

New Scientist

WEEKLY 22 July 2023

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NS Live

Ultra-processed people

Award-winning broadcaster, doctor and academic Chris van Tulleken will take to the stage at New Scientist Live on 8 October to explore the invention of ultra-processed food (UPF) and our difficult relationship with it. He will reveal what UPF is doing to our bodies and the planet – and how we can overcome its allure.

[newscientist.com/nsimag](https://www.newscientist.com/nsimag)

Tour

Science of the Incas: Peru

Immerse yourself in the Inca civilisation's most important archaeology, science and history while exploring the beautiful Sacred valley. Plus, visit Machu Picchu and investigate religious sites in the company of Emmy award-winning cinematographer and anthropologist Peter Getzels. This 10-day tour is set to begin on 17 September and tickets cost £3399.

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Podcasts

Weekly

The team is intrigued by a mathematical proof so complex that mathematicians can't agree on whether it makes sense – even 10 years after it was proposed. There is also a special birthday to celebrate! It has been a year since JWST started collecting data. The team looks back at the amazing images of the universe it has already produced. Plus: ancient jewellery made from giant sloth bones.

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Fake food How to overcome the allure of ultra-processed produce



Inca archaeology Explore the Sacred valley in the Andes of Peru

Video

Earth's demise

Naturalist, photographer and presenter Chris Packham's new BBC series, *Earth*, looks at significant moments in our planet's history – from its geological past all the way to anthropogenic climate change and biodiversity loss. These recent problems are what worry him the most. It isn't a sixth mass extinction event we are precipitating, he says, it is a mass extermination event.

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Newsletter

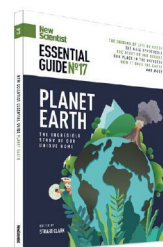
Our Human Story

Humans were hunter-gatherers for hundreds of thousands of years before starting to adopt farming around 10,000 years ago. Michael Marshall takes a deep dive into the reasons why farming became the norm and why this often-misunderstood turn of events is so important to our lives today.

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Podcast

“There’s a \$1 million prize for whoever finds an inherent flaw in the theory”



Essential guide

Our planet still holds many secrets. How did Earth form? How is it changing with global warming? And are there other Earth-like worlds out there? This *New Scientist Essential Guide* offers answers. Available to download in the New Scientist app or to purchase in print from our shop. shop.newscientist.com

IT'S TIME TO UPDATE THE SYSTEM

1.
European financial institutions are an essential part of the traditional financial system, but many rely on aging technology invented before the internet that isn't best serving them or their customers. Crypto can help make the system faster, safer, more transparent, and more equitable - for everyone.
2.
A recent consumer survey suggests that the British people have made it clear they want an update. 22% of all adults in the UK hold some form of crypto, joining the ranks of over 400 million crypto users around the world - because it offers a real technological solution. If crypto users were a country, they would be the third largest nation by population in the world.
3.
66% of crypto users live in the developing world, often in places where the current system fails to meet their needs. Here in the UK, 1.3 million people are unbanked and can face high fees to use their own money. Crypto can offer people a cheaper, more efficient way to participate in the economy.
4.
Crypto makes money portable - and much more accessible. At the beginning of the war in Ukraine, banks shut down and ATMs ran out of cash. With few ways to access crucial funds, Ukrainians turned to crypto to take back control of their financial freedom. Crypto is 24/7 and always with you.
5.
Crypto remittances in the UK reached \$33 billion according to 2021 estimates from the World Bank, demonstrating the crucial importance of crypto technology and international transfers. Traditional financial services can be slow and expensive, while crypto transactions may offer a more efficient, transparent, and nearly instantaneous alternative.
6.
Crypto isn't going anywhere. Widespread adoption has already begun, and the UK and the EU are quickly positioning themselves as industry leaders. Landmark regulations such as Markets in Crypto-Assets aim to create stable, healthy environments for important crypto innovation to flourish. This technology can help update aging financial infrastructure, giving customers more financial freedom and institutions new tools to drive innovation.

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Thinking about thinking

Subjective experience is intrinsically hard to understand – but it is worth trying

THE quest to understand the human brain and its most mysterious output – consciousness – has been ongoing for centuries. There are now several competing ideas that seek to explain how we generate the sensations of sentience, but, so far, progress has been slow.

One idea, known as integrated information theory (IIT), is an attempt to mathematically quantify the level of consciousness of any information-processing system. But it is currently impossible to work out a value for the entire human brain because we don't yet know the structure of this 86-billion-neuron organ in detail. Even if we did, the calculations would be too onerous.

A new approach gets around this problem by applying the calculations

to a simplified model of the human brain (see page 8). This is a step in the right direction, but it is still early days for IIT.

Some argue that the whole endeavour is futile and that it is beyond the scope of the thinking mind to understand how its own subjective experience occurs.

"We don't yet know the structure of the 86-billion-neuron human brain in detail"

And yet, we shouldn't lose heart. Firstly, we are making progress in understanding our inner thought processes, even if they are very different to those of others (see page 32). Secondly, some of humanity's greatest advances emerged from serendipitous discoveries

in apparently unrelated fields, often when scientists were prepared to think big.

For instance, there have been numerous unexpected spin-offs from space exploration research, from fire-fighting kit to cochlear implants. We have the gene-editing therapy CRISPR only thanks to research into bacterial defences against viruses. And the world wide web was developed as a way for particle physicists at CERN to share their data.

Research into consciousness could lead to better treatments for people with medical conditions that affect awareness levels, new forms of artificial intelligence or perhaps advances that we can't yet imagine. When scientists aren't afraid to take on these daunting challenges, who can say where their journey will end? ■

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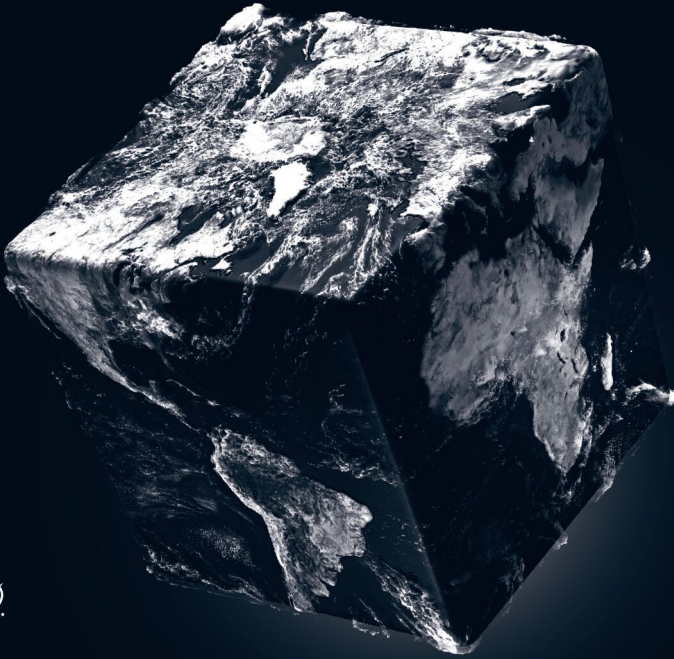
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Podcast

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Dead Planets Society

Astrophysics with a side of destruction

Have you ever wondered what might happen if we chiselled Earth into a cube or cracked the moon in half? Join the Dead Planets Society to find out.

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Racist tech

Training AIs on larger data sets may strengthen biases **p12**

Deforestation surge

Bolivia's government is fuelling habitat destruction **p13**

What goes up...

A meteorite left Earth then returned to the surface **p16**

Extended family

Two species of bird raise chicks together in one nest **p18**

Malaria vaccine

Shot may protect against relapsing form of disease **p19**



Astronomy

Staring at the sun

The Daocheng Solar Radio Telescope, located in Sichuan province, China, has just begun its first observations. It consists of 313 six-metre-wide radio antennas encircling a 100-metre-high calibration tower. The antennas are designed to continuously monitor the sun, looking for solar flares and bursts of plasma called coronal mass ejections.

A new way to know our minds

Integrated information theory, one of the leading explanations for how consciousness emerges, appears to work when applied to human brain scans, says **Clare Wilson**

BRAIN scans taken as people slip into anaesthesia are offering support for one of the foremost explanations of consciousness. The approach may lead to progress in understanding the brain as well as new ways to test awareness in people with medical conditions of consciousness, such as those in a vegetative state after head injuries.

Scientists and philosophers have long struggled to explain how the brain produces consciousness – the feeling of being aware of your surroundings or internal sensations and thoughts – and there are a number of competing ideas.

One called integrated information theory (IIT), first proposed in 2004 by Giulio Tononi at the University of Wisconsin-Madison, says something has a higher level of consciousness if the interactions between its components yield more information than when reduced to just its components. In other words, the whole is greater than the sum of its parts. The concept can quantify the complexity of any information-processing system, from brains to computers, but is a work in progress.

IIT predicts that it is possible to calculate a mathematical value for the level of consciousness, termed phi, of any information-processing system with known structure and functioning. But this requires a lot of calculations and as the number of connection points, or nodes, within an information-processing network grows, the maths involved rapidly gets exponentially bigger.

Currently, phi can only be calculated for systems with fewer than about 10 nodes. So if each of the roughly 86 billion neurons in the human brain is treated as one node, it would be impossible to work out its value of phi, even

if we knew its complete structure.

To get round that problem, Andrea Soddu at the University of Western Ontario, Canada, and his team used brain-scanning data to calculate phi for simplified models of specific neural networks within the human brain that have known functions, such as the visual cortex.

“The approach may lead to progress in understanding the brain and conditions of consciousness”

Instead of regarding each neuron as a node, they treated small, anatomically defined brain areas as nodes, selecting five nodes for each network, doing this for 11 networks in total.

To get the data, the team asked 17 people to lie in a brain scanner as they experienced four different states of consciousness – awake, mildly sedated, unconscious and in a recovery stage – brought

about by using anaesthetic.

The scans were made using functional magnetic resonance imaging (fMRI). This allowed the team to assign a value of 1 (relatively high activity) or 0 (low activity) to each small brain area, over successive time points.

To calculate phi for each network, a huge data set made from the scans was fed into a software package written by Tononi and his team. The results from all 17 people in the study had to be merged to have enough data without requiring them to spend too long in the scanner.

For two brain networks, the researchers found that phi was lower when people were in deep anaesthesia than while awake, with an intermediate level for mild anaesthesia (*Communications Biology*, doi.org/kj7). The networks – the frontoparietal and dorsal attention networks – were already thought to play a key role in consciousness. The other networks didn't show a clear, decreasing trend in phi from an awake state through mild anaesthesia to deep anaesthesia,

but showed small movements of phi either rising or falling.

As these two networks were the only ones where the calculated value for phi behaved as expected, this lends further support to their role in consciousness, says Soddu.

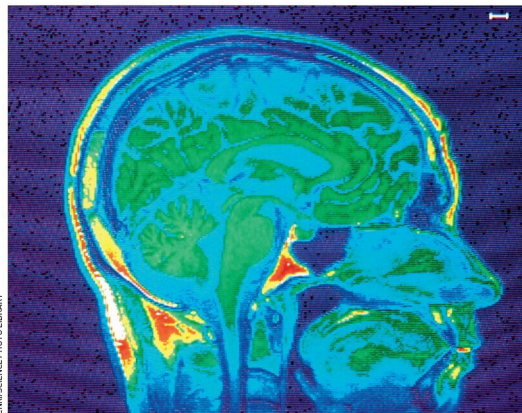
This is the first time phi has been calculated from brain-scanning data using the current incarnation of IIT, known as version 3.0, although similar studies have been done using the previous version, called 2.0.

Soddu's team is currently investigating if calculations of phi for these brain networks could be used to indicate brain function in people with conditions of consciousness. While those results aren't yet published, “they go in the right direction”, he says.

UnCheol Lee at the University of Michigan Medical School in Ann Arbor says it would have been better if phi had been calculated for individuals.

Melanie Boly at the University of Wisconsin-Madison, who helped develop IIT with Tononi but wasn't involved in this research, says the approach only gives an approximation of phi for the human brain. But she, Tononi and others have now further refined IIT and version 4.0 will be published shortly, she says.

Yet the work may not convince critics of IIT, such as Scott Aaronson at the University of Texas at Austin. “If you look at brains in fMRI while they're being sedated and woken up, it's clear and uncontroversial that you can see large changes in activity levels and in patterns of information transfer between different regions,” he says. “You can surely learn many interesting things by examining those patterns, with or without IIT.” ■



CONSCIOUSNESS PHOTO LIBRARY

For a new understanding of how we think, see page 32

Physics

Portal-like “ring wormholes” could be used as a time machine

Leah Crane

WORMHOLES are often thought of as tunnels through space-time with black holes for entrances, but they could theoretically be flat instead, like a door into another location, another universe or the past.

These “ring wormholes” would be made up of a string of exotic matter with negative energy – a property that is possible due to quantum effects, but only, as far as we know, in extremely small amounts. Because of the way this exotic matter would warp space-time, a circle made of one of these strings would act as a sort of portal to another area of space-time.

“You could go through and not even notice that you went to another universe,” says Andrei Zelnikov at the University of Alberta in Canada.

Zelnikov and his colleagues calculated that such a wormhole could actually allow you to travel through time as well. If the entrance of the wormhole were placed in a higher gravitational field than the exit – meaning one is near lots of matter and the



A ring wormhole could let you travel to the past

other isn’t – the two sides of the wormhole would experience the passage of time at a different rate. This is due to a known effect of general relativity called gravitational time dilation (*Physical Review D*, doi.org/kj44).

That means that if you passed through the wormhole and then came back, you would effectively travel through time. “The time machine is a natural consequence

of the wormhole existing,” says Toby Wiseman at Imperial College London. “Apart from the crazy matter that makes up the wormhole, there’s nothing too wild being postulated here, and then the consequence is something even more crazy.”

This wouldn’t allow unlimited time travel, says Zelnikov. You would never be able to travel back in time to before the wormhole became a time machine. “Mathematically, you can go to the past, and your older self and younger self meet,” he says. “There

are many logical paradox problems, but mathematically there are no contradictions.”

Practical issues are another story entirely. “I doubt there is any way to make such a string with known matter fields, so probably this is not a physically possible situation,” says Aron Wall at the University of Cambridge. “But we can still ask what would happen.”

Then there is another issue: some prior work has suggested that once anything that would allow you to travel back in time like this has formed, quantum effects would obliterate it.

“It may be impossible, if you take into account quantum effects, but nobody knows how to take into account quantum effects in space-time,” says Zelnikov.

Even if these effects make it impossible for ring wormholes to exist, their relative simplicity compared with regular wormholes means studying them could help us understand these quantum wrinkles better, or why time travel seems to be off-limits in our universe, says Wiseman. ■

Animals

Snub-nosed alligator chomped on snails

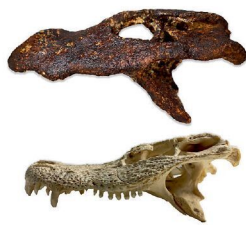
A STRANGE reptile fossil found 18 years ago has now been identified as an ancient alligator species that had an unusually short snout and may have feasted on snails.

When the near-complete skull was first unearthed in north-east Thailand in 2005, experts weren’t sure what they were looking at, other than that it was probably an alligator species. “The skull was really bizarre,” says Márton Rabi at the University of Tübingen in

Germany. “It was screaming that it has to be a new species.”

He and his colleagues recently took up the task of identifying the creature. Using computerised tomography scans, the researchers compared the mystery skull with those of four extinct alligator species and seven living species, including American alligators (*Alligator mississippiensis*), Chinese alligators (*Alligator sinensis*) and spectacled caimans (*Caiman crocodilus*).

A handful of unique characteristics stood out: a short snout, a tall skull and a broad head. The reptile also had fewer tooth sockets than



Skull of the newly identified *Alligator munensis* (top) and *Alligator sinensis* (bottom)

suggesting its diet included snails.

These unusual traits led the team to conclude it was a separate species, which they named *Alligator munensis* after the nearby Mun river. Fossils of nearby species suggest the short-snouted alligator could have lived up to 200,000 years ago or as recently as a few thousand years ago. There are no clues yet as to why the alligator went extinct (*Scientific Reports*, doi.org/kj4x). ■

Corryn Wetzel

How can we keep homes cool without air conditioning? Many countries must adapt buildings to cope with extreme heat, but there are ways to do this without increasing energy use, says **Madeleine Cuff**

AS THE extreme heatwaves currently affecting parts of Europe, Asia and the US make clear, homes in many areas of the world urgently need to be changed to help residents cope with a hotter climate. The big challenge is how to adapt for extreme heat without a big expansion in the use of air conditioning, which would be environmentally ruinous.

The need for cooling strategies around the world was highlighted last week by a study estimating how often interventions such as additional ventilation or air conditioning would be required to keep populations comfortable. While nations in central Africa face the highest needs for cooling overall under global warming of 2°C, the UK, Ireland, Switzerland and Norway will face the most dramatic relative increases in hot days (*Nature*, doi.org/kj47).

These European locations are “dangerously unprepared” for the cooling challenge they face, according to Nicole Miranda at the University of Oxford, who worked on the study, largely because their infrastructure and housing stock are built for a cool climate. “Countries in the northern hemisphere face one of the biggest adaptation challenges,” she told a press briefing.

The quickest, simplest solution is to install air conditioning. But this would lead to a huge increase in electricity demand, researchers warn, putting power grids under strain and driving further climate change. “If our homes are overheated and the first solution that we run to is air conditioners, that is going to drain our energy systems,” said Miranda.

A greener solution would be to roll out “passive cooling” technologies, which don’t require large energy inputs. Bertug Ozarisooy at the Middle



Windcatchers let cooler air flow into houses through a chimney

East Technical University in Cyprus looked at the most effective of these options for modern, efficient housing in the UK.

His focus was the three-bedroom, semi-detached Üserhuus, a concept home built in 2015 on the Building Research Establishment campus in Watford. This was designed as an affordable, modular property that minimises heating demand. But the property posed a “severe overheating risk” during the summer, says Ozarisooy. “I lived in this property for almost seven weeks during the long-term heatwave of summer 2018,” he says. At points, he says, “my bedroom temperature at nighttime was 33.5°C [92°F].”

Using computer models of the house to test the impact of different interventions, he found that adding a windcatcher, a type of ventilation chimney commonly installed in homes across the Middle East, was the most effective for reducing indoor temperatures.

Windcatchers capture the cooler breeze from high above the ground and direct it into the building, pushing out the warmer air inside the house. However, although windcatchers could be easily integrated into new-build homes, retrofitting them is likely to be complex and expensive.

Other impactful – and easier to retrofit – changes include installing external shutters and shading to windows and doors, which helped to bring the

“Opening windows at night and pulling down shades during the day can have a big effect”

temperature of the Üserhuus living room and bedroom down to manageable levels, and redesigning the kitchen and living area to create an open-plan layout with better ventilation, which cooled the kitchen by up to 5°C.

Green technologies also need to be installed thoughtfully, says Ozarisooy. Where possible, solar panels should be put on the roof of unoccupied buildings, such as

garages, since they can warm up in the sunshine, then radiate heat into the home via the roof. Meanwhile, placing battery storage devices in garages or in attics, rather than putting them in cupboards inside the house, prevents them from pumping extra heat into the home.

Immediate solutions

Households in the grip of a heatwave can take immediate steps to make their home cooler, without spending any money. A 2022 study by Alexandra Rempel at the University of Oregon and her colleagues showed that opening windows at night and pulling down shades during the day can lower peak indoor air temperatures by 14°C during a heatwave.

“Most heat in a home comes from two sources: first, people, lights and electrical appliances and equipment, and second, solar heat gain through windows,” says Rempel. “Hot outside air is actually a very small source.”

Blocking sunlight from entering the home is therefore an effective way to keep temperatures under control. External shutters and awnings work best, but internal blinds fitted with side tracks also help to a degree, she says.

As night falls and temperatures drop, windows should be opened to allow cool air to circulate. If necessary, new windows and security systems should be installed to allow this. “The important thing is to open up the entire house at night, to open the windows as soon as outdoor air is cooler than indoor air, and to leave them open all night until the next morning, closing them only when the outdoor air begins to approach the indoor air temperature again,” says Rempel. ■

Pigs open doors to free trapped companions

Carissa Wong

WHEN a pig is trapped in a separate enclosure from its group, other pigs come to its aid, suggesting they may have empathy for each other.

Researchers have previously found that domestic pigs (*Sus scrofa domestica*) become stressed when they see others of their kind in a fearful state. Liza Moscovice at the Research Institute for Farm Animal Biology in Dummerstorf, Germany, and her colleagues wanted to test whether the animals would take action to relieve each other's distress.

"It can't be ruled out that the pigs acted selfishly and simply enjoyed solving the puzzle"

They placed groups of nine or 10 pigs in a pen connected to two smaller compartments, with doors that could only be opened from the main pen.

The pigs learned to open the doors by using their snouts to nudge the door handles without human intervention. Then, the researchers trapped one pig inside one of the two compartments, while leaving the other compartment empty.

Out of 75 trials – each lasting 20 minutes and with different trapped pigs – a group member in the main pen released the confined hog 85 per cent of the time. On average, it took the pigs 2.2 minutes to open the door leading to the trapped animal. They also opened the door to the empty compartment in 68 per cent of the trials, but not as quickly, taking 3.9 minutes on average (bioRxiv, doi.org/kj48).

While the findings suggest that pigs feel empathy for each other, it can't be ruled out that they were acting selfishly and simply enjoyed solving the puzzle, says Sébastien Goumon at the Swiss Federal Institute of Technology in Zurich. ■

Elon Musk gets back into AI

The entrepreneur has big ambitions for his latest tech company, but he faces accusations of hypocrisy, says **Chris Stokel-Walker**

What is xAI?

xAI is Elon Musk's latest venture, which he announced on 12 July. Its 12-strong team plans to "understand the true nature of the universe", according to an announcement posted on the xAI website.

The venture is separate from X Corp, the umbrella company of Twitter, according to xAI's website. But it will "work closely" with Musk's other companies, including Twitter and Tesla, which uses AI for its self-driving cars. "I don't know what the deal with the Xs is," says Catherine Flick at De Montfort University, UK. "He obviously just likes Xs."

Why has Musk launched it?

It is an extension of Musk's longstanding interest in AI and his return to the field after pulling funding from OpenAI back in 2018. Musk had been the primary bankroller for the firm – which created ChatGPT – at its launch in 2015, appearing on stage at an academic conference announcing \$1 billion in funding.

Musk reportedly withdrew from OpenAI after he bid to take over running it, worrying it had lost ground to Google in

developing AI technology, and was rejected by co-founder Sam Altman. Since then, he has taken potshots at OpenAI on Twitter, including criticising a shift in how it was funded when it went from being a not-for-profit company to a for-profit firm with a \$30 billion valuation.

"He's the sort of person who has a lot of money and can afford to dump billions of dollars into vanity projects," says Flick. Musk didn't respond to a request to comment for this story.

Who is involved?

The dozen named initial members of xAI's team include former employees of DeepMind, OpenAI, Google Research, Microsoft Research and Tesla, as well as researchers at the University of Toronto in Canada.

Although the team members are drawn from a diverse range of firms and organisations, their gender make-up is significantly less diverse: they are all men.

"He's brought together a bunch of men to work on understanding the universe, whatever that means, which is, as a philosopher... it's just the cheapest version of armchair philosophy," says Flick.

What will the company aim to do?

Besides attempting to understand the universe, it seems likely that xAI will try to develop what Musk deems a safer, fairer AI system. In March, Musk was one of 1800 signatories of a letter calling for a pause on the development of AI systems, citing safety fears about their untrammelled advance.

"A lot of people who know Musk tend to think he's well-intentioned and he's worried about AI [being] developed in a wrong way, and he thinks he can do it in a safer way, but it's hard to tell whether that's sincere," says Carissa Véliz at the University of Oxford. "It's hard to separate what is genuine intention from what is an ego trip."

Véliz points out it is hypocritical for someone who, earlier this year, was saying AI development should be paused to now be limbering up to take part in the race. "It seems like he's doing exactly the opposite, further fuelling the arms race of AI," she says.

She is also concerned about the potential links between xAI and Musk's plan to create a platform called TruthGPT, which he spoke about in April: "He said he was concerned about ChatGPT because it was being trained to be politically correct and he wanted a chatbot that would speak the truth – implying the truth was sexist and racist. That is incredibly concerning."

Will it succeed?

That's the billion-dollar question. "It's impossible to tell," says Véliz. "Succeeding in what? It's not even clear what the objective is." ■



JOEL SAGE TAPPIVA/GETTY IMAGES

Big data may make AI more racist

Training artificial intelligences on larger data sets seems to strengthen their biases

Jeremy Hsu

MANY tech companies assume that training artificial intelligence on more data can help fix the ongoing problem of AIs replicating human prejudices, but it turns out that using larger data sets can produce more racist and biased results.

Abeba Birhane at the Mozilla Foundation and her colleagues compared two data sets provided by the Large-scale Artificial Intelligence Open Network (LAION), a non-profit that offers open-source data sets for AI training. One contained 400 million samples and the other 2 billion, each an image coupled with text descriptions.

The researchers trained AIs on millions of randomised samples from both data sets. Then they challenged the AIs to classify human faces with neutral expressions taken from a separate open-source data set. There were several categories the AIs could use, including: human being, animal, gorilla, chimpanzee,

orangutan, thief, criminal and suspicious person.

Compared with the AIs trained on the smaller data set, those trained on the larger data set were more than twice as likely to put Black female faces in the “criminal” category and five times more likely to classify Black male faces that way (arXiv, doi.org/kjvw).

“The findings show that the larger, the worse, as opposed to the larger, the better,” says Birhane.

A related content analysis of the two data sets also showed that the larger of the two had statistically significant increases in the percentage of samples that contained hateful, aggressive or targeted speech aimed at specific groups of people.

“They’re the first ones I know of that have looked at the impact of scale and how going between different [data set] sizes impacts biases,” says Sasha Luccioni at Hugging Face, a company that develops tools for sharing

AI code and data sets.

Such findings defy what has become an unquestioned assumption among many AI researchers that scaling up data sets makes for more diverse and less biased training data. But Luccioni pointed out that much internet data scraped to make larger data sets comes from a subset of websites that each contain certain biases.

Jenia Jitsev at LAION says the claims about larger data sets having more hateful content or producing more racist AI results are “too strong” based on the specific evaluations used in the study. Still, they say that the organisation is interested in working with the researchers on future evaluations of the LAION data sets.

Many tech companies and organisations still aren’t performing basic quality checks to scrub biased or hateful samples from training data sets, says Vinay Prabhu, an

independent researcher in San Francisco and co-author of the study. “Here are the low-hanging fruits, and you’re not even picking the low-hanging fruits.”

“The findings show that the larger, the worse, as opposed to the larger, the better”

Another challenge is that companies such as OpenAI, Microsoft and Google often train their AIs on closed data sets that aren’t available for public scrutiny. The researchers suggest that such data sets may be even more biased than the open-source versions offered by LAION and other organisations.

“We criticise LAION because they are open and because we can access that [data], but that doesn’t mean we don’t appreciate and applaud their effort,” says Birhane. “And we hope that big corporations also follow suit and open up.” ■

Animals

A little bit of guidance helps a llama succeed

LLAMAS are better at performing tasks after watching a human or llama do it first. This ability to learn from others, called social learning, is common among highly intelligent animals like primates, but had never before been documented in llamas.

To investigate if llamas (*Lama glama*) could learn from others, Annkatrin Pahl at the Leibniz Institute for Farm Animal Biology, Germany, and her team challenged 30 llamas on three farms to find a food reward behind a fence. On one side of a rectangular enclosure,

behind a V-shaped metal fence, researchers placed a bowl of food while the llamas watched.

Each llama was led to a starting position at the entrance of the pen and let loose. Some llamas were first allowed to watch humans walk around the fence to get the food, while others could observe trained llamas perform the task. A third group had no guidance. The trial ended after 1 minute or when the llama reached the food.

Overall, around half of the llamas solved the challenge, and those that watched others were more likely to find the reward, and faster. Two of the 10 llamas without guidance found the reward, while six of the 10 watching other llamas found it.



Seven out of 10 llamas observing people succeeded, making humans the most effective guide (*Animal Cognition*, doi.org/kjvr).

“Llamas are able to extract some

Learning from watching someone else is no drama for a llama

information from knowledgeable [llamas] and, interestingly, also humans,” says Pahl. While most of the llamas followed the route of the demonstrators – left or right around the fence – a few took their own path, suggesting they gleaned a more general understanding of the navigation challenge.

The species may have evolved the ability to learn from human cues over thousands of years of domestication. Pahl hopes the discovery will be used to better guide llama care. ■ Corryn Wetzel

Health

Nerve pain from diabetes treated by faecal transplants

Grace Wade

FAECAL transplants have been found to treat diabetes-related nerve pain, a complication affecting more than half of people with diabetes that causes tingling, numbness and stinging.

Liping Zhao at Rutgers University in New Jersey and his colleagues analysed faecal samples from 86 people, 27 of whom had diabetes-related nerve pain and 30 of whom had diabetes without nerve pain. The rest didn't have diabetes.

Genetic sequencing revealed a greater abundance of 1.3 species of bacteria in people with diabetes-related nerve pain than in those without it. On average, they constituted almost 12 per cent of the gut microbiome in people with this pain and less than 2 per cent in people without it, indicating that an altered gut microbiome may underlie nerve pain in diabetes.

So, the team transplanted faecal samples from people without diabetes into a separate group of 22 participants with diabetic nerve pain. Ten people with the condition received a placebo transplant of pumpkin and potato powder.

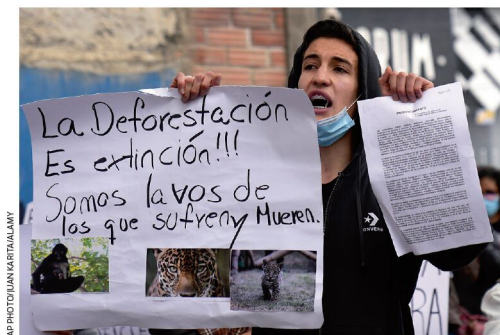
The researchers assessed participants before treatment and 84 days afterwards. On average, nerve pain decreased by about 35 per cent in those who received the faecal transplant and about 5 per cent in those who got the placebo. Additional genetic analysis found that improvements were associated with a distinct cluster of gut bacteria that reduces inflammation, which is known to underlie chronic pain. One of these is *Faecalibacterium prausnitzii*, which has previously been found to be lacking in people with chronic fatigue syndrome (*Cell Metabolism*, doi.org/kjvv).

Currently, there are no treatments approved specifically for diabetic nerve pain, but these findings suggest faecal transplants are a viable option. ■

Environment

Bolivia's deforestation surge alarms environmentalists

Luke Taylor



AP PHOTO/IAN KATZ/ALAMY

THE area of virgin forest cleared in Bolivia jumped by 32 per cent last year, fuelling concerns that government-backed deforestation could jeopardise efforts to save the Amazon.

The rate of tree clearing in the country is now so high that Bolivia accounts for 9 per cent of all the primary forest lost across the globe. Only Brazil and the Democratic Republic of the Congo – which are eight and two times larger than Bolivia respectively – lost more primary forest in 2022, according to the latest figures on forest loss from the World Resources Institute (WRI).

Primary forests – those that haven't been disturbed by human activities – are seen as the most important to protect because of their biodiversity and capacity for carbon storage.

Based on satellite data, the report finds that 386,000 hectares of Bolivian primary forest were lost in 2022. That is equivalent to the emission of 298 megatonnes of carbon dioxide, says the WRI, which makes Bolivia's per capita CO₂ emission rate among the highest in the world.

Total forest cover in Bolivia

has decreased from 63 million hectares in 1985 to 55 million in 2022, and the rate of loss is now about four times that at the start of the 21st century.

Bolivia is one of the few countries that didn't sign up to the Glasgow Leaders' Declaration on Forest and Land Use in 2021, which pledged to end deforestation by 2030. While the leaders of Brazil and Colombia have made net-zero deforestation by 2030 a central campaign pledge and are seeing rates of forest loss fall, Bolivia's government is actively promoting forest clearing.

32%

Increase in primary forest loss in Bolivia in 2023 vs 2022

Unlike in Brazil, where most deforestation is for illegal cattle ranching or mining, the majority of clearing in Bolivia is legal and encouraged by the government to increase agricultural production.

Bolivian president Luis Arce's administration has pardoned environmental crimes and is opening up new swathes of forest for development to



REUTERS/DAVID MERCADO

A protester in La Paz (left) and a burned forest in Charagua, Bolivia (above)

reduce Bolivia's imports and ramp up exports to countries such as China.

The Bolivian government's desire to expand agricultural production means that conservationists fear deforestation will only increase, accelerating the transformation of the entire Amazon rainforest.

Forest fires are a growing cause of deforestation and now make up a third of all Bolivian forest loss. A drier climate means small fires started by farmers to clear plots are increasingly morphing into uncontrollable blazes, says Natalia Calderon, executive director of the Friends of Nature Foundation in Bolivia.

"We're seeing more drought and with that drought we're seeing fires spread out of control. It's likely at least some amount of that drought is happening because of the deforestation and land use practices in other parts of South America in the Amazon," says Mikaela Weisse, director of Global Forest Watch and an author of the WRI report.

The Bolivian government didn't respond to a request to comment. ■

Cash reward to slay maths epic

A decade of disagreements over an impenetrable theory have been kicked up a notch by the promise of a large prize for anyone who can settle the matter, says **Matthew Sparkes**

A PURSE of \$1 million is being offered to anyone who can end the dispute over an impenetrable maths theory, the veracity of which has been debated for years.

Inter-universal Teichmüller theory (IUT) was created by Shinichi Mochizuki at Kyoto

"IUT theory is logically simple. Of course, I mean, technically very, very hard. But logically it's simple"

University, Japan, in a bid to solve a long-standing problem called the ABC conjecture, which focuses on the simple equation $a + b = c$.

This conjecture suggests that if a and b are made up of large powers of prime numbers, then c isn't usually divisible by large powers of primes.

In 2012, Mochizuki published a series of papers, running to more than 500 pages, that appeared to be a serious attempt at tackling the problem, but his dense and unusual style baffled many experts.

Does it add up?

His apparent proof struggled to find acceptance and attracted criticism from some of the world's most prominent mathematicians, including two who claimed, in 2018, to have found a "serious, unfixable gap" in the work. Despite this, a paper on the theory was formally published in 2020, in a journal edited by Mochizuki himself. It was reported by *Nature* that he had nothing to do with the journal's decision.

Since then, the theory has remained in mathematical limbo, with some people believing it to be true, but others disagreeing. Many mathematicians contacted for this story, including Mochizuki, either didn't respond or declined



to comment on the matter.

Now, Nobuo Kawakami, the founder of Japanese telecoms and media company Dwango, hopes to settle the issue by launching a cash prize for a paper that can disprove the theory.

Two prizes are on offer. The first will see between \$20,000 and \$100,000 awarded annually, for the next 10 years, to the author of the best paper on IUT and related fields. The second – worth \$1 million – is reserved for the mathematician who can write a paper that "shows an inherent flaw in the theory", according to a press release.

500
Number of pages detailing
Inter-universal Teichmüller theory

2012
Year that Shinichi Mochizuki
published his theory

\$1m
Prize money on offer to anyone
who can prove it isn't true

The Inter-Universal
Geometry Center
is overseeing the
competition

comprehend the concept.

Kato believes that the controversy stems from the fact that Mochizuki doesn't want to promote his theory, talk to journalists or other mathematicians about it or present the idea in a more easily digestible format, believing his work speaks for itself. Kato says that Mochizuki's current and former students are also reticent to do the same because they see him "as a god" in mathematics and don't want to go against his wishes.

Ultimate challenge

Because of this, most mathematicians are "at a loss" for a way to understand IUT, says Kato, who concedes that, despite earlier optimism about the idea, it is possible that the theory will eventually be disproved.

Ivan Fesenko at the University of Nottingham, UK, who is also deputy director at the IUGC, has long been a supporter of Mochizuki. He told *New Scientist* that there is no doubt about the correctness of IUT and that it all hinges on a deep understanding of an existing field called anabelian geometry.

"All negative public statements about the validity of IUT have been made by people who do not have proven expertise in anabelian geometry and who have zero research track record in anabelian geometry," he says. "The new \$1 million IUT Challenger Prize will challenge every mathematician who has ever publicly criticised IUT to produce a paper with full proofs and get it published in a good math journal." ■

Discovery of wrinkle-causing molecules could lead to new cosmetics

Esra Öz

HUNDREDS of biomarkers that may either drive or protect against the physical signs of ageing have been identified for the first time, a discovery that could help to develop cosmetics that target the cause of wrinkles and age-related skin sagging.

Previously, researchers have looked for epigenetic biomarkers – signs that behaviours and environments change the way genes work – to estimate the biological age of organs, such as skin.

Feeling it was unclear whether these biomarkers may drive the ageing process or be a consequence of it, Raya Khanin at biotechnology company LifeNome in New York and her colleagues looked at two existing sets of data.

The first was based on half a million participants of the UK

Biobank study, who were asked if people commonly say they look younger than they are, older or about their age. These results were then linked to the participants' genetic variants to assess whether these may influence facial ageing. The second data set linked these genetic variants to epigenetic biomarkers in nearly 7000 people.

To ensure they were uncovering how epigenetic biomarkers may cause the physical signs of ageing, rather than just a correlation between the two, the researchers then ran an analysis called Mendelian randomisation, which uses the genetic variation that occurs among people as a stand-in for the randomisation of some trials.

From this, they uncovered hundreds of what they suspect are epigenetic biomarkers, around a quarter of which may cause the

physical signs of facial ageing (bioRxiv, doi.org/kjqq). The remaining three-quarters were linked to the acceleration of this ageing, as well as delaying it or protecting against it.

“The biomarkers are thought to affect the proteins involved in skin ageing, such as elastin”

This is the first study to uncover epigenetic biomarkers that cause facial ageing, according to the researchers.

These are thought to affect the proteins involved in skin ageing, such as elastin – which enables skin to stretch – and collagen, which gives structure, strength and further elasticity to skin. They may also affect genes that cause age-related skin pigmentation.

Anti-ageing therapies could one day target these biomarkers, according to the researchers. Other teams could also use the results to gauge whether a therapy that is being developed, or already exists, is effective, says Khanin. “Knowing causal epigenetic markers will be used for developing novel anti-ageing technologies that target the root causes of facial ageing.”

Jesse Poganik at Harvard University says the study is based on somewhat subjective data, as the Biobank participants self-reported how people perceive their age. Nevertheless, using Mendelian randomisation to identify biomarkers that may drive the onset of wrinkles and other signs of ageing is an innovative approach that could lead to better interventions, he says. ■

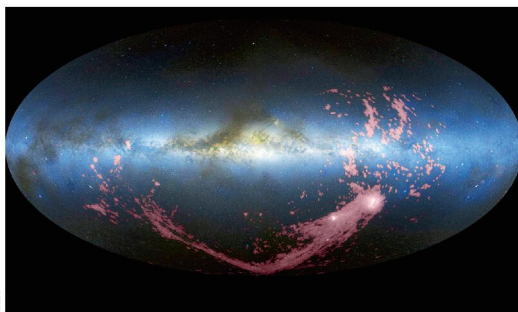
Astronomy

Missing stars found in cloud wrapped around our galaxy

A GROUP of stars hidden in a vast stream of dust and gas that wraps around the Milky Way, which astronomers have been hunting for decades, has been found. These stars could give us clues about the history of two of the Milky Way's closest dwarf galaxies, the Large and Small Magellanic Clouds, which feed this ribbon of material.

Up until now, the Magellanic stream, as it is known, appeared to be devoid of stars, despite astronomers predicting that they should exist. That, in turn, made it hard to measure the stream's position and velocity.

Now, Vedant Chandra at Harvard University and



his colleagues have identified 13 red giant stars, located between 200,000 and 325,000 light years from Earth, that appear to have the same angular momentum and chemical composition as the gas of the Magellanic stream – strongly hinting that they formed

from the material in the stream.

To make the discovery, the researchers combed through the Gaia catalogue, which contains positional and other information about more than a billion stars, filtering out any entries that seem to be moving within the Milky Way.

The Magellanic stream, in red, stretches around the Milky Way

They then further narrowed the field by looking for a group with a similar chemical composition to the Magellanic stream (arXiv, doi.org/kjt8).

“For the first time, we have this stellar counterpart [to the stream], which not only solves this decades-long mystery of why we haven't found [such] stars yet,” says Chandra. “But it also gives us all of these very useful clues and information about how the gas itself could be moving.”

Knowing more about the stream will also help us understand how the Large and Small Magellanic Clouds, and the Milky Way, might evolve, says Chandra. ■

Alex Wilkins

Space

Meteorite left Earth then returned to the surface

Alex Wilkins

A METEORITE found in the Sahara desert in Morocco may have originated on Earth, before being blasted into space and returning from orbit thousands of years later. If confirmed, this boomerang space rock would be the first of its kind we know about.

Almost all the meteorites we have found come from asteroids, but a tiny fraction are from planetary bodies, such as Mars and the moon. These come from violent impacts that launch debris into space, which later falls back to Earth. Astronomers have shown that debris from similar impacts on Earth may also have fallen back to its home planet, but we have yet to find a compelling sample.

Now, Jérôme Gattacceca at the French National Centre for Scientific Research and his colleagues think they may have found a 600-gram meteorite from Earth. The rock, called NWA 13188, has the same chemical make-up as volcanic rock from our planet. It also has a thin layer of melted crust consistent with an impact and contains isotopes of elements that only form when an object has been bombarded with cosmic rays in space.

"It's a meteorite from the Earth that has spent time in space, between 2000 and a few tens of thousands of years," Gattacceca told the Goldschmidt geochemistry conference in Lyon, France, on 11 July.

NWA 13188 was originally found in the Sahara desert by a Bedouin group that scours the landscape for potential meteorites to sell, so its exact location is unknown. It was certified as a meteorite by the Meteoritical Society in 2021, but was classified as "ungrouped"

because its origin was unknown.

When Gattacceca and his team examined the rock, they found it had a similar chemical make-up to rocks on Earth, such as the same oxygen isotope fingerprint, as well as geological structures made at the boundary between tectonic plates. Only Earth has plate tectonics.

600

Weight of the meteorite
NWA 13188, in grams

They then looked for evidence of irradiation from cosmic rays, which produce elements like beryllium-3 and helium-10 in asteroids. The levels of these elements were lower than in other meteorites, but were still significantly higher than any material found on Earth. This suggests that NWA 13188 spent a brief period outside Earth's magnetic field, from a few thousand to possibly up to 100,000 years, says Gattacceca.

But not everyone agrees. "When you're claiming extraordinary hypotheses, you need extraordinary

evidence to back it up. I am still unconvinced," says Philippe Claeys at the Free University of Brussels (VUB) in Belgium.

The lack of a known impact crater, which Gattacceca estimates should be around 20 kilometres wide, counts against it, says Claeys. "When you have an impact crater that young, you would have an impact melt that is still 'hot and smoking' – it would be really hard to miss."

Gattacceca and his team are now trying to determine the age of the meteorite more accurately, using argon and carbon dating, to help narrow down a potential source.

There is also a question of whether the object can even be called a meteorite if it comes from Earth and only orbits the planet for a relatively short time. There are many other rocks that reach high in Earth's atmosphere from processes like volcanic eruptions, says Stepan Chernozhukhin at the University of Leoben in Austria. "If you define an Earth meteorite, you're stretching the definition of meteorite." ■



The meteorite NWA 13188 seems to have travelled to space and back

ALBERT JAMSON

Longevity

Giving birth at an older age linked to longer life in women

Sara Novak

WOMEN who give birth at an older age live slightly longer than those who do so earlier.

Niels van den Berg at Leiden University Medical Center in the Netherlands and his colleagues looked at more than 11,500 women from two existing studies. All lived to age 50 or older and had at least one child without the use of assisted reproductive techniques. No transgender men were included.

Those who gave birth to their last child at an older age lived longer, with each additional year linked to an extra 22 days of life overall (medRxiv, doi.org/kjqh).

When comparing the women who gave birth to their last child while aged 40 or younger to those who did so at 45 or older, they found that the latter group lived 1.7 months longer. "Given all the risk factors of mortality, a 1.41-year difference can be considered as quite large," says van den Berg.

Previous research has linked giving birth at age 40 or older to an increased risk of complications, compared with giving birth while younger than 40. But according to van den Berg, women who give birth later in life may live longer because they are healthy, which extends their lifespan and enables them to conceive at an older age.

However, having long-lived relatives wasn't linked to the women giving birth at a later age. The length of their reproductive health may not just be genetic, but also related to their lifestyles, according to the researchers. Van den Berg adds, though, that the team can't rule out the role of genetics.

Better understanding the relationship between reproductive health and longevity could have profound implications for women's health, says Jennifer Garrison at the Global Consortium for Reproductive Longevity and Equality in Novato, California. ■

Carbon taxes should target luxuries

Variable levies could reduce social inequality and tackle climate change, an analysis finds

Madeleine Cuff

TAXING luxury goods and services like plane travel and SUVs would be a fairer and more effective way to slash household carbon emissions than applying a flat rate of carbon tax to all purchases, researchers have concluded.

Carbon taxes are levies applied to goods and services according to the carbon footprint associated with their manufacture or delivery. They are designed to raise revenue and reduce consumption of polluting products.

Such taxes are in operation around the world, but usually carbon is taxed at a uniform rate no matter what product it is associated with.

Some economists argue this is an unfair and largely ineffective system for tackling household emissions, particularly in higher-income countries. This is because some high-carbon spending, such as heat and fuel, is essential for many households and therefore carbon taxes will do little to change spending habits. Meanwhile, lower-income



REUTERS/ALFRAEDENBACH

Air travel should incur a higher rate of carbon tax, a study suggests

households – who spend a larger proportion of their income on essential goods and services – are hit harder by higher prices.

Yannick Oswald at the University of Leeds, UK, and his colleagues modelled the outcome if 88 countries adopted a policy of

taxing luxury products at a higher rate. Each country categorised “luxury” goods slightly differently, based on how responsive consumers would be to a sharp change in prices.

In the US, for example, a uniform carbon tax of \$150 per tonne was modelled against a variable tax on luxury goods, with carbon costing \$100 per tonne for home heating, \$200 per tonne for household appliances and almost \$300 per tonne for a package holiday.

Under a uniform carbon tax, the average national emissions reduction was 4.4 per cent, compared with a 4.8 per cent reduction under the policy where luxury goods were taxed at a higher rate.

If all 88 countries adopted luxury taxes, it would deliver 75 per cent of the emissions reduction needed to limit global warming to well below 2°C by 2050, the study found (*One Earth*, doi.org/kjvg).

Meanwhile, across the board –

and particularly in higher-income countries – inequalities were reduced under the system of luxury taxes. A higher proportion of emissions reductions came from curtailed discretionary spending on transport and holidays, rather than cutbacks

“Some high-carbon spending, such as heat and fuel, is essential for many households”

to essentials, such as heat and electricity use. “It does have fairer distributional effects and better results in the short term,” says Oswald.

But these luxury taxes would be politically difficult to pursue. Patrick Diamond, a former head of policy planning at the UK prime minister’s office who is now at Queen Mary University of London, says voters need to be convinced that taxes on the wealthy are justified. “There is evidence that voters can be put off by gratuitous attacks on the wealthy.” ■

Palaeontology

Extinct carnivores might have been inbred

SABRE-TOOTHED tigers and dire wolves that lived in the last glacial period had surprisingly high rates of an inheritable bone disease, which might reflect inbreeding as the ancient carnivores approached extinction around 10,000 years ago.

Osteochondrosis occurs when small sections of growing bone fail to form, leaving holes that can provoke pain and limping. While rare, the disease affects most mammalian species and tends to

run in families or in specific breeds. In most modern mammal species, the prevalence of osteochondrosis is under 1 per cent.

Mairin Balisi at Raymond M. Alf Museum of Paleontology in Claremont, California, and her colleagues examined 1163 leg and shoulder bones from sabre-toothed tigers (*Smilodon fatalis*) and 678 leg and shoulder bones from dire wolves (*Aenocyon dirus*), then took X-rays of some of the bones.

The team found that 6 per cent of the sabre-toothed tigers’ femurs had osteochondrosis lesions. In the dire wolves, the researchers found most of the lesions in the shoulder joints, with a prevalence of 4.5 per



ROMAN UCHTEL/SPL

An illustration of a sabre-toothed tiger (*Smilodon fatalis*)

a lot of new questions, I think.”

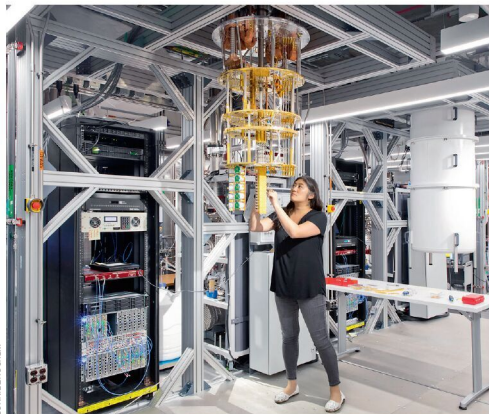
It makes sense that the high rates of an inheritable disease would be tied to inbreeding as their populations declined, says Balisi, and she hopes to be able to confirm this in the future.

“I think it’s only a matter of time before we are able to extract DNA from the targets. And it wouldn’t be surprising to me if that does reflect that these animals were becoming more and more inbred,” she says. ■ Christa Lesté-Lasserre

Technology

Quantum algorithm might actually prove useful

Matthew Sparkes



CONNETHOUBA

A QUANTUM version of a computer algorithm widely used in finance, engineering and scientific modelling shows promising signs of operating much faster than existing methods. Experts say there are many hurdles still to overcome before it overtakes versions running on ordinary computers, but that the gains could be dramatic.

Several research groups claim to have achieved “quantum advantage” – the point at which a quantum computer can complete a task that would be impossible for ordinary machines. But the benchmark problem typically used in these experiments, involving simulating quantum circuits, has little real-world application.

Now, Guglielmo Mazzola at the University of Zurich in Switzerland and researchers from IBM have demonstrated that quantum computers can speed up an extremely common algorithm that is already used in a wide range of scientific fields and industries. Monte Carlo

simulations – named after the gambling destination in Monaco – are used to predict systems that have a lot of randomness in their variables. Models are run many times with differing inputs and an average output is calculated.

“It’s a clever application to a really widely used type of optimisation problem”

The team demonstrated that, although the effort required to calculate a Monte Carlo problem increases as the size of the input increases – just like with classical computers – it does so much more slowly. This means that if larger problems can be run on a quantum machine, they could be solved much faster than the classical equivalent (*Nature*, doi.org/kjvb).

Mazzola stresses that the team isn’t yet claiming quantum advantage – the result shows future potential, rather than current ability. A quantum computer running the

Quantum computers don’t yet offer a practical advantage

algorithm would be likely to need at least 1000 qubits, or quantum bits, to pull ahead of a classical machine. And experts expect that even upcoming quantum computers that will be more powerful will only perform up to thousands of operations a second, whereas a classical computer can perform billions. That means a speed-up of several orders of magnitude may be necessary just to catch up with classical computers, let alone overtake them, says Mazzola.

“If this works, it’s going to enhance, by a lot, the way in which we model systems and that, in turn, will allow us to make better predictions in a wide range of fields,” says Mazzola. “[But] we cannot exclude that our classical friends can devise something even better.”

Josh Nunn at quantum computing firm Orca Computing says that previous claims of quantum advantage have involved problems that are “manifestly useless”, but this Monte Carlo algorithm is different. “It’s a clever application to a really widely used type of optimisation problem that could be relevant to lots of commercial applications,” he says. “It’s definitely promising.”

Scott Aaronson at the University of Texas at Austin says the work is potentially exciting because the speed-up promises to be significant enough to overcome the downsides of quantum computers, such as the need for large amounts of qubits to be devoted to fixing errors. ■

Zoology

Birds from two species raise chicks in the same nest

Gennaro Tomma

TWO species of bird have been observed brooding in the same nest and raising offspring together. Such cooperative breeding between different species has never been documented before, says Rosario Balestrieri at the Stazione Zoologica Anton Dohrn of Naples, Italy.

The nest-sharing parents were a pair of common redstarts (*Phoenicurus phoenicurus*) and a pair of black redstarts (*Phoenicurus ochruros*). Giacomo Bruni, who also worked on the study, spotted them sharing a nest box he had put on the wall of his house in Tuscany, Italy.

Three black redstart chicks and two common redstart chicks hatched in the nest. Using video cameras, the researchers observed that each parent fed both its own chicks and those of the other species (*Bird Study*, doi.org/kjvf).

All five chicks successfully fledged. When the researchers collected the nest later, they found that one common redstart egg had failed to hatch.

Unlike with parasitic species such as the cuckoo, which tricks other birds into raising its chicks, it seems that both redstart species benefited from the relationship.

“The young of both pairs successfully fledged. That makes us think of a real collaboration in this extraordinary, rare extended family,” says Balestrieri. “This is something very interesting, which deserves to be studied further.” ■

A male common redstart attending the nest with chicks from two species



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Human evolution

Jewellery made from giant sloth bones

EARLY humans living in South America carved giant sloth bones into decorative ornaments that may have been worn as jewellery.

Giant sloths armoured with bony plates roamed South America before becoming extinct around 10,000 years ago. Three bony plate fossils, each between 16,000 and 27,000 years old, have an unusual shape and smooth texture, plus complete or partial holes drilled near the border as if to be threaded on a string.

Mirian Pacheco at the Federal University of São Carlos in Brazil and her team examined the bones and found repeated gouges made by early stone tools. The bones' shape and texture couldn't be explained by natural erosion or animal bites (*Proceedings of the Royal Society B: Biological Sciences*, doi.org/kjvk). **Corryn Wetzel**

Technology

Blanket for electric cars helps battery

DRAPING an electric car with a temperature-regulating blanket while it is parked could help keep its battery in prime condition.

When an electric vehicle is parked, its temperature can vary from below freezing to above 40°C (104°F), depending on where it is. But to stay in optimum condition, its battery should be stored between 15°C (59°F) and 35°C (95°F).

Kehang Cui at Shanghai Jiao Tong University, China, and his colleagues have now developed a blanket to regulate an electric car's temperature while it is stationary. An outer layer made from silica and boron nitride reflects heat and sunlight, while an inner aluminium layer traps heat. In tests, it cooled a car by 8°C (14°F) on a hot day, compared with the outside temperature, and warmed it by 7°C (13°F) at night (*Device*, doi.org/gsggd6). **Madeleine Cuff**



Marine biology

Sea snake has re-evolved the ability to see more colours

A MARINE snake has evolved to see colour after losing the ability millions of years ago. It is one of only two reptiles known to have regained this type of colour vision.

Throughout evolutionary history, snakes mainly dwell in the dimly lit undergrowth of forests where they were exposed to limited colours, so they mostly evolved to drop two of their five types of colour-seeing genes, known as opsins.

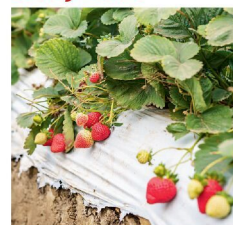
Over the past 25 million years, more than 60 snake species have moved into brighter, more colourful marine environments. One of these is the venomous, blue-banded sea snake (*Hydrophis cyanocinctus*), found in the shallow waters of tropical Australia and Asia.

Prior research suggested that some *H. cyanocinctus* had a colour-seeing opsin called SWS1, but that this was down to more of a "genetic lottery", says Isaac Rossetto at the University of Adelaide in Australia.

He and his colleagues compared the genomic data from five species of snakes in the Elapidae family – including *H. cyanocinctus* – to see whether they consistently had this SWS1 colour gene. In what Rossetto calls an "extremely rare" turn of events, they found that the *H. cyanocinctus* species has evolved to bring back four copies of the ancestral SWS1 gene (*Genome Biology and Evolution*, doi.org/kjvd).

Like the ancestral SWS1 opsin, two of these copies sense ultraviolet light, which is abundant at the sea surface. The other two copies have evolved to sense blue light, the primary wavelength that reaches the depths. This "makes sense", says Rossetto, as these are both environments the snakes have now adapted to. **Sofia Quaglià**

Really brief



Microplastics linked to poor soil quality

Soil containing higher levels of microplastics has lower levels of moisture, nutrients and respiration, according to an analysis of six strawberry farms in California. The research was presented at the Goldschmidt geochemistry conference in Lyon, France, on 10 July.

Birds make use of anti-bird spikes

Spikes placed on buildings to deter birds are being used by birds to build nests, according to a study in the journal *Deinsea*. This behaviour has been observed in carrion crows (*Corvus corone*) at one site in the Netherlands and in Eurasian magpies (*Pica pica*) in Belgium, the Netherlands and Scotland.

Superbubbles seen around quasars

Astronomers have observed three distant quasars surrounded by enormous blobs of ionised gas termed "superbubbles". These blobs seem to be caused by winds whipping around huge black holes, and the same winds may also be preventing their home galaxies from forming new stars (*Science Advances*, doi.org/kjvc).

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The columnist

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Culture columnist

Sally Adee explores a remarkable magical-realist sci-fi debut **p30**

Letters

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Comment

Taking a bite out of reality

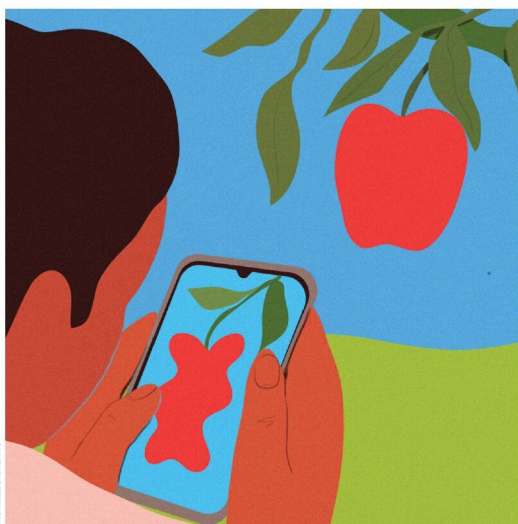
Conspiracy theories like QAnon are more than misinformation. They need to be treated like a pandemic, says **James Ball**

WHEN we think about a conspiracy theory – assuming it is one we don't ourselves believe – it is easy to be dismissive. Why should we care if a few misguided people think the world is flat or the government is covering up evidence of aliens? Conspiracy theories feel like a niche problem, affecting the ignorant, that could be fixed with a fact check here and an algorithm tweak there.

The reality is very different. Millions of people worldwide have come to believe aspects of QAnon – a conspiracy theory that, when it began in 2017, claimed that then US president Donald Trump was battling a global Satanic paedophile ring led by his political rival Hillary Clinton. It has since expanded, pulling in everything from Bill Gates and vaccines to the 5G phone network and Davos, the location of the World Economic Forum's elite annual conference in Switzerland. It has been linked to serious unrest in Australia, Canada and Germany, and has a firm following in many other nations – including in the UK.

Just as it isn't restricted to one country, it isn't restricted to one demographic or political persuasion. It seems to have as many women followers as men, and to have recruits from the political left and middle as well as right – people are just as likely to be drawn in by vegan or yoga influencers as they are by far-right YouTubers.

High intelligence is also no



MICHELLE POURBAND

guarantee against being enticed: more than one winner of the Nobel prize has, in later life, been lured into ludicrous conspiracism. In other words, these ideas aren't someone else's problem. Anyone can be sucked in.

In the three years I spent investigating QAnon for my new book, I became increasingly convinced that conspiracy theories must be considered from a public health standpoint, more than as an issue of media literacy or misinformation. The harms of falling down the conspiracy rabbit hole are very real. Cancer patients can stop their treatment. Other

people grow fearful of leaving their homes and some become isolated and alienated, including from their own families.

But it is how conspiracy theories emerge that really makes me think we need to consider them in public health terms. While some groups are more susceptible – such as young men and people interested in alternative medicine – there is no subsection of society with total natural immunity to conspiratorial thinking.

New online conspiracy theories or groupings tend to originate on fringe websites, like the notorious 4chan forum, which is generally

viewed as something of a no-go area, with minimal moderation even of hateful content. But there are relatively few people on 4chan – a mere few hundred thousand at a time, versus 2 billion on Meta – that anything on there that doesn't escape the site barely has an impact on the world.

4chan and its ilk are the digital equivalent of real-world viral reservoirs. The danger comes when these digital pathogens cross over into the internet's answer to cities – Facebook, YouTube and Instagram. The vector here tends to be influencers: people seeking new content to boost their audience.

With QAnon, the big platforms waited too long before they took action – meaning that many, many more people were radicalised on Facebook and YouTube than ever were on 4chan. Getting someone to drop a conspiracy theory takes months or years, and may never succeed. We don't have enough resources to get everyone out – prevention is the only option and hope. It is time to work out what a digital public health system that could help do this would look like, from vigilance to inoculation.

We will never eradicate online conspiracy theories, just as we will never eradicate the common cold. But we do need to learn to live with them. ■



James Ball is the author of *The Other Pandemic: How QAnon contaminated the world*

Field notes from space-time

Why physics is political In these times we live in, who is researching and shaping science is more crucial than ever, which is why tenureships matter, writes **Chanda Prescod-Weinstein**



Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading

*An advance copy of astrobiologist Aomawa Shields's **Life on Other Planets: A memoir of finding my place in the universe.***

What I'm watching

I finally got TikTok and have been watching a lot of very skilled satires of reality TV show Vanderpump Rules.

What I'm working on

I'm preparing to teach stellar astrophysics this fall!

This column appears monthly. Up next week: Alex Wilkins

NOW we are halfway through 2023, I can confess to something that astute readers may have already noticed: I made it my mission to return to basic and foundational questions in physics this year. Some of this was motivated by teaching a quantum mechanics course for the first time earlier this year. But it was also possibly due to the theoretical physicist's version of a midlife crisis. As I revealed last month in my Substack newsletter, I have been formally awarded tenure and will be promoted to associate professor as of August. I am officially mid-career.

Since *New Scientist* has a global readership, let me translate a little. Whereas university faculty in the UK, for instance, go through a probationary "lecturer" phase, in the US and Canada, faculty begin as assistant professors. After five or six years, they go up for tenure. At this point, a substantial document known as a tenure dossier is submitted that outlines contributions to teaching, research and service to the institution and intellectual community. Mine was almost 400 pages.

My department has a committee that read my dossier alongside letters they solicited from academics in my discipline asking them about my impact on the field, as well as letters from my current and former students. After this, the committee made a recommendation, which went to the full department, who passed it to a school committee, who then passed it to the dean, who then passed it to the provost, who then made a final recommendation to the university's governing board. It is an involved process that takes about a whole academic year.

I went up for tenure in secret because the current conditions

for employees like me at US public universities are such that I wanted to avoid political interference from people who feel threatened by my scholarship. I wanted my case to be considered on its merits and I didn't want ignorant, bad faith actors to have a say in whether I obtained what the American Association of University Professors (AAUP) defines as, "an indefinite appointment that can be terminated only for cause or under extraordinary circumstances such as financial exigency and program discontinuation".

When I say that I wanted to avoid political interference,

"It is hard to focus on getting work done when daily news items suggest that what I do might be labelled 'illegal'"

I don't mean that I think tenure isn't political. As AAUP states: "The principal purpose of tenure is to safeguard academic freedom, which is necessary for all who teach and conduct research in higher education."

It is easy to wonder why a scientist would ever worry about this. Just ask Galileo Galilei, is an easy retort. Galileo was famously persecuted by the Catholic church for 23 years before finally being sentenced to house arrest for life. But that is an example from the 17th century. More recently, in 2016, the world watched as a minority of people in the US elected a president who was openly hostile to the scientific consensus about global warming and the need for environmental protections.

For me, there is more to the story than worrying about hostility to science. I have received some

vocal feedback from readers who are unhappy when I mention that I am not a straight white man. But I am not, and it is relevant to my life as a scientist. Actually, when I earned tenure, I became the first Black woman (in global history, as far as is known) to do so in either particle theory or theoretical cosmology. I carry this mantle in a moment when there is growing hostility in the so-called developed world to migrants, people of colour and the bodily autonomy of women and queer people.

I am unusual in another way. Unlike most people who do physics and astronomy research, I also have expertise in a discipline outside of the sciences. I am active in Black feminist science, technology and society studies, where I conduct research and develop explanations about how sex, race and class shape how science happens. This work formed part of my tenure dossier, though very much secondary to my research on dark matter and neutron stars. And it made my push for tenure more urgent given the current political conditions, with laws being passed across the US to prevent people from teaching about race, sexuality and gender in American classrooms, from kindergarten to university.

It is hard to focus on getting work done when daily news items suggest that what I do might be labelled "illegal" by people who clearly subscribe to a "free speech for me, not for thee" philosophy. In the midst of all of this, it has been helpful to return to why the world of physics is interesting and this column has given me space to do that. I want to thank my audience for being on this journey with me, and next month I promise to be back with more to say about the sticky problem of "What is mass?" ■



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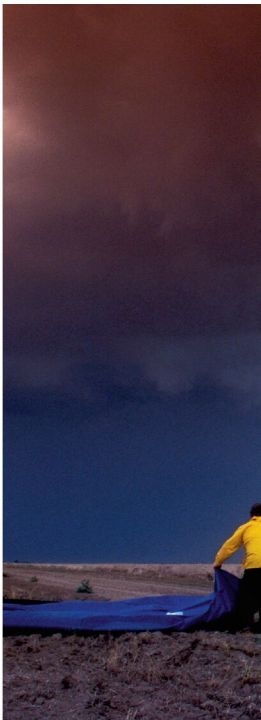
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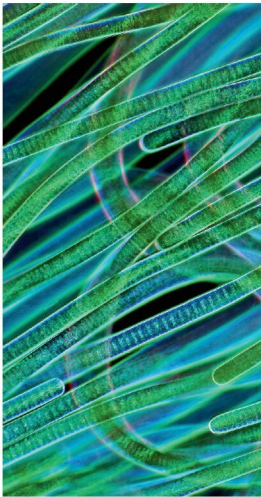
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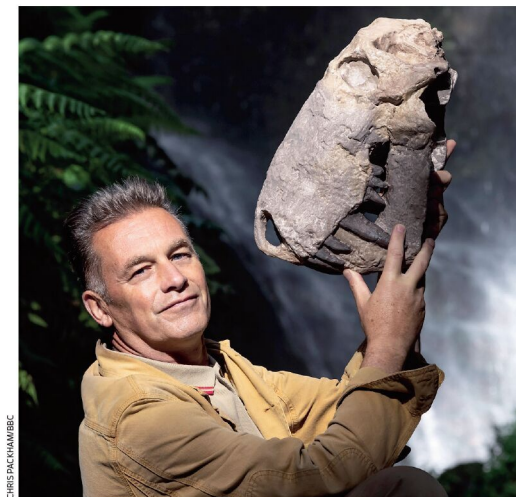
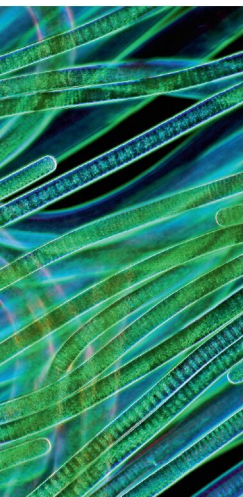
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Super nature



Earth: Over 4 billion years in the making, HarperCollins

A PLUCKY weather balloon (top right) is about to be hurled into a supercell, a rare and destructive type of thunderstorm that often spawns potent tornadoes. The meteorologists facing down this tempest in Kansas are probing complex weather systems.

Without such work, we would know little about our atmosphere. Its formation and development, along with other tumultuous periods in our planet's past, play a big part in a new book, *Earth: Over 4 billion years in the making*, the source of all the images here.

Conservationist Chris Packham (pictured holding a dinosaur skull, bottom right) co-authored the volume with Andrew Cohen, head of the Science Unit at BBC Studios. It is a counterpart to *Earth*, a five-part documentary that brings the deep past to life through cutting-edge research and vivid CGI.

While our world is still peppered with active volcanoes, such as Tungurahua in Ecuador (bottom left), Earth's early days were rocked by a glut of them, roiling with lava and spewing gases. Yet some of today's successful organisms emerged from planet-altering eruptions relatively unchanged.

Cyanobacteria, for example, took root 3.5 billion years ago. Seen through a microscope (bottom middle) is a filamentous cyanobacterium of the genus *Oscillatoria*. Organisms like this are part of the "microbial mats" that create vibrant colours in the thermal waters of Grand Prismatic Spring, Yellowstone National Park, US (top left). Heat-loving bacteria are extremophiles, organisms that can survive in environments once thought to rule out life.

The book *Earth* is out now and the TV series is on BBC iPlayer. ■

Bethan Ackerley

Virtually real music

Mixed reality is challenging music fans in new and amazing ways, including bringing the dead back to life – in a manner of speaking, finds **Arwa Haider**



Concert

Kagami

Ryuichi Sakamoto and Tin Drum
Manchester International Festival

I AM sitting at Ryuichi Sakamoto's feet, watching the legendary musician and composer play his prize-winning score for the 1983 film *Merry Christmas, Mr Lawrence* on a grand piano. I watch his fingers move precisely on the keys, his concentration, the folds of his jacket as he hunches over the instrument. Tears well in my eyes inside the headset I am wearing, and I am only vaguely conscious of the battery processor around my neck like a pendant.

When the piece ends, Sakamoto dissolves and I am left gazing into empty space, alongside other spectators. This is Kagami ("mirror" in Japanese), a "mixed-reality" concert staged at the Manchester International Festival, UK, this month. It is the result of a collaboration between technology collective Tin Drum and Sakamoto, and was recorded early on in the pandemic.

To experience it, we have all been sitting in a circle around the darkened performance space, wearing Magic Leap 2 augmented reality headsets. When Sakamoto first materialised, the effect wasn't perfect. His 3D form occasionally froze and the 70-degree field of vision meant that when you turned to look at the surrounding effects, such as cascading snowflakes and constellations, the artist himself disappeared – but it was still quite mesmerising.

Kagami creates an exceptional intimacy with the virtual artist,

as spectators are encouraged to leave their seats and move around so they can see from any perspective during the show. While conventional gigs generally feel communal, Kagami draws us both closer to Sakamoto and into ourselves. The headsets create weird effects: they enable you to look right through fellow gig-goers, and even your own hands. Suddenly, virtual Sakamoto is the realest thing in the room.

Even though Sakamoto died earlier this year, Tin Drum founder Todd Eckert says that the project wasn't intended as a memorial to him. "It's meant to be an energetic connection," he says. "It's about the relationship between Ryuichi and an audience that will keep coming to his work."

Kagami reflects Sakamoto's

keen curiosity about technology throughout his career, both as a solo artist and as a co-founder of the Yellow Magic Orchestra. He agreed to work with Tin Drum after seeing *This Life*, its 2019 mixed-reality work with performance artist Marina Abramovic.

"The headsets create weird effects. Suddenly, virtual Sakamoto is the realest thing in the room"

Creating something that feels as real as Kagami takes techniques such as volumetric capture, which uses cameras and sensors to film a subject, creating a "full volume" recording rather than a flat image. As Eckert says: "That's why, when

you look at Ryuichi, you think 'that's really him', because it is." But, of course, it is data from a 48-camera rig at Crescent Studio, Tokyo. "We simultaneously captured the audio MIDI data, so we know which key on the piano is being pressed at what intensity and for what duration," he explains. "We had to capture him with markers on his fingers, then get light box data of his hands."

Sakamoto's facial features were also created using motion-capture sensors, and months were spent adding more data to recreate details such as his glasses and the texture of his silver hair.

As well as the enhanced realism of the event, there is also a ritualistic quality to it – much more than at a conventional gig. When we entered, it was through a specially fragranced anteroom via a pathway inspired by a Japanese torii gate, which symbolises the transition from secular to sacred worlds. Images of Sakamoto were everywhere, alongside his droll quote: "There is, in reality, a virtual me. This virtual me will not age, and will continue to play the piano for years, decades, centuries. Will there be humans then?"

The current generation of fans are likely to see more virtual stars at concerts, from ABBA in 1970s disco mode to holographic versions of Maria Callas. And while it is hard to imagine a world without the spontaneity and atmosphere that makes live music joyous, such concerts offer new possibilities – including headlining dead performers.

Kagami is scheduled for the 2024 Sydney Opera House and Tennessee's Big Ears Festival; other international dates are to follow. ■

Arwa Haider is a music and culture writer based in London



COURTESY TIN DRUM

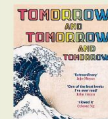
Ryuichi Sakamoto (left) and Tin Drum members recording Kagami in 2020



Jeremy Hsu
Reporter
New York, US

My young son is a fan of the sea creatures in the Pixar film *Finding Nemo*, so we recently visited the **Long Island Aquarium** in New York. The highlight was a living coral reef tank featuring hundreds of fish and other marine life, including several clownfish hanging out in the anemones.

I was also incredibly moved by Gabrielle Zevin's novel **Tomorrow, and Tomorrow, and Tomorrow** (pictured), which explores the professional and



personal ties that develop among young people who share a love of creating video games.

There are dark themes in the story, too, such as gun violence and an abusive relationship, but the novel is a compelling exploration of how the most powerful bonds can be tested by grief and creative differences.

In recent years, I have rediscovered board games. Lately, I have played the Viking-themed game **A Feast for Odin**, a fun reminder that Vikings farmed and traded as well as pillaged and explored. You can also play it for free online.

Fungal killing fields

Forget fictional brain-eaters. A guide to fungi shows a scary list of real dangers, including a new pandemic, says **James Dinneen**



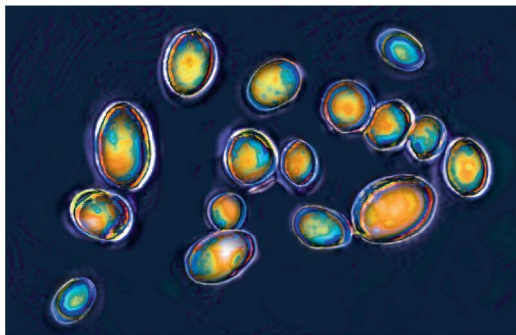
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Emily Monosson
W. W. Norton

EVEN if you haven't seen the TV show *The Last of Us*, by now you will probably have heard someone describe its terrifying depiction of a world overrun by a brain-eating fungus – a *Cordyceps* – that evolves to infect humans due to warming temperatures. The show has done for fungal pathogens what *Jaws* did for shark attacks: it focused attention on an overlooked threat and people freaked out.

Unlike giant, vicious sharks, however, fungal pathogens are common. In fact, as toxicologist and science writer Emily Monosson explains in *Blight: Fungi and the coming pandemic*, deadly fungal outbreaks have actually occurred across the tree of life. "Collectively, infectious fungi and fungus-like pathogens are the most devastating disease agents on the planet," she writes.

That isn't to say all fungi are bad, of course. Most of the roughly 6 million species that surround us are not only harmless, but are essential parts of ecosystems. Some fungi form mutualistic relationships with plant roots, improving their ability to absorb nutrients from soil, for instance. Without fungi to decompose dead organic matter, Monosson writes, "the world would be piled high with the deceased and would be virtually uninhabitable".

As for the fungi that aren't so friendly, Monosson focuses on several of the worst fungal epidemics and the researchers studying them. Frogs all over the world have been killed by the skin-eating chytrid fungus *Batrachochytrium dendrobatidis*, or Bd, which is probably spread



JAMES CAVALINIER

Candida auris, a drug-resistant fungus, is an emerging threat for those with weakened immunity

through the global animal trade.

Billions of American chestnut trees were killed by a fungus that travelled to North America aboard a ship. And a fungal disease called white nose syndrome, which probably spread to North America from Europe via people, has killed millions of bats in the past decade.

Like most mammals (apart from bat species that cool down during hibernation), human temperatures are too high to make us susceptible to most fungal pathogens. There has never been a fungal pandemic in humans, but our luck may be running out, writes Monosson.

A fungicide-resistant fungus called *Candida auris* is an emerging threat for those with weakened immune systems. (Other human fungal pathogens can be a side effect of antibiotics altering the microbiome.) Some researchers argue the emergence of *C. auris* in humans may be down to adaptation to warmer temperatures due to climate change. It is no brain-eater, as in *The Last of Us*, but it is real.

Fungal disease doesn't have to infect humans directly to have dire consequences. Take Costa Rica.

Monosson describes how a fungal outbreak among vulnerable banana plantations would wreck its economy and social fabric. Wheat, soya, corn, rice and other important crops also face threats from fungi.

Monosson outlines the elaborate strategies fungal pathogens use to infect and spread. But humans are implicated because we "travel, plant massive monocrops, trade plants and animals". We haven't simply opened Pandora's box, she says, we have swung it around and shaken out the contents.

Here, Monosson makes a vigorous defence of attending to the interconnections between humans and species of all kinds when it comes to preventing pandemics. She also explains how researchers, farmers and governments are fighting back against fungal pathogens, from monitoring for new threats to developing new fungicides and breeding or engineering trees that can resist fungal invaders.

For all its devastation, *Blight* isn't the most engrossing book. It lacks narrative and is repetitive at points. But if you find fungi fascinating, and want to know more about the nasty ones, it is well worth reading. Fungal reality may prove scarier than fiction. ■

The sci-fi column

Only remember A man with a dark childhood. A deceptively easy-going city where surreal, brightly painted doors are worshipped – and feared. The nature of memory is at the heart of a remarkable, magical-realist debut, says **Sally Adee**



Sally Adee is a technology and science writer based in London. Follow her on Twitter @sally_adee



Book
The Saint of Bright Doors
Vajra Chandrasekera
Tordotcom

Sally also recommends...

Book
Rabbits
Terry Miles
Del Rey
If you like the idea of following a trail of false memories through a complicated magical universe, you might like Rabbits, a book that is part conspiracy podcast and part pure fun.

WHEN he is born, Fetter's mother rips off his shadow and strangles it. This violent act is the source of unusual powers that manifest as he grows. He can see things others can't – or fear to – and he has to learn to obey gravity: it takes great practice to keep his feet grounded.

But the core curriculum in his mother's tutelage is "gramarye, dialectics, revanche, deferral, and murder". She is training Fetter to kill his father, one of the many prophets who stalk the world Vajra Chandrasekera has built in *The Saint of Bright Doors*, a debut that marries speculative fiction and magical realism.

Fetter rejects his mother's training and grisly plans, opting for a new life in cosmopolitan Luriat, a balmy, lazy city that takes in migrants of all stripes and gives them free food, medical care and housing. It is also an authoritarian horror that sorts citizens according to a racial and caste classification system that touches all life and prospects in the city.

Now a sullen 20-something, trying to forget his past, Fetter attends a support group for the unchosen: the progeny born and bred to take on the mantle of the prophets of arcane religions, but cast out. His misfit friends have powers, too: prophetic dreams or persuasive vocal harmonics. Their leader is Koel, the unchosen acolyte of a minor religion. Quiet about her own powers, she itches to burn the system down.

Fetter is happy enough to eke out a pleasant, aimless, existence – until he notices the "bright doors" scattered around the city. They never open and are painted vivid colours to mark them out. Some people worship them; the government fears them. Koel realises that, although they don't open, they are never closed – and the unseen entities they admit



ANDRUSUTTER/STOCK

could bring everything down. What are they? What is Luriat? Is anything real? The more Fetter struggles, the more he must yield to the powers his mother bestowed on him to turn him into a weapon. His journey is a classic story of trying to outrun your past only to discover that no one ever does. But this book is so much more.

"The 'bright doors' admit unseen entities that could bring everything down. But what are they?"

It is about making sense of an abusive childhood, about how authoritarian governments instil fear. And it is about how religions turn old hurts and fears to their own advantage.

Somehow, Chandrasekera keeps all these plot lines coherent, orchestrating their orbit around his deepest theme: how people use memory for their own dirty ends. It is well established among cognitive scientists that memory is unreliable. We can misremember

What do the mysterious doors scattered about the city of Luriat mean?

an event mere seconds after it has occurred. This glitch is easily exploited to build consensus, often for darker ends. This is dangerous, because our biographical and collective memories are central to our identities and sense of self.

Fetter's descent through the increasingly bizarre layers of unreliable memories that define his existence (and that of Luriat itself) is dreamlike and piercing in its emotional truth. Clashing incompatibilities seem to be Chandrasekera's stock in trade: he effortlessly braids the minutiae of modern life (email spam, crowdfunding, apartments) with the less familiar (shadowless people, trees with floating roots).

The pleasant disorientation that ensues makes the book as hard to put down as it is to step out of a dream: and like a dream, even when it doesn't make sense, it is true. What's truly unbelievable is that this is someone's first book. ■

Editor's pick

On the retelling of the story of civilisation

1 July, p 32

From Ira Livingston, New York, US
"Rethinking civilisation" recognises that the story of the superiority and inevitability of hierarchical social organisation is a fiction, but without daring to admit that this must be because the science on the subject has been compromised by its political and economic allegiances; a history written by the winners.

Perhaps admitting this would seem too activist, too Marxist or just too critical of science. As anarchists and anti-capitalists have told us, "another future is possible".

From Alanna Sherry, Wollongong, New South Wales, Australia

When it comes to discussions about the invention of farming, Australia needs a mention. Here, Indigenous people domesticated the entire landscape. Pleistocene Aboriginal people built vast prey farms (using fire to do so) with herds of grazing kangaroos and constructed massive eel farms.

From Steve Harris, Mobile, Alabama, US

Could civilisation have been kick-started by an infectious agent? *Toxoplasma*, carried by cats, causes mice to lose their fear of felines. Some studies indicate this parasite may be connected to behavioural effects in humans. Is it possible that a microbe emerged 10,000 years ago that changed our behaviour in a way that created civilisation?

Excited by new views on the origins of life

24 June, p 32

From Hilda Ruth Beaumont, Brighton, UK

Every once in a while, an article appears that changes my way of thinking about things. This was the case with Thomas Lewton's interview of Sara Imari Walker.

I have puzzled over the origins of life on many occasions and found the prevailing orthodoxies unsatisfactory. Walker's Assembly Theory shone a completely new light on the topic. I suggest that you ask her for a timeline of her proposed research for the next four years and that Lewton interviews her at six-monthly intervals so that readers can keep abreast of progress on this.

One easy climate win: scrap cryptocurrencies

Leader, 24 June

From Adam Kalinowski, Stockport, Greater Manchester, UK
Thank you for your timely, urgent and compelling leader on net zero, in which you conclude that we must cut emissions now and fast to avoid climate tragedy. Where better to start than with the cessation of the generation of cryptocurrency? The immediate end of mining cryptocurrency that relies on "proof of work", and that uses a staggering amount of energy, equivalent to Sweden's annual energy budget, would seem to be a good place to begin. How did we ever let this go so far?

Another easy climate win: scrap all meat production

1 July, p 22

From Pete Sudbury, Woodcote, Oxfordshire, UK
When it comes to the climate challenge posed by land use for farming, note that three-quarters of all farmland is devoted to pasture or growing crops to feed animals, plus two-thirds of the farming carbon footprint and three-quarters of food waste is due to meat products. A switch to plant-based diets would, by some accounts, be the third-largest

contributor to keeping warming to 1.5°C above preindustrial levels; up alongside utility-scale solar.

A complete switch to a vegan diet would reduce the land needed for agriculture by 75 per cent. The real problem isn't "how to meet rising human demand for food", but meeting unsustainable demand for unhealthy quantities of meat.

Jolly outing in search of a gravity anomaly

1 July, p 13

From Roger Morgan, London, UK

You report on Earth's lowest relative gravity spot, just south of India. This brought to mind an account of a UK equivalent: the Warlingham gravity anomaly in Surrey. This was found in the 1950s, with interest in the press and some reports implying a complete absence of gravity.

Apparently, a masonic lodge out for a day found themselves in nearby Caterham. After lunch, and a few drinks, one suggested they investigate the anomaly. This was taken up by the party, who, grabbing a number of plates, went to the nearest railway bridge to drop them to see if they hovered or floated slowly down. Needless to say, the result was a pile of broken crockery.

No one should be allowed to trade in dead butterflies

1 July, p 14

From Pamela Manfield,

The Narth, Monmouthshire, UK
Thanks to Jason Arunn Murugesu for alerting us to the sale of butterflies on eBay. Given the vast decline of these and other insects due to climate change, pesticides, agribusinesses and other things, no one should be able to make

money out of killing and selling butterflies. It doesn't matter if only 2 per cent of these butterflies are endangered; in the UK, for example, 80 per cent of butterflies have been in decline since the 1970s, according to Butterfly Conservation's report of 2022, a situation that is getting worse.

Politicians need to get wise much sooner

17 June, p 21

From Christine Wolak, Dublin, California, US

It is with dismay that I read Sadiq Khan's commentary, in which he says that he had no idea of the scale of air pollution's impact on health until he was diagnosed with asthma. When we vote for our representatives, we expect them to know about these issues and do something about them. They shouldn't have to be personally affected before they act.

Weightlessness problem could be easily solved

8 July, p 21

From Eric Kvaalen, Les Essarts-le-Roi, France

I don't understand why there is so much worry about weightlessness during space travel. Getting to the moon takes just a few days, and for longer trips there is a solution. Tie two space capsules together with a tether 2 kilometres long and set the whole turning, like a gaucho's bolas, at a rate of one revolution per minute. This way, each capsule experiences 1 g of artificial gravity.

Space telescope's massive price tag is offensive

Leader, 1 July

From Ann Bliss, London, UK

I have never been so incensed or upset than by your editorial hailing the \$10-billion James Webb Space Telescope's findings of distant galaxies. How can the cost be justified when, under our feet, Earth's ecosystems are being destroyed by human actions. ■



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How are you thinking?

A new understanding of the nature of thought is helping answer existential problems about our experience of reality – and how unique it is, finds **Kate Douglas**

WITH hindsight, it is clear this has been puzzling me for years. It started with the realisation that I don't always see things the way others do. Then I began to wonder what was going on inside other people's minds. I don't mean what they are thinking, but how they are thinking. What form does their stream of consciousness take – and could it be entirely different from mine?

Thinking about thinking is hard. Sure, you may have heard of inner voice and inner vision: there was that buzz about people who don't have any internal monologue, and huge interest in aphantasia, the phenomenon where people have no mind's eye. But there is more to inner experience than that. What about sensations and emotions and abstract ideas? How do these all mesh together to create thoughts? Why do certain things pop into our minds? And what makes someone prone to ruminations or anxiety?

To find out more, I turned to scientists who study the mind. I discovered that we are finally getting to grips with the different ways people think – allowing us to identify whether we think the same way as other people... or not.

Philosophers have mulled over the nature of thought since at least the time of Aristotle. A century ago, it was also a popular subject for psychologists. "But it got kicked out the door by behaviourists," says psychologist Charles Fernyhough at Durham University, UK. "They claimed that it's impossible to be scientific about the subjective nature of experience." So, with the rise of neuroscience, psychology

focused its efforts on objective, measurable phenomena. Thought became sidelined. But it wasn't forgotten entirely.

Enter Russell Hurlburt. In 1973, he invented a method that would give us a better handle on introspective experiences: a beeper that attaches to the ear and goes off at random intervals each day. At the beep, volunteers record their current inner experience. Later, in one-to-one sessions with researchers, they drill down into the exact nature of these thoughts. Over the decades, Hurlburt, at the University of Nevada, Las Vegas, has used this method, called descriptive experience sampling, with thousands of people. "After four or five days, you have a pretty good sense of someone's inner experience," he says.

That's not to say it is easy. The first surprise was that people really struggle to introspect, so much so that beeper studies tend to ignore the first day's data as it is too unreliable. Even defining a "thought" is tricky. We assume we are all talking about the same thing – a conscious mental state – but, in fact, everyone has their own ideas, says Hurlburt. What his method reveals is that our thoughts seem to include five common phenomena: inner speech, inner seeing, feelings or emotions, sensory awareness (such as the sensation of your shoe rubbing) and unsymbolised thinking (explicit thoughts that don't include the experience of words, images or symbols).

The second surprise was that we are poor judges of what is going on inside our own heads. Beeper studies are time-consuming,



PAWEŁ ŁONKA



so self-report questionnaires asking people how they think are more common. Comparing these two approaches reveals shocking discrepancies. Research suggests that we massively overestimate the amount of thinking we do in all five main phenomena, with the results of self-report questionnaires being between two and four times higher than those of descriptive experience sampling. So, while I conceive of myself as almost always thinking with pictures, it is likely that only around a quarter of my inner experiences contain them.

What has become clear is that we all think using our own combination of phenomena. Each of the five main ones turns up in about 25 per cent of beeps. "Many people have multiple things going on [in their mind] at the same time and those multiple things can be unbelievably complex," says Hurlburt. A single thought might contain five or more separate simultaneous images along with inner speech about something else entirely.

Intiguously, descriptive experience sampling also undermines a long-held idea about different states of consciousness: that we switch between mind wandering and task-focused thinking. Mind wandering is related to activity in the brain's "default mode network". The DMN is deactivated in focused thinking. However, Fernyhough and his team found that around 40 per cent of thoughts don't fit neatly into one or other category, suggesting that both states could be active at different levels at any one time. "People's experiences seem to unfold on multiple, parallel, simultaneous tracks," he says.

Even something as straightforward as inner speech isn't just one thing. "It's a kind of language, and language is incredibly versatile," says Fernyhough. It can take the form of a monologue, dialogue or debate, it can be articulate or slangy, nagging or rallying, emotional or dispassionate. Although you are likely to have a combination of any or all of these, one or two may dominate. My own inner voice is largely didactic and encouraging, but others have told me that theirs is so negative they try to drown it out with podcasts.

The same is true for inner seeing. It varies in amount and clarity, with around 4 per cent of people having no inner eye and an unknown proportion experiencing super-vivid imagery. There also seem to be different forms of inner vision. In her book, *Visual Thinking*, Temple Grandin at Colorado State University



How the experts think

If studying inner experience tells us one thing, it is that people tend to have little insight into the way they think. So, with years of research, what have the people who study the mind learned about their own thinking?

"I'm much more silent internally than I used to think I was. I think that has all kinds of benefits. Inner speech is an incredibly useful thing, but I'm very happy to go quiet when I can."

Charles Fernyhough, psychologist at Durham University, UK

"I have a fantastic memory for things I see. The more things I go out and do, the more pictures are in my memory. And then I can surf around in all these pictures, associate them and invent new things."

Temple Grandin, author of Visual Thinking, researcher at Colorado State University and autism advocate

"I've spent a lot of time trying to understand what's going on with other people. That is a daily confrontation with my own presuppositions about the way inner experience ought to be. So I'm guessing my personality has changed as a result."

Russell Hurlbut, psychologist at the University of Nevada, Las Vegas

"I may be inclined to negatively interpret bodily sensations, and have this kind of hypervigilance. So it's taught me to relax about changes in my body. I used to wear an Apple watch and I don't any more. I don't think that's useful information for me to know."

Jenny Murphy, psychologist at Royal Holloway, University of London

"The surprise is that most people seem to have a lot more inner speech than I do. You always hear that meditation trains you to quiet your mind. Well, my mind is fairly quiet. I listen to a lot of podcasts and audiobooks because if I don't I get bored."

Gary Lupyan, psychologist at the University of Wisconsin-Madison

distinguishes between object visualisers and spatial visualisers. "An object visualiser, like me, thinks in photorealistic pictures," says Grandin. Spatial visualisers think in patterns. The former make good engineers and builders, the latter scientists and strategists, she says. "A lot of people are mixtures."

This mixing holds for all forms of thinking. Take the intuition that people tend to be either visual or verbal thinkers. "It's a kind of myth that there's a trade-off," says Gary Lupyan at the University of Wisconsin-Madison. "We consistently find positive correlations." In other words, people with vivid inner seeing also tend to have a loquacious inner voice, and those with quiet inner seeing also have a quiet inner voice. What's more, our minds meld different forms of thought in all sorts of ways that resemble synaesthesia, in which the senses become mixed, says Fiona Macpherson at the University of Glasgow, UK: "Lots of people have [internal] number lines, or a visualisation for where numbers might be, and these can be quite complex and unusual."

People are often unaware of their idiosyncrasies. Lupyan describes a chat with two scientists during which it emerged that one visualises only still images while the other has imagery that only moves in one direction. More

"Your internal voice can take the form of a monologue, dialogue or debate, it can be articulate or slangy, nagging or rallying, emotional or dispassionate"

common is the practice of visualising spoken words as text. About 10 per cent of people do this, research by Lupyan and his team reveals. Their Internal Representations Questionnaire enables you to see how your imagery compares with other's. It is enlightening – even if the results come with the caveat that we all tend to overestimate our inner experiences.

"Until very recently, both philosophers and scientists have assumed that everybody thinks just like them," says Macpherson. "We now know there's a lot that is very different." This

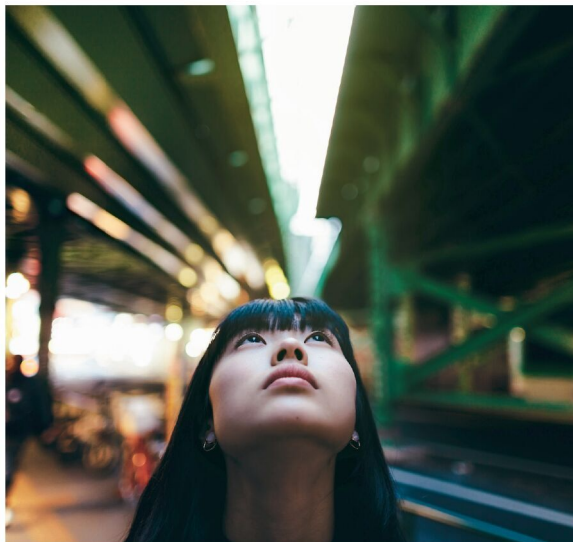
is especially true of our sensory experiences of the world – our perceptions – although, again, we may be unaware of our peculiarities. Anil Seth at the University of Sussex, UK, goes so far as to describe perception as a "controlled hallucination" rather than a reflection of reality. "The brain is continuously making its best guess of what's out there," he says. It works like a prediction machine, using all the information available to create our inner experience. "The part that constitutes our conscious perception is the prediction – it's not the readout of the sensory signals," he says.

Perceptual personalities

In an attempt to map the hidden landscape of perceptual diversity, last year Macpherson, Seth and others launched the Perception Census. It consists of a huge range of online interactive tests and illusions spanning perceptions of colour, music, shapes, time and much more. (Give it a try – I discovered that my brain invents whooshing noises to accompany the rhythmic movement of simple shapes.) There are no results as yet, but with thousands of participants already, there has never been such an ambitious attempt to shed light on our inner experience. "I'm hoping this will reveal what correlates with what – whether we have perceptual personalities," says Seth. What we already know for sure is that there is a massive amount of diversity in perception. "You and I might describe ourselves as neurotypical, so we assume it's the same. It's not the same," he says.

The form of our thoughts is one thing, but then there is also the question of content. Your subconscious mind is a hive of activity dealing with everything from controlling breathing and movements to receiving constant input from your body and your senses. What reaches your consciousness is just the tip of the iceberg. Scientists have pinpointed how this happens: information that was previously unconscious becomes available to our conscious mind when there is a burst of synchronised activity distributed across many areas of the cortex – called the global workspace theory. But why we have the thoughts we do is a stickier problem.

Obviously, some of our thinking is focused on the tasks at hand. But many thoughts just seem to emerge unbidden from the subconscious, and that is much harder to explain. "We don't even know how memories look in our mind," says Valerie van Mulukom



RECEP-80GETTY IMAGES

Women are more vulnerable to negative “chatter”

with anxiety pay more attention to these minor bodily fluctuations or anxiety results from inaccurate interoception. Last year, in an analysis combining many studies, Murphy and her colleagues found no evidence for the latter. “It’s the amount of time you’re spending evaluating signals that is linked to increased anxiety,” she says. But there is a second factor. “It is well established that negative interpretations of internal signals creates a feedback loop,” she says. In other words, catastrophising plus excess interoceptive attention might explain why anxious ruminations seem to dominate some people’s inner experience.

It is hard to say what counts as excess, though, because interoception provides essential warning signals that something is wrong with the body. “Maybe it’s more how flexibly you can attend to signals when you need to, but also ignore them when it’s not ideal for you to do so,” says Murphy. Meditation may help us learn to do this. Other evidence-based ways to assist in reducing chatter fall into three main categories: distancing methods, such as coaching yourself using your name, and keeping a journal; seeking support from someone who can help you put your worries in perspective; and environmental interventions, such as exposure to green spaces and experiencing awe.

I’m grateful my mind isn’t prone to chatter or catastrophising, but reflecting on the way other people’s may be has been eye opening. We all have our own ways of thinking, central to who we are – and yet we seldom stop to consider how they shape our approach to the world and each other. While the research into its impact is still in its infancy, it hints that how each of us thinks may influence our behaviour. It has already been shown to affect how well we learn. For instance, children with better ability to manipulate mental images of shapes in their mind in preschool were quicker to learn maths when starting school. Similarly, tennis players who combine self-talk with mental imagery perform better on court. The way you think can even make you more (or less) susceptible to hypnotism or conspiracy theories.

Thinking about thinking will also explain why you don’t always see things the way others do – both literally and metaphorically. “Other people are different to us: sometimes better or worse, but mostly just different,” says Macpherson. “If only we could keep that in mind, I think we could be kinder and more understanding of each other.” ■

at the University of Coventry, UK. The brain seems to store them not as discrete entities but distributed around a network. “We think what happens is that, for some reason, some connection is made between previously disparate ideas,” she says. “That can then trigger a cascade of links.” This process may have been cued by a smell, taste or thought. Nevertheless, certain memories seem more likely to pop into consciousness than others. They include ones that are recent, emotional, frequently repeated and key to your identity.

This has all sorts of implications for your individual inner experience, including how often you have aha! moments, creative ideas and unwanted intrusive thoughts, which, by the way, are far more common than you might imagine. For instance, one study found that 64 per cent of women and 56 per cent of men experience intrusive thoughts about driving a car off the road. But it doesn’t explain why certain thoughts – often dark ones – get stuck in our minds.

Ethan Kross at the University of Michigan calls this “chatter” and notes that it usually entails thinking about oneself – your experiences, emotions, desires and needs. “We become flooded with emotion and we lose sight of the bigger picture where solutions to our problems often lie,” he says. Everyone gets this from time to time, but some people are more susceptible. “Women are more vulnerable to chatter than men,” says Kross.

So are people with certain personality traits. “Neuroticism has been linked with chatter – it’s almost built into the definition,” he says.

Negative chatter

There is an intriguing idea about why people differ so much when it comes to negative rumination and the anxiety that often accompanies it. The key could be interoception – our processing of signals coming from our own bodies, such as heart rate, breathing and hunger. “There are two competing ideas with regards to anxiety and interoception,” says Jenny Murphy at Royal Holloway, University of London. Either people

Learning how we think may help us understand our differences



IBRAHIM EZZATIAN/DOUGLAS AGENCY VIA GETTY IMAGES

The proton puzzle

We need a better understanding of the particles at the centre of every atom to help reveal the secrets of the universe, finds **Harry Cliff**

DEEP in the heart of every atom lurk protons, tiny particles from which the chemical elements were forged, first in the searing heat of the big bang and then in the nuclear furnaces of stars. The number of protons in an atom determines whether it is hydrogen, carbon, oxygen or uranium. They make up more than 86 per cent of the visible matter in the universe by mass, and they are fundamental to our existence. Yet we still don't really understand them.

It was just over a century ago that Ernest Rutherford demonstrated that protons are one of the basic building blocks of all atomic nuclei. Yet despite our best efforts in the intervening years, much about this ubiquitous particle remains shrouded in mystery.

Whether protons live forever, how big they are and what they are really made from are just some of the questions physicists continue to grapple with. Finding the answers won't just change how we think about the particles themselves. It could alter our understanding of the universe and the fundamental laws that govern it. Here are five of the biggest unanswered questions about the proton.

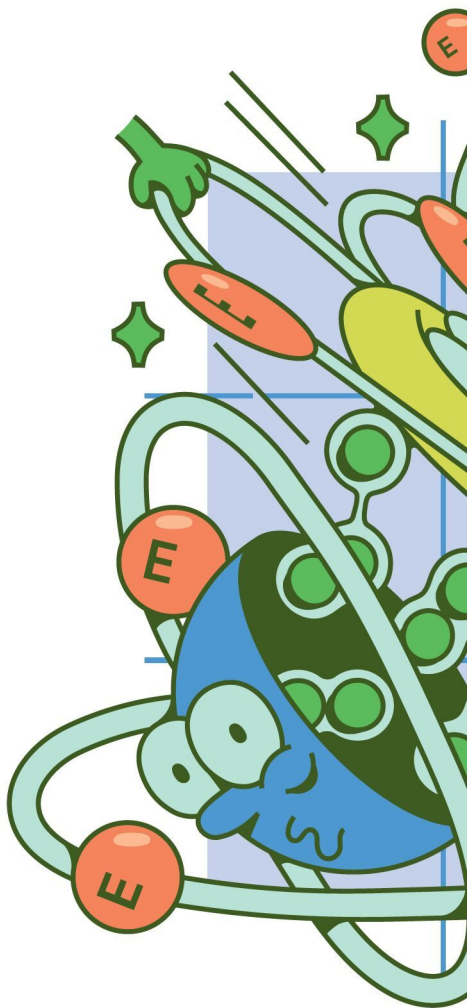
1 WHAT ARE PROTONS MADE OF?

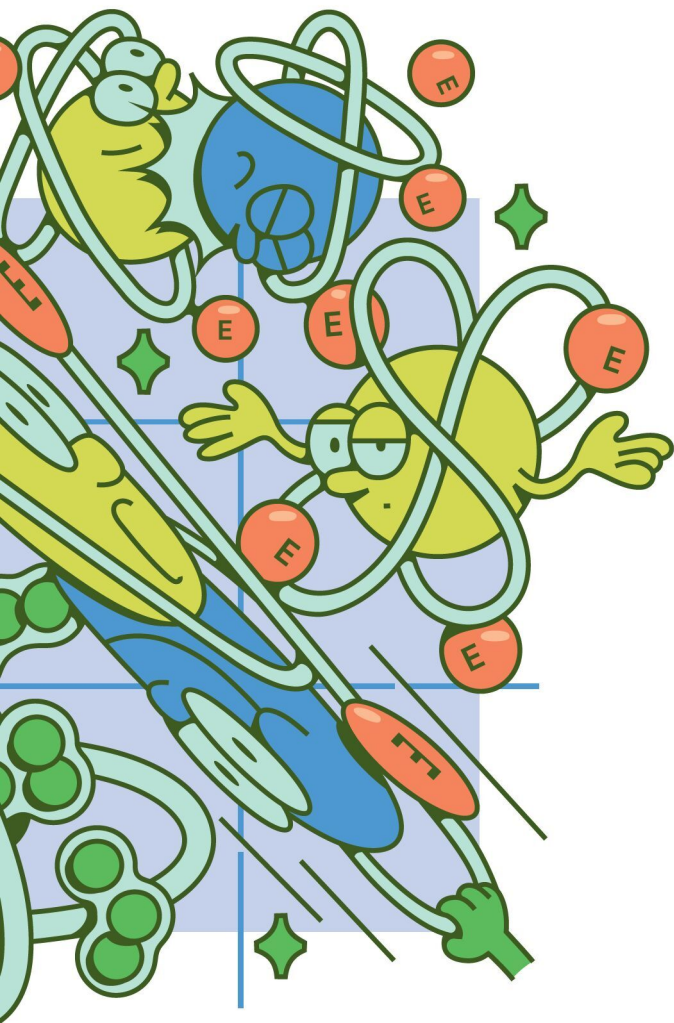
The simple, oft-repeated story is that the proton is made of three quarks – two up quarks and one down quark – locked together by the vice-like grip of the strong nuclear force that binds atomic nuclei. However, when physicists started looking at higher and higher resolution, they discovered that around these three “valence” quarks in a proton is a churning, quantum-mechanical sea of

other particles that pop in and out of existence.

Most of the time, when particle physicists smash protons together at the Large Hadron Collider (LHC) at the CERN particle physics lab near Geneva, Switzerland, we don't see quark-on-quark collisions, but collisions between particles called gluons, the carriers of the strong force that bind the proton's three valence quarks together. Gluons are responsible for the majority of the proton's mass. But experiments at even higher energies reveal that these gluons, too, are constantly splitting into fleeting quark-antiquark pairs, including so-called strange and charm quarks.

The charm quark is about 35 per cent heavier





than the proton, so you might very reasonably wonder how a proton could contain one. It would be like opening a 1-kilogram package to discover the stuff inside weighs 1.3kg. The answer is that all particles, including charm quarks, can be thought of as tiny vibrations in underlying quantum fields. This means it is possible to have a contribution from the charm quark field that doesn't correspond to a well-defined particle, but is more akin to a low-energy quantum-mechanical echo. It is as if just a part of a charm quark is there.

Beyond the short-lived quark-antiquark pairs, there has been a long-running investigation into whether charm quarks,

or at least a taste of them, may loiter inside the proton on a more permanent basis.

This is known as an "intrinsic" charm component and it would show up inside the proton even when viewed at low resolution.

In 2022, Juan Rojo at Free University of Amsterdam in the Netherlands and his colleagues used a combination of large, experimental datasets and machine learning to discern what they called "unambiguous" evidence of just such an intrinsic charm contribution to the proton. Crucially, they claim their technique can distinguish between a genuine intrinsic charm contribution and the short-lived one from gluons splitting into

charm quark-antiquark pairs. The evidence they found doesn't meet the gold-standard 5-sigma threshold of statistical significance usually required to claim an unambiguous discovery in particle physics. However, their claim got a boost from the LHCb experiment at the LHC, which separately reported signs that protons may indeed contain intrinsic charms. That said, the jury is still out, for now at least.

Understanding what the proton is really made of is crucial for interpreting the results of collider experiments, such as those at the LHC, that search for signs of new particles. It is only by resolving mysteries like whether the proton contains charm quarks that physicists will ultimately be able to make progress on some of the biggest outstanding questions in physics.

2 HOW BIG IS A PROTON?

This is such a basic question that you might assume physicists would have a clear answer, and until relatively recently, they did. More or less everyone agreed that the proton's radius was around 0.88 femtometres – 0.88 trillionths of a millimetre. In other words, you could line up around a trillion protons across the full stop at the end of this sentence.

Then, in 2010, a new measurement blew this consensus apart. A team based at the Paul Scherrer Institute in Switzerland performed an experiment that showed protons were smaller than previously believed. The new result was just 0.04 femtometres smaller, but the measurements were so precise that this discrepancy represented a yawning chasm. The only ways to bridge the gap would be if there were errors in one or more of the experiments or, tantalisingly, there were new particles outside of the standard model, our best theory of particle physics.

Earlier measurements of the proton's size had used two methods. The first involved firing electrons at protons and measuring how often they bounced off and at what angles. The second studied quantum jumps taking place within hydrogen atoms, as electrons were excited between different orbits. Crucially, both techniques – electron scattering and atomic transitions – gave an answer of around 0.88 femtometres.

However, the 2010 measurement used a variant of the quantum jumps approach where the electron in orbit around the proton in hydrogen was replaced with a muon, a heavy ➤

cousin of the electron, to form muonic hydrogen. Since muons are about 200 times heavier than electrons, they orbit the proton much closer and are more likely to be found inside it. This means the size of the proton has a far stronger effect on the energy levels of muonic hydrogen than for the garden-variety version of this element, making the new experiment significantly more sensitive.

Since the original 2010 result, other experiments using muonic hydrogen have confirmed that the proton appears smaller than previously believed. One exciting possibility was that an unknown force was acting on muons and electrons with different strengths, causing the proton to appear a different size depending on which particle was used. To rule out a mistake, physicists went on a deep dive to see if they could improve the earlier techniques.

This culminated in new, improved measurements using electron scattering and ordinary hydrogen transitions, released in 2019, that agreed with the smaller proton radius result from the muonic hydrogen experiments. Then, just last year, researchers at the University of Bonn and the Technical University of Darmstadt, Germany, reanalysed old collision data with a new technique, also finding results that favoured a smaller proton.

So is the proton's size solved? Not quite. There is still no clear explanation for the larger values reported by earlier studies. Ultimately, new experiments will be needed to confirm once and for all that the proton really is a little bit tinier than previously thought.

3 HOW STRETCHY IS A PROTON?

You can think of a proton as a messy bag of quarks, gluons and other ephemeral particles that are constantly flitting in and out of existence. Expose a proton to an electromagnetic field and its innards get pulled this way and that depending on their electric charge and magnetism. This means that protons have an inherent stretchiness in response to electric and magnetic fields – technically called the electric and magnetic polarisability. But it is up for debate just how stretchy they really are.

The standard model of particle physics predicts that as you zoom in on a proton and study it in smaller and smaller pieces, it should appear less and less stretchy. It is a little like how an orange is squashy, but its pips are hard. However, in 2000, an experiment carried out using a particle accelerator in Mainz, Germany, revealed that as you zoom in, the proton does indeed get harder, but at a certain scale becomes briefly stretchier again, before once again becoming more rigid as you continue to zoom in.

Physicists have long doubted that this effect is genuine, particularly given those experiments were rather imprecise. However, in 2022, researchers working at Jefferson Lab in Virginia appeared to confirm the effect at roughly the same scale as before. They measured the proton's electric and magnetic polarisabilities by firing a beam of electrons

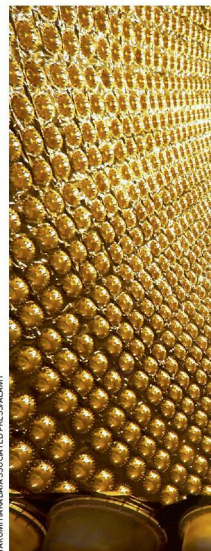
at a liquid hydrogen target. As an electron whizzed past a proton, a photon was produced, distorting the proton in the process. By watching how the proton and electron recoiled, they were able to measure how much the proton was stretched by the interaction.

While this new measurement was more precise than the original Mainz result, the effect they measured was half as strong. Overall, the purported anomaly is still too weak for us to be confident that it is more than a statistical fluke or systematic bias, but it remains intriguing. If confirmed by further experiments, it would suggest that our theoretical model of the proton is missing some crucial effects, with significant implications for how we think about the strong force that binds it together.

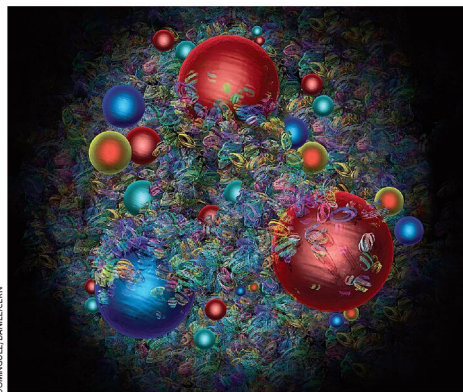
4 HOW OFTEN DO PROTONS COLLIDE INSIDE A NUCLEUS?

Something strange appears to be happening inside atomic nuclei. Protons are banging into each other more often than expected, which suggests there are things about the strong nuclear force that we don't understand.

This force binds protons and particles called neutrons together inside atomic nuclei. But it isn't always a force of attraction. As it pulls two nucleons – a catch-all term for protons and neutrons – together inside a nucleus, the attractive force between them gets stronger, accelerating the particles towards each other. But when they are around a quadrillionth of

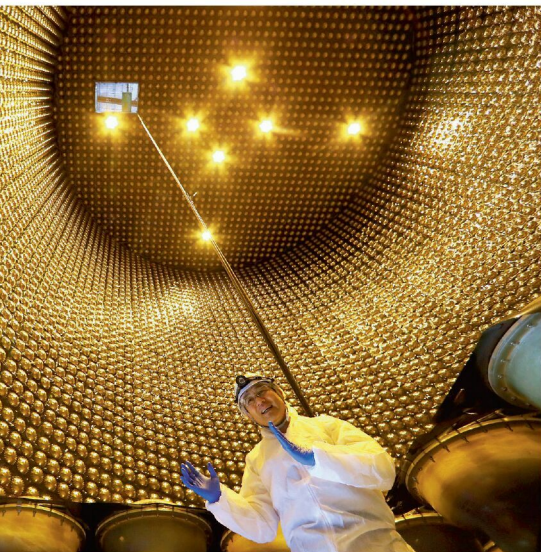


TAKUMI HARA/ALAMY ASSOCIATED PRESS/ALAMY



Inside a proton is a sea of quarks, gluons and other particles that pop in and out of existence

DOMINGUEZ DANIEL/CEIN



The Super-Kamiokande experiment in Hida, Japan, has searched for signs of protons decaying

a metre apart, the force between them suddenly becomes repulsive, causing them to bounce off each other and whizz apart at high speed.

Previous studies of the nuclei of elements such as carbon and lead had shown that the vast majority of these head-butts happened between a proton and a neutron, with only 3 per cent being between two protons. However, in 2022, a team of physicists announced the result of an experiment at Jefferson Lab using a helium isotope made of two protons and one neutron, called helium-3, and a radioactive form of hydrogen made of one proton and two neutrons, called tritium. What they found was surprising.

The work involved firing a beam of electrons at helium-3 and tritium and watching how they were scattered. In doing so, the team could estimate how often the electron bounced off a recoiling nucleon from a proton-proton or proton-neutron interaction. Rather than the 3 per cent measured in earlier experiments, proton-proton interactions were involved 20 per cent of the time.

The researchers suspect the difference may be related to the fact that protons and neutrons are much less tightly packed in helium-3 and tritium than in much larger carbon and lead nuclei. This suggests that the strong nuclear force behaves in ways we don't currently understand at very short distances. If this is the case, it will have significant implications for nuclear physics and even the study of astronomical bodies such as neutron stars, which are, in effect, giant, city-sized atomic nuclei.

5 ARE PROTONS ETERNAL?

Nothing lasts forever, or so the saying goes, but perhaps protons do. Every other composite particle we know of lives a short and uncertain life. A solitary neutron, for instance, survives for a mere 15 minutes on average before decaying. Yet, despite decades of searching, no one has ever seen a proton snuffing it.

The question of whether protons decay is more than a bit of scientific bookkeeping. It is connected to one of the great quests of modern science: the search for a grand unified theory (GUT). Such a theory would unite the strong, weak and electromagnetic forces, the three different forces at the heart of the standard model, into a single entity. It may also explain many of the apparently arbitrary features of the standard model. The catch is that new particles predicted by GUTs are so heavy as to be out of reach of any conceivable collider, making the theories extremely difficult to test. But there is one

"If we find evidence of proton decay, it could challenge theories of quantum gravity"

way they might be probed: GUTs usually result in new forces that allow protons to decay.

The problem is that even if such forces exist, the proton's average lifetime would still be billions upon trillions of times longer than the age of the universe. But gather enough protons together in one place and wait for long enough, and you might just spy a handful of decays.

In the 1980s, when GUTs were all the rage, two teams of physicists attempted just that. Under Lake Erie in the US and in a mine in Hida, Japan, physicists placed vast subterranean tanks filled with thousands of tons of ultra-pure water, each surrounded by detectors. A flicker of light emerging from the dark water would herald the decay of a proton, but, after years of watching and waiting, both experiments drew a blank. In 1996, a souped-up version of the Japanese experiment, more than 10 times the size and named Super-Kamiokande, continued the search for proton decay, but has so far come up empty handed. From this outcome, physicists were able to conclude that the average lifetime of the proton must be longer than 10^{34} years, a truly inconceivable span of time, a trillion trillion times longer than the age of the universe. In the process, they also ruled out many of the most popular GUTs.

However, undeterred, physicists are now planning an even larger detector called Hyper-Kamiokande. Its tank will contain 260,000 tons of water and it will begin taking data in 2027. Ultimately, Hyper-K should be able to spot protons decaying, even if their average lifetime is up to 10 times longer than the current lower limit for this. Not only would this provide the first evidence that the forces of nature really do unify at high energies, it could even challenge theories of quantum gravity, which aim to overcome the problem of our seemingly disparate descriptions of the quantum realm and gravitation by uniting them. In April this year, theorists Astrid Eichhorn at the University of Southern Denmark and Shouryya Ray at the Technical University of Dresden in Germany showed that quantum gravity should extend the proton's average lifetime well beyond the reach of even Hyper-K. So, if we do witness the death of a proton in the coming years, it could spell trouble for one of the most confounding problems in physics. ■



Harry Cliff is a particle physicist at the University of Cambridge



XEE SUMMER

AS WE emerged into the world as newborns, each of us lost something important: a body part that had provided us with oxygen and nutrients, removed waste products and kept pathogens at bay. What became of this crucial organ? It was probably thrown in the bin – assuming it wasn't served up to your parent in the belief that eating it would do them good.

Never mind, you might say. After all, the body part in question – the placenta – is supposed to be a temporary organ. No one wants to go through life attached at the navel to a blob of tissue that looks like a meaty, 20-centimetre-wide mushroom. The moment the umbilical cord is cut, the placenta's influence on our well-being is severed too.

Or so we used to think, but we were wrong. We are now learning that your placenta may have a surprisingly large hold over your health decades after you lose it. Heart disease, obesity, asthma, several forms of cancer – your long-term risk of all of these conditions might be influenced by the way your placenta grew.

This news comes too late to help anyone already born. But future generations could

benefit if we can develop tools to spot unhealthy placentas during pregnancy and new therapies to treat any problems. Motivated by the potential of such tools to improve human health, researchers are now racing to develop them – and in the past 12 months, their efforts have begun to bear fruit. So, are we poised to give babies-to-be a better chance of enjoying a healthy life?

The placenta begins to develop from an embryo's cells within about 10 days of conception. As the embryo grows into a fetus, the placenta serves as its interface with the parent (see "War of the womb", page 43). This means it brings oxygen and nutrients to the developing fetus. But it does much more, single-handedly performing all of the jobs that, after birth, require the coordination of organs including the lungs, liver and kidneys. To achieve this feat, the placenta oversees the complete remodelling of the nearly 150 spiral arteries – small, coiled blood vessels in the uterus – that supply it with blood. However, the process doesn't always go smoothly.

"The placenta is an incredibly weird and miraculous organ that we grow for this very

short period of time, but there's any number of ways it can go wrong," says Chavi Eve Karkowsky at the Montefiore Medical Center in New York City. When it does, the health of the parent or the fetus – or both – may be at risk.

Placenta problems

Take pre-eclampsia, which each year leads to the deaths of 70,000 women and is also a factor in 500,000 stillbirths. Although the exact cause of pre-eclampsia is debated, it occurs when the spiral arteries remodelled by the placenta don't transform properly. The vessels don't widen correctly, starving the fetus of oxygen. The fetus responds by pumping hormones like oestrogen and a protein called soluble FLT-1 into the bloodstream of the parent. This ultimately causes blood vessels to constrict and blood pressure to spike. Unchecked, pre-eclampsia can cause damage to the parent's brain, heart, liver and kidneys and leave the fetus at risk too.

Then there is placenta accreta, a serious condition in which a newly formed placenta doesn't stop growing after invading the uterus. In severe cases, it pushes all the way through the wall of the uterus into adjacent organs, including the bladder or bowel. Then, when the baby is delivered "the placenta can't unattach as it's embedded too deeply", says Karkowsky. "People just bleed a tremendous, life-threatening amount."

It is also thought that as many as 66 per cent of preterm births may be explained by problems with the placenta. This is a concerning figure given that research in the past 20 years has linked preterm births with long-term health issues in the parent. For instance, in a 2020 study, Casey Crump at the Icahn School of Medicine at Mount Sinai, New York, and his colleagues looked at data collected from more than 2.1 million women in Sweden who gave birth between 1973 and 2015. They found that women who delivered their babies preterm had a heightened risk of developing ischaemic heart disease many years later. For women who gave birth extremely early – 22 to 27 weeks into pregnancy – Crump's team found that the risk was four times higher than for women who gave birth at full term.

What might explain this heightened risk? It is possible that underlying biological or genetic factors predispose people to developing heart problems and also to delivering pregnancies ➤

Your long-lost organ

We may lose our placenta at birth, but it continues to influence our health and well-being far into our life, finds **Jasmin Fox-Skelly**



"The new tool uses laser light to monitor placenta oxygen levels and predict who might have complications"

preterm. A genetic explanation would fit with evidence that preterm birth can run in families. However, Crump's team pointed out an alternative: in at least some cases, the process of preterm delivery itself might trigger inflammation that raises the risk of later heart disease. In line with this idea is a 2018 study of blood samples taken from 235 women who, years later, either did or didn't have a preterm birth. There were no obvious biological markers in the blood to indicate that the women who later had a preterm birth were predisposed to do so.

Other pregnancy complications may also have consequences for long-term health. Last year, for instance, one study suggested that pre-eclampsia can trigger an accelerated ageing process in those carrying a pregnancy that affects health years later.

A fetus's long-term health is at risk too. Evidence for this began to emerge in the late 20th century, when David Barker, a physician at the University of Southampton, UK, and his colleagues analysed the health records of 15,000 men in southern England. They found a clear relationship between a person's weight at full-term birth – which is determined largely by the placenta – and their risk of dying from coronary heart disease later in life. More specifically, people who had been closer to 2.3 kilograms at birth were at a three to five times greater risk of dying from cardiovascular disease as adults than people who had been nearer 4 kg at birth. The finding persisted even when taking into account the social class of the men, although the researchers couldn't work out the extent to which nutrition later in life also played a role.

Barker and his colleagues went on to show

that people are also at greater risk of stroke, high blood pressure, type 2 diabetes, asthma and some forms of cancer if they had a low birth weight. In other words, they argued, the origins of many health conditions can be traced back to before birth.

The idea – which became known as the fetal origins hypothesis, or the Barker hypothesis – wasn't without its critics. They contended that much of the evidence in its favour was purely correlational and didn't consider all of the potential confounding factors, including the role of genetics. But over recent decades, the idea has become increasingly influential. Advocates include Kent Thornburg at Oregon Health & Science University, who collaborated with Barker on some studies. He says that your risk of developing cardiovascular disease – among the commonest causes of death worldwide – is influenced more by the way you grow before you are born than it is by your later lifestyle choices, although both are important. "The placenta literally influences your health for the rest of your life," he says.

As the popularity of the hypothesis has grown, some researchers have begun responding to critics by exploring exactly how the placenta might influence fetal development and long-term health. One idea is that a poorly functioning placenta might reduce the supply of nutrients to the fetus at the moment that internal organs such as the heart and kidneys are growing. This may compromise the developments of these organs and leave them more vulnerable to health problems later in life.

In line with this, one study showed that 9-year-old children who experienced reduced

fetal growth have smaller arteries that supply blood to the heart than 9-year-olds who didn't experience reduced fetal growth. Other studies show that infants with a low birth weight have kidneys containing fewer than the typical number of nephrons – the structures that filter blood to make urine. In these individuals, it is believed that the remaining nephrons might experience damage from overwork and may be more likely to fail.

Experiments with animals – sheep in particular – have identified further potential developmental problems. If deprived of nutrients in the uterus, sheep have less elastic tissue in their arteries and their lungs and liver can also be compromised. A study in rats, meanwhile, shows that being starved of nutrients during gestation can reduce the number of insulin-producing beta cells in the pancreas – potentially explaining the link in humans between birth weight and type 2 diabetes.

"At some point in life, you may run out of insulin as a result of something you experienced in the womb, leading to you developing diabetes," says Abigail Fowden at the University of Cambridge.

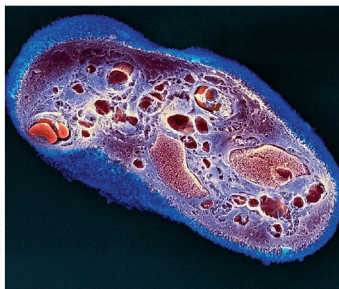
Life-long effects

Collectively, this body of research suggests that looking after the placenta during pregnancy may be one of the best things we can do to keep people healthy throughout their lives. But how can we achieve this?

Simply identifying who is at risk of having a problematic pregnancy would be helpful. In a 2020 study, Thornburg and his colleagues reviewed previously published data and concluded that fetal growth rates are lower if someone carrying a pregnancy experiences what the researchers call chronic "toxic" stress – meaning the sustained stress associated with racism, housing insecurity, food insecurity and partner violence.

Thornburg says it is important that this finding isn't misinterpreted. "Mothers are not at fault for the size of their baby, or how the placenta grew," he says. Instead, the results show how vital it is for society to do more to protect and support people during pregnancy.

Other researchers are looking beyond social factors. Last year, Gordon Smith at the University of Cambridge and his colleagues analysed blood samples taken from 4200 women undergoing their first pregnancies and



Electron microscopy scan of a cross section of the placenta, showing its complex anatomy

War of the womb

The placenta has evolved several times, including in reptiles and even fish. But it is mammals that are most famous for having one. Here, the placenta may have originated when an ancient egg-laying mammal contracted a virus that changed its DNA irrevocably. Over generations, this led to the transformation of the external hard eggshell into a sort of permeable layer inside the body. Eventually, it became the placenta.

Placental mammals thrived, benefiting from the fact that the fetus could now feed directly from its parent's blood. But, in time, that led to conflict. The placenta is part of the fetus, which means its genome is different to the genome of the cells of the uterus. This leads to genetic complications: while fetal genes may act to extract all the nutrition they can from the parent, the parent's genes may act to keep the parent healthy enough to support future pregnancies.

In fact, there is a growing consensus among researchers that some of the most well-known pregnancy complications like pre-eclampsia, gestational diabetes, miscarriages and preterm births may best be explained by unchecked genetic conflict.

However, relations between the placenta and uterus also involve at least some cooperation. In 2020, Daniel Stadtmayer and Günter Wagner at Yale University argued that, in order for implantation to be successful in placental mammals, adaptations on the parent's side are needed. Indeed, cells in the decidua – the thick layer that lines the uterus during pregnancy – have even been seen to move towards and “embrace” the embryo during implantation. There are moments of peace during the war of the womb.

LENNART NILSSON, TISCIENCE PHOTO LIBRARY



identified that pre-eclampsia and fetal growth restriction are both associated with a high ratio of the protein soluble FLT-1 to a protein called placental growth factor. This year, Smith's team reported that this high ratio is also associated with spontaneous preterm birth.

Identifying those potentially at risk is only the beginning. The broader hope is that we will eventually have technology to monitor the placenta in unprecedented detail, which is a central goal of the Human Placenta Project, an ongoing research effort launched in 2015. This should allow us to spot exactly who has a poorly functioning placenta, so they can receive the care they need.

There is one thing in particular that placenta-monitoring technology should focus on, says Nadav Schwartz at the University of Pennsylvania. “I think if you asked any obstetrician around the world what the holy grail is in terms of placental measurements, it would be oxygen,” he says. Last year, Schwartz and his colleagues unveiled a new tool that uses laser light and ultrasound to monitor placental oxygen levels. In a proof-of-principle trial involving 24 women, it identified a subset of them who carried less oxygen in the placenta and who went on to develop pregnancy complications. It had previously been impossible to get this level of insight into the placenta, says Schwartz. “It was very exciting to finally be able to measure this.”

The field is moving quickly, and tools that provide even more information about the placenta are becoming available. For instance, in another study published last year, Yong Wang at Washington University in St. Louis, Missouri, and his colleagues used machine learning tools to analyse standard MRI scans

A human fetus at 11 to 12 weeks old, surrounded by the nest-like placenta

taken from five women who went on to develop pregnancy complications. They found that the algorithm could interpret the data in such a way to pinpoint precise regions inside the placenta where oxygen levels were lower than expected. “We think our technique is very accessible to physicians,” says Wang.

The next step will be to develop techniques that allow for the treatment of placentas identified as functioning poorly. Although this is another goal of the Human Placenta Project, the research is still in its infancy, says Thornburg. But there are some promising leads. He singles out therapeutic ultrasound, which has already been used elsewhere in the human body to bring more oxygen into tissue by helping increase the flow of blood. Thornburg says it might work in the placenta too, but the idea will need further testing.

Today, there is far more awareness that the placenta has profound and long-term effects on our health. Thornburg has even described it as being at the centre of the chronic disease universe. He is, however, realistic about where we currently stand. “We are just learning now how to define the health of the placenta,” he says. But as our understanding grows, our long-forgotten organ should finally gain the recognition it deserves. ■



Jasmin Fox-Skelly is a science writer based in Cardiff, UK

Puzzles

Try our crossword, quick quiz and logic puzzle **p45**

Almost the last word

Why do cats wash themselves, while dogs don't? **p46**

Tom Gauld for *New Scientist*

A cartoonist's take on the world **p47**

Feedback

Biting remarks and parasite-swapping ducks **p48**

Twisteddoodles for *New Scientist*

Picturing the lighter side of life **p48**

Debunking gardening myths

What a crock

The belief that putting broken pottery in a plant pot ensures adequate drainage is widespread – but wrong, says **James Wong**



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

AS A kid in 1980s Singapore, I remember my mum coming home from a fancy Korean supermarket with a brand new electric fan. Wow! The sleek plastic design. The pivoting function. To my 7-year-old self, it was like stepping into the future. What I never understood, though, was why it had a “safety timer” that would automatically cut the power after a set number of minutes.

Years later, I learned of the curious Korean belief in “fan death”. Dating back to the early 20th century, the idea behind this is that falling asleep in a closed room containing a running fan carries a real risk of death due to asphyxiation. Despite the fact there is no scientific evidence to support this claim, the belief is so widespread it is cited by South Korean government bodies as a genuine summer health concern, and electric fan makers have created built-in safety switches.

In Korea, the reality of “fan death” is seemingly not just plausible, but plain common sense. The fascinating thing about culture is that it is often invisible to those who participate in it, and of course the Western world is no exception. To me as a gardener, an everyday example of this is the practice of “crocking”.

Take a look at essentially any segment on container gardening in the media, and you will encounter the claim that placing a layer of broken pottery, or “corks”, in the base of containers is a key step to ensure adequate drainage. This is despite the fact that soil



BLICKWELF, HECKER/LAMY

scientists have shown for nearly a century that water passes more slowly through layers of material with different particle sizes than through a homogenous mix.

Air pockets in the coarser material below impede the gravitational pull of the water through the finer material, meaning water tends to only percolate down across the interface when the above layer is fully saturated. This means crocking is likely to have the exact opposite of its desired effect, the potentially impeding drainage rather than improving it.

But is it possible that water behaves differently in domestic flowerpots than on the vast scale of agricultural fields? Perhaps, but to date there seems to be only one study tackling this. Carried out by

consumer magazine *Which?*, it compared the performance of *Calibrachoa* plants (which are highly susceptible to root rot in soils with poor drainage) grown in a range of pots, including those lined with a layer of crocks and those without. They found adding the crocks made no measurable difference to plant growth.

Bottom line: if you are breaking perfectly good pots just to make crocks (which loads of people do), and find the whole business a bit of a faff, remember that all the scientific evidence we have to date says the practice is at best unnecessary, and at worst may even give you poorer results. ■

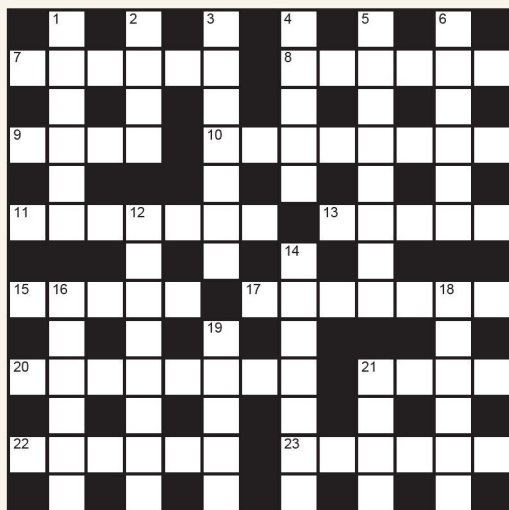
Debunking gardening myths appears monthly

Next week

The science of cooking

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

Cryptic crossword #114 Set by Wingding



Scribble zone

Answers and the next quick crossword next week

ACROSS

- 7 Basic information given by 2 for 1 offer at last (6)
- 8 Snail is soft and French (6)
- 9 Fuel going wrong way around centre of Hanoi - that's a problem (4)
- 10 Breeding colony makes pair of nests inside supporting structure (8)
- 11 Stray dog is now dropping ball and searching for water (7)
- 13 Component found in radio device (5)
- 15 Graduate's taking extremely tough subject (5)
- 17 Shrinking a cup (7)
- 20 Golf in German city? It happens after a few drinks (8)
- 21 Hydrogen bus touring centres (4)
- 22 Sea creature made us sick (6)
- 23 Two schools making stand (6)

DOWN

- 1 Physician about to leave bird (6)
- 2 Small cat causing pollution (4)
- 3 Supporting millennial offspring (7)
- 4 Good country where hormone is made (5)
- 5 Skin infection from writer's favourite island - get away! (8)
- 6 Members of quite traditional quartet (6)
- 12 "Human GPS" getting lost - it's found in bog (8)
- 14 Bone at the back? I'm not sure (7)
- 16 Colourful stones made by top-class tech entrepreneur (6)
- 18 Sounds of disapproval kicked up dust storm (6)
- 19 Fleming, for one, supports a version concerning birds (5)
- 21 Celebrate precipitation (4)

Quick quiz #211

set by Bethan Ackerley

- 1 Which RNA base isn't normally found in DNA?
- 2 What branch of astronomy are Karl Guthe Jansky and Grote Reber best known for?
- 3 In which organ would you find the bundle of His?
- 4 How do we refer to animals that walk on the soles of their feet, such as humans?
- 5 The seeds of dicot plants contain two of what?

Answers on page 47

Headscratcher

set by Howard Williams

#231 Bark run

My dog, Zippy, can't wait for me to take him for a walk. I say "walk", but it is only me that does the walking.

As soon as we get through the gate into the field to begin his exercise, I unclip Zippy's lead and he bounds off straight to the other end 200 metres away while I stroll along the path directly towards him.

As soon as he gets to the far end, he turns round and hurtles back again, brushing past me on his way to the gate where he waits for me to put his lead back on. I, of course, reverse direction as soon as he passes me on the return leg.

I have figured out that, while in the field, Zippy runs three times as fast as I walk. How far do I walk in the field?

Solution next week



Our crosswords are now solvable online

newsscientist.com/crosswords

The back pages *Almost* the last word

Early riser

When was the first sunrise on Earth?

Eric Kvaalen

Les Essarts-le-Roi, France

That is simply a question of how you define “Earth”. Assuming that our planet came together gradually as dust and particles slowly agglomerated, at what point do we start calling a particular chunk “Earth”?

Maybe we should say it was the first chunk that was bigger than anything that subsequently fell onto it. In any case, it was always rotating, so as soon as we can call it Earth, the first sunrise on Earth occurred.

Hillary Shaw

Newport, Shropshire, UK

For a sunrise, you need a transparent atmosphere and a solid or liquid surface. Earth probably acquired these at the end of the Hadean Aeon, just after the Late Heavy Bombardment, when dust began to clear from the atmosphere. This was 4 billion

“Within another 1.3 trillion sunrises, the sun will go nova. If this doesn’t vapourise Earth, it will melt the surface”

years, or some 1.5 trillion sunrises, ago, even allowing for the shorter days then. Early in Earth’s history, days were just 17 hours long due to tidal effects.

Within another 1.3 trillion sunrises, the sun will go nova. If this doesn’t vapourise Earth, it will melt the surface and, for a while, the “atmosphere” may go opaque again as the planet becomes a sea of boiling lava.

However, our sun will then become a white dwarf and the scorched cinder of our world will experience some 4 quadrillion more sunrises before the intense, brilliant point of white light that the sun has become finally cools to blackness.



RICHARD NEWSTEAD/GETTY IMAGES

This week’s new questions

All in the mind Why can’t we conjure up smell and touch in our heads, but we can “listen” to music when nothing is coming through our ears? *John Howes, Cardiff, UK*

Two of a kind How do dogs recognise that another animal is also a dog when there is such a vast array of canine shapes and sizes? *Justin Baker, Melbourne, Australia*

Garry Trethewey

Arkaroola, South Australia

Assuming the sun had ignited, the first sunrise on Earth was the first day that the planet existed. Then the question becomes something like: “When did all the material that was to become Earth actually become Earth?” or “How do we define a boundary between a proto-Earth and Earth?”

I don’t suppose a rotating gas ball can really be called Earth. At some stage, it would have condensed enough to form solids and liquids and would be big enough to be round.

Perhaps that was the first day Earth existed.

Malcolm Campbell

Brisbane, Australia

Earth’s early atmosphere was

opaque because of the formation process of the planet (which involved volcanic activity and impacts from asteroids and comets). The light from the young sun wouldn’t have been able to reach Earth’s surface, so the “first sunrise on Earth” wouldn’t have happened until the atmosphere cleared.

While it is difficult to determine the exact moment when the atmosphere cleared enough for sunlight to reach the surface, the gradual rise of oxygen during the Great Oxidation Event, which occurred 2.4 billion to 2.1 billion years ago, played a crucial role in allowing sunlight to penetrate the atmosphere.

Over time, various geological and biological processes, such as volcanic activity and the

Why can we conjure up music in our heads, but not smells or tastes?

emergence of photosynthetic organisms like cyanobacteria, contributed to transforming the atmosphere. Through photosynthesis, the organisms produced oxygen as a by-product, leading to its gradual build-up in the atmosphere.

So, the first sunrise on Earth would have happened around the time of the Great Oxidation Event.

Richard D. Cooper

via Twitter

It’s in my diary: On this day, 4.543 billion years ago, first sunrise. Think it was Tuesday.

Dirty mutts

Why do cats wash themselves, while dogs don’t?

Guy Cox

Sydney, Australia

Most cats hate getting wet and therefore have to clean themselves with their mouths.

Most dogs, on the other hand, love playing and swimming in water, which cleans them quite effectively. Another factor is that dogs like to roll in smelly substances to disguise their own smell and, well, licking dead rat from your back wouldn’t be a terribly good idea.

Garry Trethewey

Arkaroola, South Australia

Perhaps because cats are stealth predators, who rely on being quite close to prey before making a sudden lunge.

If that fails, the hunt is pretty much over. So, for a cat, not smelling is important.

On the other hand, dogs run after a prey animal (often in packs) and make no secret of their presence, eventually exhausting it, so smell is irrelevant.

Arvind Joshi

Mumbai, India

Every animal needs to clean



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itself or get cleaned. Cats lick themselves clean, but dogs do have ways to clean themselves too. They are often seen gnawing at their fur, thereby dislodging parasites. Some prefer their humans to bathe them.

For the past few years, I have observed a pack of free-living dogs. They regularly go into a nearby stream.

These dogs either like to play in water or they are enjoying the luxury of a bath.

"Cats aren't washing themselves. They are transferring allergens in their saliva to their fur before jumping on whoever has allergies"

Chris Nieass

Sydney, Australia

Actually, cats aren't washing themselves. They are transferring allergens in their saliva to their fur before zeroing in on the person in the room who has allergies and jumping on their lap.

Russell Branch

Ipswich, Suffolk, UK

My personal theory, as a custodian of several cats, is that they have evolved to a superior level to dogs. Therefore, they can't help but be more high-gene-ic than them.

Lined up

Will there ever be a time when all the planets of our solar system line up in a row, one behind the other, as seen from Earth? (continued)

Richard Swifte

Darmstadt, Germany

An exact line-up would mean that each of our seven neighbouring planets eclipses those behind it, which, given their small angular sizes as seen from Earth, is incredibly unlikely.

Realistically, you should allow a lining-up to within at least a few degrees.

As an example, just considering longitude, Mercury (nearest the sun) laps Venus every 0.396 years. Allowing 1.8 degrees of separation gives an arc of 3.6 degrees, or one-

hundredth of a circle. The chance of any other planet lining up within this arc is 1 in 100, so, on average, Earth will be in the arc every 39.6 years.

But actually, from Earth, we can see Mercury and Venus line up in four possible combinations (each planet on either side of the sun), so we can adopt about 10 years as the average line-up time. Adding in a further planet multiplies this period by 100. So a line-up of all the other seven planets as seen from Earth occurs every 100 billion years on average – much longer than the lifetime of the current stable solar system.

If we ignore Uranus and Neptune and just consider the planets visible with the naked eye, the average period is 10 million years. This makes it remarkable that, in 1993, researchers calculated that, in early March 1953 BC, the naked-eye planets formed a group within less than 4.5 degrees. This astronomical event may have been the starting point of the traditional Chinese calendar. ■

Answers

Quick quiz #211 Answers

- 1 Uracil
- 2 Radio astronomy
- 3 The heart – it is a collection of muscle cells within the organ
- 4 Plantigrade
- 5 Cotyledons, the embryonic leaves of seed-bearing plants

Quick crossword #137 Answers

ACROSS 6 Azurite, 7 Pink eye, 9 Rifle, 10 Factorial, 11 Rovelli, 13 Demist, 15 Asian elephant, 19 Square, 20 Alchemy, 23 Drip valve, 24 Viral, 26 Prior to, 27 Antigen

DOWN 1 Ruff, 2 Pineal, 3 Leaf miner, 4 Infotech, 5 Resilience, 6 Aurora, 7 Pica, 8 Eolith, 12 Vasculitis, 14 Beta decay, 16 Aardvark, 17 Used up, 18 Myelin, 21 Cavity, 22 Alto, 25 Rigs

#230 Train of thought Solution

There are seven stations. Each is visited twice, except for the station at the end of the line, halfway through the journey. So, for six of the stations we just have to make one of two choices: to take the photo on the way out or on the return.

This yields $2 \times 2 \times 2 \times 2 \times 2 = 64$ possible photo orders.

Biting biting remarks

Biting remarks about bite marks are evident in several papers in the current issue of the *Journal of the California Dental Association*. One paper, called "Is it likely that bite mark analysis will in the future meet the criteria necessary for use in the justice system?", expresses the general sentiment that, no, courts cannot and should not trust a bite mark as scientific proof of which person did the biting.

Another paper decries the "community" of persons who give expert-witness opinion in criminal court proceedings, saying that that community is tiny and "composed of a few dozen adherents in the US" and that bite-identification evidence is unreliable.

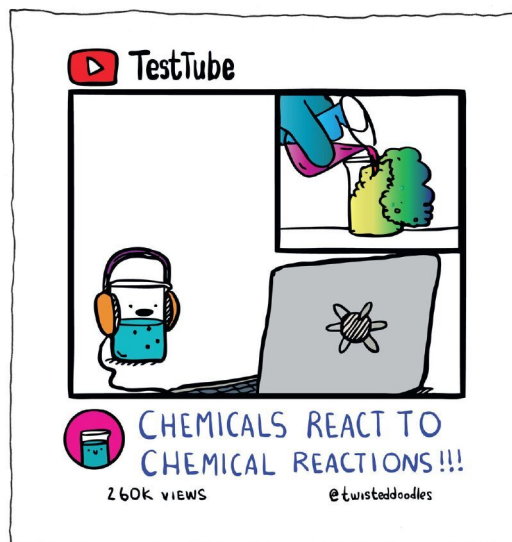
As Feedback remarked not long ago (10 December 2022), bite mark-assessment assessment entered a Pretty/Sweet era in 2010, when David Pretty and Iain Sweet published a paper warning legal and dental authorities that there had been "A paradigm shift in the analysis of bite marks".

The prognosis for relying on bite marks to forensically identify individual biters seems dim, but hope exists. Researchers in Indonesia, Peru, Brazil, Malaysia, Cambodia and India have published a paper about "3D bitemark analysis in forensic odontology utilizing a smartphone camera". They assert that "technologies have been developed to obtain an adequate bitemark analysis".

Bite-mark analysis hoo-ha, so far, mostly applies to identifying human biters. Mostly, but not entirely. Enter a new paper called "Forensic determination of shark species as predators and scavengers of sea turtles in Florida and Alabama, USA".

It reports several cases of bitership (please note and celebrate Feedback's word coinage) identification of bite marks on turtles. Detectives reportedly "narrowed down" the list of suspected biters to one or perhaps two species of shark. They neglected or failed to identify the individual shark or sharks.

Twisteddoodles for New Scientist



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He is Lean

Nominative determinism can be a heavy burden for individuals whose life work immediately seems, to everyone who meets them, a fat target for jokes.

With that in mind, Feedback expresses sympathy to Michael Lean, professor of human nutrition at the University of Glasgow. Lean has written, in Lean prose, about many subjects that relate either directly or oppositely to leanness. Among them: how to understand obesity when your data about it is too lean; staying slim; and people who are too lean.

He is Stout

Michael Lean, meet Michael Stout, assistant professor of nutritional sciences at the University of Oklahoma. Stout has done much

research related to stoutness.

Among his topics: nutrient excess; human fat cell progenitors; obese dogs; and gorging-related fat deposition in mice.

Duck dining

"A cross-sectional survey of gastrointestinal parasites in an ornithological garden", a new study by Ali Salavati and colleagues at the University of Tehran, Iran, is comprehensive and crowd-pleasing (who could resist its mention of "using Sheather's sugar solution for detection of helminth eggs and apicomplexan oocysts"?).

But it overlooks a curious reciprocal exchange of parasites that almost inevitably happens between certain whooper swans and certain mallard ducks.

The whooper/mallard

relationship becomes evident to anyone who chances to read two old research reports. Each tells half of the story of the two kinds of bird.

In 2012, Tetsuo Shimada published a paper called "Ducks foraging on swan faeces". Shimada tells about his "observations made of five Mallard *Anas platyrhynchos*... seen feeding on Whooper Swan *Cygnus cygnus* faeces, on the ice in Lake Izunuma, Japan, on 10 February 2010".

In 1984, Yoshiaki Iijima wrote a paper called "Strange feeding behaviour of the whooper swan *Cygnus cygnus*". There he says: "On 20 March 1984, young Whooper Swans were seen to peck at and eat two Mallards *A. platyrhynchos* which were caught in fishing nets at a salmon culture pond... According to the staff of the fish farm, two adult and four young swans had frequented the pond since the beginning of March, and it was primarily the young which ate the Mallards... The reason for this strange feeding behaviour is not clear."

When considered together, the reports are further evidence that different species do sometimes provide each other with succour and nourishment.

Well-knitted superpower

Bryn Glover makes a measured, although slightly deteriorating, contribution to Feedback's list of trivial superpowers. He says: "Half-a-century ago, when we were producing babies, my wife spent many evenings in front of the telly with her knitting needles. The patterns usually required specified lengths to be knitted on to one needle, and we found that if she held up her work, I could instantly estimate the length to about one-quarter of an inch. This meant she did not have to fiddle around with her tape measure until the work was very close to its intended length. I can still do it, but my accuracy has seriously deteriorated to about plus/minus half an inch."

Marc Abrahams

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