whether penile fractures – technically "the rupture of the tunica albuginea surrounding the corpora cavernosa", as "heralded by an audible crack" – were more common at certain times of year, using data from 2005 to 2021 from Germany. Apparently, the Christmas period (24 to 26 December) and the summer show higher rates of penile fractures, but curiously not the New Year period (31 December to 2 January). The authors suggest that "Christmas might be a risk factor for penile fractures due to the 'Christmas spirit' related to the intimacy and euphoria of these holly jolly days."

The paper concludes: "Last Christmas penile fractures occurred more often. This year to save us from tears, we will NOT do something special."

Apologies for any typos: Feedback wrote this entire section curled up in the fetal position.

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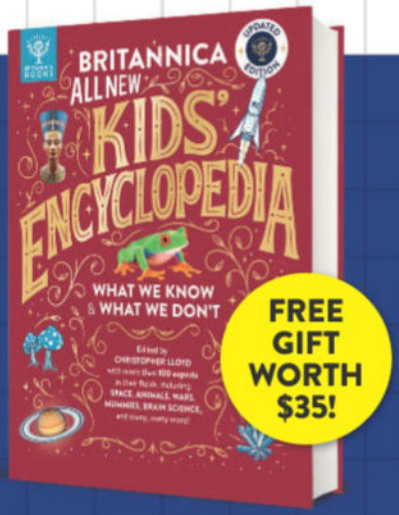

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