

New Scientist

WEEKLY 8 August 2026

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ANCESTOR DISCOVERED
IN OUR DNA

THE CONTROVERSIAL
ALZHEIMER'S SURGERY
GIVEN TO THOUSANDS

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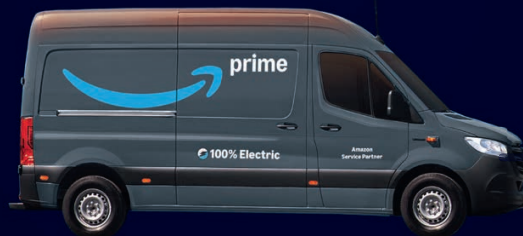
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A burning question

We must tackle the root cause of climate change, not just adapt

WHEN your house is on fire, should you call a firefighter, an architect or a politician? OK, that's an easy one – but what about when the world is on fire? That is a question many of us will be wrestling with as dangerous blazes spring up across much of the world.

Calling a firefighter fixes your immediate problem, which is that your house is burning down. What it doesn't address is why your house is burning, or the steps you could have taken to reduce the risk of disaster.

As we report on page 4, the question of how to prevent wildfires in Europe is now at the top of many minds on the continent. This means changing the way that land is used in order to build in resilience, much as an architect

might design a home with fire doors or other safety features.

Learning to live with wildfires in this way is a form of climate adaptation. It is essential that we redesign our way of life to ease the burden of the warmer world we have created, but that doesn't mean

"As long as our society is dependent on fossil fuels, Earth's climate will continue to warm"

we should ignore the underlying cause: burning fossil fuels and greenhouse gas emissions.

And yet, in responding to Europe's extraordinary summer, some people seem to want to do just that. "We've lost the war against global warming –

so we should ditch net zero and learn to handle hot weather" was the view of one columnist in *The Telegraph*, a UK newspaper known for publishing climate-sceptic views.

This is entirely wrong, and it is where our politicians must step in. If society is organised in such a way that your house keeps getting set on fire, there is only so much an architect can do – eventually, it will burn down. Similarly, as long as our society is organised around burning fossil fuels, Earth's climate will continue to warm and the wildfires will continue to get worse. Achieving net zero, meaning we no longer emit a meaningful amount of greenhouse gases, is the only way to do that. Politicians who say otherwise might as well hand out matches. ■

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Europe faces fiery new reality

Paradoxically, suppressing wildfires has also made European countries more vulnerable to huge blazes. Experts say prevention strategies need updating, finds **Alec Luhn**

AS UNPRECEDENTED wildfires continue to burn in France and Spain, the blame game has also heated up. Right-wing opposition politicians have claimed that both nations' governments under-invested in water bombers because nearly half of their Canadair planes are out of operation. Officials have accused conservative-led regions like Madrid, where the forest fire service is only half-staffed, of undermining fire control.

But experts say the debates over firefighting are focusing on the symptoms, rather than the disease. Instead, Europe must invest more in fire prevention measures, such as intentionally starting controlled fires to manage vegetation. That includes the UK, where a wildfire in Suffolk came within 5 kilometres of the Sizewell nuclear power station and another burned 25 square kilometres of moorland and forest in the Cairngorms in Scotland.

"You can double the number of planes; you can triple it. It will be very, very costly, and every single euro you put there is not a euro that is invested in prevention," says Sebastien Lahaye at the

"Shrubs and brush have proliferated, so those fires that do get out of hand are more likely to blow up"

French wildfire consultancy Warucene. "You will nevertheless have one fire or several fires that will escape and that will become this huge fire."

The ingredients of a catastrophic wildfire are drought, heat and an accumulation of fuel, and this year has mixed in a generous portion of all three. A wet spring in parts of Europe increased vegetation, which then dried out in a widespread drought this summer. Now, much of the continent is suffering

through its fourth heatwave.

More than 4300 square kilometres have gone up in flames across the European Union, a pace that, if it continues, will break the record of 10,800 square kilometres burned last year. Record-sized wildfires near Bordeaux and Madrid forced one of the largest evacuations since the second world war.

In southern Europe, the average number of wildfires each year and the area burned has actually declined since 1981, according to a study published last week by Raúl Cordero at the University of Groningen in the Netherlands and his colleagues. Mediterranean countries have warned the public against campfires and cigarettes in woodlands, and got better at quickly extinguishing blazes by training firefighters and buying planes and helicopters.

But this crackdown has created a tinderbox. Shrubs and brush have proliferated, so those fires that do get out of hand are more likely to blow up into extreme megafires. This "suppression paradox" has been compounded by an exodus of people from rural areas to cities, leaving former farms and pastures overgrown. At the same time, more houses have sprung up in forests outside cities like Barcelona, raising the risk of wildfires, which most often are ignited by humans.

Now, global warming is catching up with the improvements in wildfire suppression. Hot, dry and windy fire-weather days have more than doubled across much of southern Europe, the study found.

"What's occurring this year seemed to confirm our hypothesis... that we are about to enter a new era of large fires that didn't exist in Europe because of the successful fire suppression and education," says Cordero.



CESAR MANSO/AFP VIA GETTY IMAGES

Firefighters battle a blaze in Ávila, which was the largest in Spain's history

Rather than responding with more suppression, Europe must embrace the often-uncomfortable task of making landscapes fire-resilient. Roughly speaking, 90 per cent of the fire budget in many countries goes towards fighting fires and 10 per cent towards preventing them, according to Johann Goldammer at the Max Planck Institute for Chemistry in Germany. "It should be the other way round," he says.

The EU has been working to restore nature in 20 per cent of its land area by 2030 to combat the climate and biodiversity crises. But in many cases, woodlands need to be more intensively managed, including through sustainable logging, Goldammer argues.

Logging alone isn't enough. The fire near Bordeaux raged through Europe's largest human-made forest in Landes, 10,000 square kilometres of land that was once

so swampy that shepherds walked on stilts. Napoleon III reclaimed the marshes by planting maritime pines, which are still harvested for paper and lumber.

Especially since a devastating 2022 fire there, landowners have built access roads, water ditches and fire breaks. But they also replanted the pine monoculture, a practice that raises fire risk. Similar monocultures of eucalyptus in Portugal have fuelled blazes like the Pedrógão Grande fire, which killed 66 people in 2017. While diversifying trees in Landes may be difficult, the fire breaks at least need to be widened and increased, says Lahaye.

Fighting fire with fire

Even where forests don't have fire breaks cleared to the bare ground, trees can be thinned and brush cleared to create fuel breaks. Re-establishing orchards, vineyards, pastures and agriculture can help create

'Fire clouds' are making wildfires more dangerous



a “mosaic” of higher and lower fire fuel loads, rather than the uninterrupted tree cover that allowed the Bordeaux and Madrid fires to explode out of control.

Spanish regions have deployed herds of goats, sheep and cows to devour flammable brush. But in France, only 30 per cent of risky brush has been cleared due to conflicts between wildfire regulations and biodiversity regulations.

The most effective way to clear undergrowth is often through prescribed burns. Wildfires in the western US in 2020 were 16 per cent less severe in areas that had previously undergone prescribed burns, and they emitted 14 per cent less harmful particulate pollution as well.

But Europe is much more densely populated, and locals often see the technique as a threat. In some areas, regulations still often prevent it. While prescribed burning has been conducted along roads in Landes, it is excluded from the timber plantations. ■

A PYROCUMULONIMBUS cloud, a thunderstorm generated by an intensely hot wildfire, has been observed with radar for the first time in France. These deadly “fire clouds” of rising hot air, smoke and moisture, which accelerate blazes with strong winds and soaring embers, are expected to become more common in Europe.

“You have this tilted column that is sucking air and then propagating embers in front, and it also creates lightning. That’s another way of lighting up fuels in front of the fire, so these cells are unstoppable,” says Jean-Baptiste Filippi at the University of Corsica, France.

The wildfire burning in the Gironde region of France, close to the city of Bordeaux (see main story, left), generated a pyrocumulonimbus cloud on 24 July and another on 25 July, according to regional officials. Embers and lightning ignited new fires around the original inferno.

Sometimes called the “fire-breathing dragon of clouds”,

A fire cloud seen near the village of Saumos in France

pyrocumulonimbus are typically generated by massive wildfires in the forests of North America, Siberia and Australia. They have spurred on infamous fires like the Black Saturday bushfires that killed 173 people in Australia in 2009.

In Europe, however, there have been only a handful of confirmed pyrocumulonimbus in Spain and Portugal, including

“Dozens of lightning strikes can ignite blazes as far as 100 kilometres ahead of the main fire”

one during Portugal’s devastating Pedrógão Grande fire in 2017, which destroyed hundreds of homes and killed 66 people. But that appears to be changing.

“You have to have two things happening at the same time: an extreme heat source and an unstable atmosphere that interacts with the fire,” says Francesca Di Giuseppe at the European Centre for Medium-Range Weather Forecasts. “If... the heat from the fire increases, like it’s projected to increase from our studies, then yes, you should see more of these events.”

This firestorm begins to take shape when temperatures as high as 800°C send a plume of smoke into the sky. As the hot air rises and cools, water vapour condenses onto the ash to form pyrocumulonimbus clouds.

If the plume is hot enough and the atmosphere is unstable enough, the cloud can keep rising to reach the upper troposphere at 10,000 metres, the cruising altitude of a passenger plane. It sometimes reaches the stratosphere, spreading as much smoke as a moderate volcano. It becomes a pyrocumulonimbus when the static electricity from colliding ice particles sparks thunder and lightning.

Although rain from the cloud often evaporates in the hot air, this kind of thunderstorm nonetheless creates its own weather system. The cloud’s updraft pulls in air, fanning the flames with winds reaching 160 kilometres per hour and accelerating the fire’s spread by up to five times, according to Filippi.

Meanwhile, strong downdrafts create erratic gusts that carry embers off to start new fires. Dozens of lightning strikes can ignite blazes as far as 100 kilometres ahead of the main fire. It can also create fire tornadoes of twisting flames. As the winds, embers and lightning strengthen and expand the wildfire, it releases more heat and smoke, a feedback loop that can amplify the rising cloud for many hours.

Both wind shear higher in the atmosphere and erratic gusts at the ground can take the fire in unpredictable directions, making it nearly impossible to contain its acceleration or plan targeted evacuations. ■ **AL**



SDIS33/HANDOUT/EPFL/SHUTTERSTOCK

Questions over dementia surgery

Thousands of people in China have had a now-banned experimental procedure that aims to help the brain flush away Alzheimer's-linked proteins, reports **Carissa Wong**

MORE than 2000 people in China are thought to have undergone an experimental surgery to treat Alzheimer's disease, which allegedly helped a man with the condition who was bedbound walk again. The procedure – which involves connecting the lymphatic system to nearby veins to remove Alzheimer's-associated proteins – has now been banned in the country.

"When I first heard of this treatment, I was shocked," says Steven Proulx at the University of Bern in Switzerland. "There is basically no evidence supporting this."

But initial results from small safety trials in the US and Singapore, which were presented earlier this month at the Alzheimer's Association International Conference in London, suggest the approach is safe for up to six months, with some signals of cognitive improvement.

An ongoing randomised trial is now comparing the surgery with a sham procedure, which should provide a clearer picture of its potential, but some have questioned the ethics of this and how helpful the trial will be.

The surgery, called deep cervical lymphovenous anastomosis (DCLVA), aims to enhance the drainage of brain waste via the lymphatic system, a network of vessels and nodes that collects waste from tissues to be broken down or removed from the body. The idea is that surgically attaching this network to nearby veins accelerates this process to more efficiently clear Alzheimer's-related proteins like beta-amyloid and tau.

A computed tomography (CT) scan showing the brain of a woman with Alzheimer's

It was developed by Xie Qingping at Hangzhou Qiushi Hospital in China, based on a routine treatment for chronically swollen limbs. In 2024, Qingping – who didn't respond to *New Scientist's* requests for comment before going to press – and his colleagues reported in the journal *Plastic and Reconstructive*

"It is unclear whether any improvements were substantial enough for people to notice them"

Surgery that they had conducted DCLVA on 50 people with Alzheimer's disease. They also released a video of a man with Alzheimer's who had been bedbound briskly walking eight months after the surgery.

But some have concerns over the reliability of this case report. "A video from one patient I would not find trustworthy," says Proulx,

who added that the researchers didn't assess for other improvements, such as changes to the man's brain-imaging scans.

Still, the footage went viral in China, says Fan Fan at Augusta University in Georgia. By May 2025, thousands of people were estimated to have had the procedure in around 300 private and public hospitals across China.

Reports suggest that many of these were done by plastic surgeons, says Proulx, with fees ranging from tens of thousands to several hundred thousand Chinese yuan (thousands to tens of thousands of pounds).

Lack of evidence

But in June 2025, China's National Health Commission banned the procedure outside of research settings, citing a lack of evidence for safety and effectiveness. The

commission didn't respond to *New Scientist's* request for comment before going to press. "It was appropriate for China to stop DCLVA from being offered for Alzheimer's disease," says Shiju Gu, who previously researched Alzheimer's disease at Harvard University.

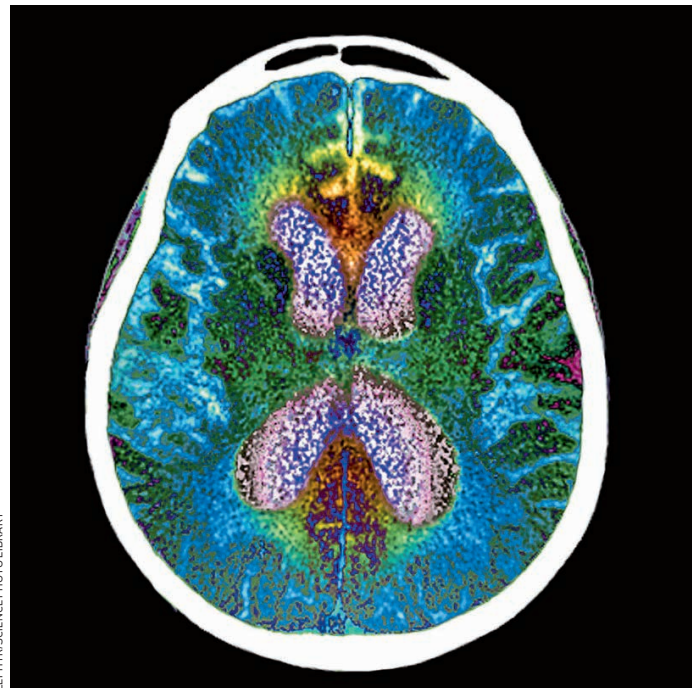
To date, about a dozen case reports and trials have reported doing DCLVA on people with moderate or severe Alzheimer's. The US and Singaporean trials presented at the recent Alzheimer's conference suggest it is safe over the short term. The Singaporean trial also found evidence of small cognitive improvements in two out of its four participants.

These improvements aren't necessarily trivial, says Jeff Iliff at the University of Washington in Seattle, but none of these trials was randomised or blinded.

"Based on the evidence currently available, I would describe DCLVA's effectiveness as uncertain because the existing clinical studies in China have generally been uncontrolled, short term and methodologically limited, making it difficult to separate a real surgical effect from placebo effects, postoperative care or fluctuations in the patient's condition," says Gu.

It is also unclear whether any improvements were substantial enough for people or their families to notice them, says Per Kristian Eide at the University of Oslo in Norway.

A randomised controlled trial comparing DCLVA with sham surgery is now ongoing. Led by Hui-Sheng Chen at the General Hospital of Shenyang Military Region in China, who didn't respond to *New Scientist's* request for comment before going to press, the trial is aiming



We all have DNA from 'ghost' ancestors in our genomes

Michael Le Page

to recruit 50 people with mild to moderate Alzheimer's. Results are expected next year.

Ethical concerns

Despite previous trials being criticised for not having control groups, some have questioned the ethics of sham surgery. "The risks of any kind of surgery and the accompanying anaesthesia in an elderly and potentially frail population makes the performance of a 'fake' intervention very difficult to justify, despite the importance to the overall study," says Iliff.

Eide, who shares these ethical concerns, also points out that the trial's protocol says it will look for cognitive improvements four days after the surgery. "You wouldn't expect any improvement in such a short time," he says.

Yet the surgery could have one major advantage: it is a one-off intervention. That makes DCLVA worth pursuing, says Vincent Tay at Changi General Hospital, who is involved in the Singapore trial.

Treatment for Alzheimer's generally focuses on relieving symptoms, but antibody therapies such as lecanemab that remove beta-amyloid clumps from the brain are approved in the US and the UK. But their questionable efficacy and high cost, partly due to being infused, mean they aren't available through the UK's health services. "The upside is this [surgery] is a one-time thing," says Raag Airan at Stanford University in California.

So, could this procedure one day be routine in China, and even around the world? "I'm paying close attention to results being published in this space, as is everyone working on this question," says Iliff. ■

S. ENTRESSANGLE/IE. DAYNES/SCIENCE PHOTO LIBRARY



***Homo heidelbergensis* may be the source of a small fraction of our DNA**

these regions," says Moorjani.

But much more of the DNA deriving from one ghost ancestor appears to have been selected for, or it was at least neutral in evolutionary terms. This is probably because the population of this ghost ancestor was much larger, she says.

The team's work suggests that the ghost ancestor split away from the main lineages leading to modern humans around 800,000 years ago. Then, some time later, the two lineages came back together and interbred (*Science*, doi.org/rhtb).

"Because all modern humans carry signatures of the ghost ancestry, it's most likely that the gene flow occurred in Africa, and that this population existed in Africa," says Moorjani. Based on all these factors, this ghost ancestor could be a species known from fossils, such as *Homo heidelbergensis*, the researchers speculate.

A second ghost ancestor identified by their approach is much older. It split from the main lineage leading to modern humans around 1.8 million years ago, but later interbred with Denisovans in Eurasia. Modern humans inherited its DNA via Denisovans, says Moorjani.

The most likely candidate for the older ghost lineage has to be *Homo erectus*, says Chris Stringer at the Natural History Museum in London.

"These results are exciting," says Stringer. "They provide indirect ways of reconstructing parts of the genomes of more primitive species like *Homo erectus* and *Homo heidelbergensis*." ■

IN ANY person alive today, between 0.5 and 1 per cent of their DNA comes from an unknown hominin species that interbred with *Homo sapiens* before they left Africa.

Different people have different bits of DNA from this "ghost" ancestor and, crucially, they are spread fairly evenly around the genome. This means that, if all the bits could be put together, it might be possible to assemble almost an entire genome of this ancient species.

Earlier research using ancient DNA sequences from fossils revealed that *Homo sapiens* interbred with Neanderthals and Denisovans within the past 50,000 years.

While previous work has also identified ghost ancestry from at least two other lineages, Priya Moorjani at the University of California, Berkeley, and her colleagues used a new method that is much more powerful. It is based on constructing a "family tree" for parts of the genome, which has only recently become computationally possible.

"I believe it is the next frontier

of research in human genetics, because it allows us to even learn about our ancestors for whom we don't have any fossil [DNA] evidence," says Moorjani.

Only a small part of the Neanderthal and Denisovan genomes remain collectively preserved within us. "Long segments of the genome are devoid of, or have very low

"It might be possible to assemble almost an entire genome of this ghost ancestor"

fractions of, Neanderthal or Denisovan ancestry," says team member Arjun Biddanda at Johns Hopkins University in Maryland. "Yet we were able to find high-ish fractions of this ghost ancestry in these regions."

The researchers think this is because the populations of Neanderthals and Denisovans were very small, and therefore were more likely to have detrimental mutations. "Most likely there was selection against Neanderthal or Denisovan ancestry in

Amazon's huge lost civilisation

The little-known Aquiry society built tens of thousands of giant earthworks in the rainforest and had a population of up to 3 million people, finds **James Woodford**

SURVEYS over the dense Amazon rainforest using canopy-penetrating lasers have revealed hundreds of vast structures built by a lost civilisation that thrived for almost 1500 years. The findings lend weight to suggestions that millions of people once lived in areas today regarded as wilderness.

The Aquiry civilisation, which lasted from roughly 600 BC to AD 850, built vast geometric earthworks, whose shapes may represent various deities, without using metal tools or animals. Many are also connected by ancient roads.

These people were little known to science until recent decades because the part of Amazonia where they lived constituted what was thought to be “an almost uninhabited pristine rainforest”, says Martti Pärssinen at the University of Helsinki, Finland. But researchers have been learning more about the civilisation’s extent using lidar, a laser-scanning technique that can create a three-dimensional map of the ground under most vegetation.

From aircraft flying over the forest, around 30 laser pulses are shot at the ground every square metre. Small gaps in the forest canopy allow some of these pulses to reach the terrain below and return to the aircraft.

In 2024, Pärssinen and his colleagues flew over an area of nearly 4500 square kilometres, in the Brazilian states of Acre and Amazonas. The survey revealed 432 ditched geometric enclosures called geoglyphs, nearly 400 of which were completely new to science.

By extrapolating these results across the 183,000 square kilometres of territory inhabited by the Aquiry civilisation, the



MARTTI PÄRSSINEN, RISTO KALLIOLA & FABIO DE NOVAES

team estimates there may be as many as 30,000 geoglyphs.

On average, the earthworks cover 3 hectares, but they can be as large as 50 hectares. The ditches are typically about 12 metres wide and up to 5 metres deep. “The scale and precision of these constructions is simply astonishing,” says Pärssinen.

Each of the average-sized geoglyphs would have required around 300 people to build and maintain, the researchers estimate. The findings suggest a total population of between 1.25 million and 3 million people at the civilisation’s peak between AD 100 and 300, says Pärssinen, and his feeling is that the upper end of the estimate is most likely.

“The notion of Amazonia as an untouched wilderness is largely a myth and [the truth is] that ancient human societies played an important role in

“Each of the average-sized geoglyphs would have required about 300 people to build and maintain”

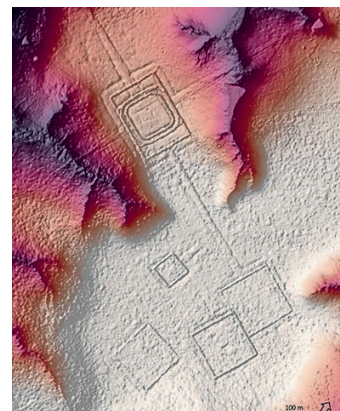
shaping the present-day tropical rainforest,” he says.

Over the past 20 years, Pärssinen and his colleagues have excavated more than 40 ceremonial and settlement sites in Acre, Amazonas and Rondônia (another Brazilian state), as well as in Bolivia.

Mind-blowing magnitude

This showed that the geoglyphs were ceremonial centres used as “venues for gatherings, political decision-making and displays of chiefly generosity, ritual dancing, music, feasting, athletic competitions and ball games”, he says. Long dwellings that housed several families were probably situated in a dispersed pattern around the earthworks (*Nature*, DOI: 10.1038/s41561-026-02054-6).

The Aquiry had a major impact on the Amazon rainforest, says Pärssinen, burning bamboo forest to make way for maize, squash and manioc, as well as clearing forests for the huge earthworks and the extensive



The Aquiry geoglyphs discovered in Brazil (left) were revealed using canopy-penetrating laser scans (above)

roads leading to them. The Aquiry also grew many fruit-bearing tree species, including the Brazil nut tree and peach palm. It isn’t known what caused their demise.

Michael Heckenberger at the University of Florida says the claims about population size are bold, but they are “plausible and extremely important, even mind-blowing”.

“The idea of pre-Columbian urbanism in southern Amazonia has gained momentum over the past two decades. What we now need to know is what is going on around the detectable earthworks, such as occupational sites to support the high estimated population,” he says.

Charles Clement at the National Institute of Amazonian Research in Manaus, Brazil, says the new research “puts a large-scale culture in the Amazon forest”.

“Needless to say, they have not ground-truthed the entire set of new geoglyphs, but previous lidar studies have been remarkably efficient, so I feel that their numbers are solid,” he says. ■

Astronomy

Extraordinary supermassive black hole caught straying

Leah Crane

THE most extreme example of a so-called wandering supermassive black hole has just been spotted.

Black holes don't emit light, so Robert Stein at the University of Maryland and his team found this one only when it devoured a star in what is known as a tidal disruption event, or TDE. A machine learning algorithm identified the burst of light as a possible TDE in data from the Zwicky Transient Facility in California, and the researchers performed follow-up observations with several other telescopes to confirm it.

This TDE is the most distant from the centre of its host galaxy that we've ever seen. It is more than 30,000 light years from the centre of its galaxy – for comparison, our solar system is about 26,000 light years from the centre of the Milky Way (*The Astrophysical Journal Letters*, doi.org/hccvkm).

Wandering supermassive black holes usually begin their journeys away from a galactic centre due to a merger: two galaxies slam together and one of their central black holes is flung away. Finding these black holes can tell us about the history and growth of their galaxies. "What's exciting about this result is that we think it's the tip of the iceberg," says Stein. "If we can understand how many wandering supermassive black holes there are, then it can tell us about how many mergers the galaxy has been through and how it's evolved over time."

There is a limit to how much we can learn about this particular black hole and its environs. The light from the star being devoured is still too bright to see much of anything else around it.

There is probably a small cluster of stars that is gravitationally tied to the black hole, and one of those caused the TDE as it fell in, but we can't confirm that until the light fades. ■

Health

Could eating less protein extend our lifespans?

Carissa Wong

PROTEIN-RICH products – from cereal to crisps to coffee – are all over supermarket shelves, but mounting evidence in non-human animals suggests that restricting our intake could slow ageing and extend lifespan.

According to the latest review of the evidence, "increasing dietary protein, beyond what's needed, for sedentary individuals or animals leads to metabolic problems and can lead to shorter lifespan", says Dudley Lamming at the University of Wisconsin-Madison.

Lamming and his colleague Bailey Knopf, also at the University of Wisconsin-Madison, sifted through more than 300 studies, mostly in sedentary mice and rats, that explored how restricting protein intake to the minimum required to prevent deficiency affects ageing and lifespan.

In these studies, rodents generally either ate the equivalent of the minimum protein requirement recommended by US guidelines, 0.8 grams of protein per

kilogram of body weight, or about double that. The latter is similar to the intake recently recommended by US dietary guidelines for optimal health, 1.2 to 1.6 grams of protein per kilogram of body weight.

In one study, rats that ate around the minimum protein intake lived for nearly 120 days, or more than 50 per cent, longer than those that ate about double that (*Cell Press Blue*, doi.org/rh2n).

This may be because protein restriction increases levels of the hormone FGF21, says Lamming. In rodents, this acts on the brain, fat tissue and the liver to improve blood sugar levels and reduce the number of senescent cells. These cells, which accumulate with age, have stopped dividing and cause chronic inflammation.

Restricting protein intake has also been shown to dampen the activity of a protein called mTORC1 in mice. mTORC1 ordinarily stimulates cell growth, but reducing its activity boosts cellular repair. "It essentially switches cells from a proliferative state, where they're growing and engaging a lot of metabolism, to one where

they're dividing more slowly, if at all, and focusing on repair," says Lamming. Studies suggest this cuts the risk of age-related conditions and extends lifespan in mice, he says.

All this suggests that the recent trend to up our protein intake is probably fine among people who exercise regularly, because they may need more protein to repair muscle

"Increasing dietary protein, beyond what's needed, for sedentary individuals leads to metabolic problems"

damage, but eating more than is needed could cause harm in sedentary individuals, says Lamming. But Donald Layman at the University of Illinois Urbana-Champaign points out that rodents vary hugely from people when it comes to protein metabolism. Protein restriction may therefore affect mTORC1 pathways differently between the different species, he says.

What's more, the review doesn't include most of the studies in people that suggest upping our protein intake beyond the minimum cuts our risk of frailty, he says.

Lamming says no studies were intentionally omitted. Beyond building muscle and preventing frailty, there is mixed evidence on whether a higher protein intake helps with ageing, he says.

For instance, one study linked this to a reduced risk of age-related muscle loss, or sarcopenia, among older twins in the UK. But the rates of sarcopenia were so low that the link is unreliable, says Elizabeth Williams at the University of Sheffield in the UK. ■



CARLOS GAWRONSKI/GETTY IMAGES

Quantum advantages multiply

Three problems that conventional computers couldn't crack have been solved by quantum computers, showing their potential importance for science, says **Karmela Padavic-Callaghan**

QUANTUM computers are pushing further into the world of the impossible. Three new examples of calculations that no other type of machine can do show how such computers are becoming useful as scientific tools.

There are many situations in science where solving a problem requires extensive computer calculations, such as when trying to predict the behaviour of large molecules. But in some cases, the calculations are so complex that traditional computers will never reach an answer.

This is the point at which quantum computers can have “quantum advantage”, as they can use quantum phenomena to produce a solution. But how do you know whether you can trust an answer that only one machine can produce?

Researchers at IBM and their colleagues have now claimed three new cases of quantum advantage, together with arguments for why these calculations should be trusted.

Two of the cases were simulations of mathematical models that are of particular interest to physicists who study materials. In one, the model aims to capture how quantum materials behave when they are hit by laser light, focusing on a type of magnet. Using a quantum computer, the researchers discovered that some of the magnet's properties oscillate, which wasn't known before. Notably, simulations on the Fugaku supercomputer in Japan, as well as on an Nvidia GPU, failed to produce results.

In the second case, the team focused on how information

gets scrambled within a very uneven material, which could help researchers to better understand the chaotic processes that take place when, for example, a catalyst is used to accelerate a chemical reaction.

Here, researchers compared the quantum computer's output with a leading simulation method for traditional computers – and one that has dispelled quantum advantage claims in the past.

“You can actually take the data from the experiment and get an estimate for how good the runs were”

For some simulation parameters, these methods couldn't measure up to the quantum computer.

For both simulations, the team made an effort to estimate how much the quantum computer could be trusted by repeating the simulation on several different quantum computers, each of which had slightly different

amounts of noise, and they also deliberately injected noise into some computational runs. The comparison between these differently noisy computations enabled the team to quantify how much of the quantum computer's output can be trusted and how much is just noise, says Abhinav Kandala at IBM.

The third example focused on a sampling problem that looks at the output of many quantum-computing circuits that have pre-specified properties, such as the distribution of mathematical operations within them. Researchers already knew that sampling problems are difficult for conventional computers, but even though a quantum computer could output an answer, it previously struggled to verify how meaningful it was – whether it was mired by errors. The team devised a procedure that also involved tweaking and then repeating the computation to quantify the fidelity of the

quantum computer's answer.

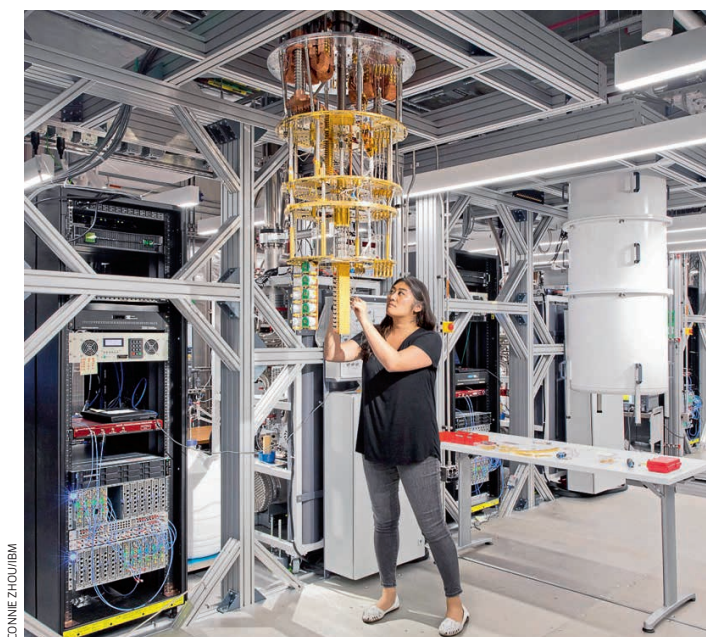
Quantum computers are now operating like we have always wanted them to, says Kandala. “I hope people begin to use them as scientific instruments that have trusted outcomes.”

Creating a toolbox

These new efforts to verify just how well quantum computers are doing are a step in the right direction, says Dominik Hangleiter at ETH Zurich in Switzerland, who wasn't part of the team. “You can actually take the data from the experiment and get an estimate for how good the experimental runs were.” This process is still not ideal, as it isn't fully agnostic of the quantum computer's specifics, but it is necessary for the still fairly small and noisy quantum computers we have today, he says.

In addition to further improvements on the verification front, quantum computer simulations of materials also need to be pushed further. Emanuele Dalla Torre at Bar-Illan University in Israel says the magnet simulation made findings significant from a fundamental-science perspective, yet it was still idealised compared with real-world magnets. “The problem itself is, at the end, a basic science problem, which doesn't [necessarily have] a clear usage right now.”

But the team is optimistic about how these new developments could jump-start an era of quantum usefulness. “We are creating the toolbox for how we can trust the output [of quantum computers]. And once we can trust the output, then we can start to nail down applications,” says Jay Gambetta at IBM. ■



CONNIE ZHOU/IBM

IBM researchers have used simulations to test quantum machines

Smallpox in 400-year-old Chilean mummies came from Europe

James Woodford

DNA samples collected from Inca mummies have confirmed the presence of a strain of smallpox that first emerged in Europe.

"We interpreted this as the first direct molecular evidence of smallpox introduction into the Americas through European colonisation," says Shigeki Nakagome at Trinity College Dublin, Ireland.

Smallpox was the scourge of humanity for centuries until its eradication in the 1980s, through vaccination, from all but a few high-security medical laboratories. Severe strains of the virus had a mortality rate of up to a third and left survivors with scars from the blisters and scabs that cover the skin and fill with pus.

The disease was particularly brutal in parts of the world colonised by Europeans, such as Australia and the Americas, where Indigenous populations had no natural immunity, resulting in millions of deaths.

In the Americas, historical reports record that smallpox began devastating Indigenous

communities in the early 16th century, after the arrival of European colonists.

Matthew Ward at the University of Dundee in the UK, who wasn't involved in the new research, says the waves of epidemics, including smallpox, that spread across the Americas were some of the most important events in history. "These diseases killed perhaps 95 per cent of

Francisco Pizarro led the Spanish conquest of the Inca Empire



FOTOTECA GILARDIGETTY IMAGES

the Indigenous population of the Americas and allowed for European colonisation," he says.

Nakagome and his colleagues studied samples of bone from mummies found at an archaeological site known as Camarones 9 in northern Chile, discovered in 1957. Over subsequent decades, 41 mummies wrapped in blankets and buried with grave goods were recovered from the site.

"While the original aim was to study the human DNA, we also searched for DNA from ancient pathogens," says Nakagome. "That is when we discovered fragments matching the smallpox virus in two individuals."

The first was a woman who was 30 to 35 years old at the time of her death, and the second, an 18-to-20-year-old man, was revealed by carbon dating to have died between 1492 and 1631.

By reconstructing the virus's genomes and comparing them with other ancient and modern smallpox viruses, the team found that they belonged to a lineage of smallpox that

includes early medieval and early modern European strains (*Science*, doi.org/rhsr).

The discovery adds weight to the possibility that small skin lesions on the trunks of the mummies, previously attributed to chronic arsenic exposure, may in fact have been the distinctive pustules that scar the skin of smallpox victims.

"This finding allowed us to identify a small group of people impacted by the virus for which no historical record exists," says team member Constanza de la Fuente Castro at the University of Chile in Santiago. Before the new research, the pathogen was known only from historical accounts of large-scale outbreaks, she says.

The work was particularly sensitive because of the disturbance of the original remains and the loss of material during analysis, both considered extremely controversial subjects to Indigenous people and the scientific community. "We never forget that behind every DNA extraction is a person, not a data point," says de la Fuente Castro. ■

Health

Guillain-Barré drug switches off part of immune system

THE first targeted treatment for Guillain-Barré syndrome has worked well in a late-stage clinical trial.

"Patients got better sooner and more completely on every measure in our studies," says Doug Love at Annexon Biosciences, the Californian company developing the treatment.

Guillain-Barré syndrome is a rare condition that can affect anyone who has recently had an infection. After fighting the infection, a person's

immune system starts mistakenly attacking their nerves. This assault causes weakness or tingling in their arms and legs, which can progress to difficulty walking, speaking, swallowing and breathing, and sometimes paralysis or death.

The new treatment, called tanruprubart, is a monoclonal antibody that works by blocking a protein in the blood called C1q. This switches off a branch of the immune system called the classical complement pathway that is misdirected to attack nerves in Guillain-Barré syndrome.

In a late-stage trial in Bangladesh

and the Philippines, 241 people with a recent diagnosis of the condition were given an intravenous infusion of tanruprubart or a placebo infusion. On average, those treated with the drug required 28 fewer days of mechanical ventilation and seven fewer days in intensive care, and were able to walk independently 31 days earlier.

The participants who received tanruprubart experienced greater

"On average, those treated with the drug required 28 fewer days of mechanical ventilation"

quality of life and mobility after two months compared with those who had the placebo. The results were presented at the Congress of the European Academy of Neurology in Geneva, Switzerland, in June.

No serious side effects occurred in the trial, and even though tanruprubart switched off part of the immune system, it didn't appear to make the participants more vulnerable to infection.

Based on these results, Annexon Biosciences recently submitted tanruprubart for approval from the European Medicines Agency. ■ Alice Klein

Eye implant partly restores sight

A device that lets people with severe vision loss read has been granted EU and UK approval

Oluoma Aneke

A RETINAL implant that improves vision in people with a common form of blindness has been approved for use in Europe. This is the first time that such a device – which enables people with a type of severe vision loss to read – has been approved anywhere in the world.

“We’ve had patients who could recognise the face of the queen and others who’ve drawn the Sydney Opera House through the device,” says Darius Shahida at Science Corporation in Alameda, California, the company behind the implant.

Called the PRIMA implant, the device restores functional central vision – the straight-ahead sight required to see fine details and read – in people with geographic atrophy. This is a progressive and irreversible form of dry age-related macular degeneration, which involves the slow deterioration of a part of the retina called the macula as retinal cells die off and aren’t renewed.

Existing treatments for geographic atrophy are extremely limited. In the US, two medicines – given as shots in the eye – are approved that block proteins that may damage the retina.

The implant – which is about



SCIENCE CORPORATION

The implant is about the size of a pinhead and is inserted beneath the retina

the size of a pinhead and is inserted beneath the retina – is used alongside glasses with a frame-mounted camera. This captures and processes images, then projects the result onto the implant’s chips using near-infrared light. We can’t see in this wavelength, so the process doesn’t interfere with any existing vision.

These chips then convert the

near-infrared light into electric pulses to stimulate neurons called bipolar cells, which are typically not damaged by macular degeneration, in the retina. Ordinarily, bipolar cells work with rod and cone cells, which convert light into electrical signals and are affected by macular degeneration. The PRIMA system bypasses rod and cone cells so bipolar cells can create electrical signals that can be interpreted by the brain.

The glasses generate electricity directly from light, similar to solar panels. “This means patients don’t need a tethered power source,” says Shahida.

In a small study published in October last year, PRIMA restored central vision and improved visual acuity in about 80 per cent of cases. “Normal vision in the US is 20/20 and blindness is 20/200,” says Frank Brodie, also at Science. “Patients using PRIMA reached about 20/160, so they went from blind to not blind.”

Most of the side effects were related to the surgery and resolved within two months. “The physical recovery is quick, and some people feel better within a day,” says Brodie.

Before the intervention is widely used, more research is needed on a larger group of people with long-term safety data, says Sunir Garg at Wills Eye Hospital in Philadelphia, Pennsylvania. The researchers also need to uncover if the implant only benefits people with certain patient- or condition-related characteristics, he says.

The intervention has received a CE certification mark under the European Union Medical Device Regulation, which enables it to be used in the European Union and the UK. PRIMA has also received Breakthrough Device and Humanitarian Use Device designations from the FDA, “which is an important pathway toward approval in the United States”, says Shahida. ■

Palaeontology

An ichthyosaur had a very unexpected last meal

A FOSSIL found in Australia’s outback is the first-ever evidence that ichthyosaurs, large marine reptiles, consumed pterosaurs, the earliest known vertebrates to evolve powered flight.

Recreational fossil hunters discovered some of the ichthyosaur’s fossilised bones in 2019 at a designated public site near the town of Richmond, in a semi-arid area of Queensland’s outback. During the Early Cretaceous, between 120 million and 95 million years ago, the area was part of the Eromanga Sea, a shallow inland

sea that covered over one-third of the Australian continent.

When palaeontologists excavated the site three years later, they uncovered a huge, partially articulated ichthyosaur. Identified as *Platypterygius australis*, it was almost 7 metres long, the size of an adult orca.

“What startled me was not only the size of the animal, but the way its skeleton had been damaged,” says Matt White at the University of New England, Australia, who led the investigation. He explains that the vertebrae were split, ribs were missing and numerous bones

The ichthyosaur ate the pterosaur before being gobbled up itself

displayed large crushing bite marks.

The only explanation, the team concluded, was that a powerful predator had dismembered and chewed the ichthyosaur, most likely the giant pliosaur *Kronosaurus queenslandicus*, says White.



DR PETER TRUSLER

The team also found globular masses near the ichthyosaur’s skull. Mechanical removal of rock around the fossil and 3D imaging revealed that one of these globules contained fragments of fish, squid-like cephalopods, and, remarkably, two pterosaur bones, including a jaw fragment. The researchers think this was the ichthyosaur’s gut contents, which probably fossilised near the skull due to its digestive tract spilling out (*Gondwana Research*, doi.org/hccxs5).

“It is almost certainly a case of predation or scavenging, and the first-ever example of a pterosaur consumed by an ichthyosaur,” says David Unwin at the University of Leicester, UK. ■ James Urquhart

Is district cooling the solution to extreme heat in cities? Pipes carrying cooled water are more efficient than air-conditioning. Could they help to chill heatwave-stricken cities in the US and Europe, asks **Alec Luhn**

MORE than 77 million people in Europe enjoy district heating, where hot water is piped from a central plant to homes and buildings. The US has hundreds of these networks, mostly in multi-building campuses like airports, universities and business districts.

But as both Europe and North America swelter through heatwave after heatwave, many are wondering whether the mirror image, pipe networks of chilled water, could be a better cooling option than air conditioning.

“District cooling systems operate at twice the efficiency, or half the operating expense, of a typical in-building chiller plant,” says Rob Thornton at the International District Energy Association. “There’s emissions reductions, lower costs of manpower and... by concentrating the function to a central plant, you can serve dozens if not hundreds of buildings.”

Heatwaves are getting stronger, longer and more severe around the world, driving a boom in air conditioner sales. But in Europe, the fastest-warming continent, only about 1 in 5 households have air conditioning, and the lack of cool spaces can be deadly in an ageing population.

Air conditioning, while necessary for hospitals, schools and care homes, worsens planet-warming carbon emissions and urban heat islands. It isn’t a long-term solution, according to a 2025 report by the European Union Covenant of Mayors, an alliance of local governments. District cooling, on the other hand, can both cool cities and cut emissions, the group said.

Middle Eastern and Asian cities that face scorching heat for months of the year have already begun to build gigantic district cooling networks. Dubai’s state-



Some district cooling networks already exist in places like Dubai

backed district cooling company now pumps around 6 gigawatts of refrigeration – equivalent to freezing 1.5 million tonnes of ice per day – to more than 1700 buildings.

The US has about 500 of these district cooling networks, mainly on university and hospital campuses, according to Thornton, and Europe has about 200, mostly in cities in France and Sweden.

These cooling systems typically cool water to 6°C or 7°C in refrigeration tanks and pipe it to heat exchangers in each building in the network. These work like radiators in reverse, cooling the air in a home through contact with the cold water.

A simulated district cooling network of 37 public and commercial buildings consumed 15 per cent less energy and lowered operational costs by 10 per cent compared with individual air conditioning, according to a study in Hong Kong. The Paris district cooling system has cut electricity

and emissions by half compared with individual cooling.

Office buildings often install air conditioning systems that are two to three times larger than is typically needed so that the AC doesn’t go out on the hottest day of the year, says Thornton. District cooling can shrink that huge pool of excess capacity.

To increase efficiency even further, district cooling systems in Geneva and Paris chill their liquid

“District cooling systems operate at twice the efficiency, or half the operating expense”

with water from Lake Geneva and the Seine, respectively, while one in Heerlen, the Netherlands, draws on flooded coal mines. In the US, some district cooling networks make ice at night, when electricity is cheap, and pipe it out once it melts during the day.

While most district cooling networks still serve public or commercial buildings, a few, like the one in Geneva, are starting to expand to residential buildings. But district cooling can cost

hundreds of millions of dollars to build, mainly because streets and pavements need to be dug up to lay pipes. It is cheapest if it can be installed alongside an existing district heating system, according to Wangda Zuo at Pennsylvania State University.

“It works for places with really dense buildings that have high demands, and ideally if you already have the tunnels to lay out the piping,” he says.

Two-in-one

But a newer technology called an ambient loop system, which combines district heating and cooling in one, could enjoy more uptake in Europe. Upscale projects that include both commercial and residential buildings have installed this technology, but for wider adoption, government backing will probably be needed, says Zuo.

The approach is a way to supercharge individual electric heat pumps, which typically cool or heat air they take from outside the home. An ambient loop system circulates water at whatever temperature the pipes are currently at, usually 10°C to 25°C (50°F to 77°F), although it must occasionally heat it in winter.

Then water-based heat pumps in each building cool or heat this liquid. So, rather than cooling outside air from 40°C to 20°C (104°F to 68°F) during a heatwave, for instance, the heat pump can convert water from 25°C to 20°C, which requires far less electricity.

“If you want to carry something from the foothill of a mountain to the top of a mountain, you have to work very hard,” says Zuo. “If the difference in height is low, it’s easier. With the ambient loop, the temperature difference is relatively smaller.” ■

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Health

'Hypoxia in a pill' may ease symptoms of neurodegenerative conditions

Ute Eberle

A PILL that simulates the effects of high elevation and low oxygen on the brain seems to have eased neurological decline in mice with three neurodegenerative conditions, including Parkinson's disease.

"With 'hypoxia in a pill', we can now manipulate the very air we breathe," says Vamsi Mootha at Massachusetts General Hospital.

While severe altitude sickness can be deadly, anecdotal evidence suggests that symptoms of neurological conditions like Parkinson's disease ease at high elevation, where the air is thinner.

For the past decade, Mootha and his colleagues have done studies in which mice with models of conditions like Parkinson's are kept in air with 11 per cent oxygen, matching the environment at roughly 5000 metres above sea level. They have found that

this can halt, prevent or even reverse symptoms.

Although these mice didn't experience any known side effects from the intervention, breathing thin air around the clock isn't safe for people in the long term. "Given that hypoxia can be dangerous, it should not be attempted at

"When tested in a Parkinson's disease model, the mice improved their coordination and balance"

home," says Mootha. But now, Mootha and his colleagues have combined two experimental drugs to create hypoxia in a pill.

One drug – called osivelotor – alters haemoglobin so it grips oxygen more tightly, preventing the gas from reaching tissues. But this can cause the body to produce a dangerous amount of red blood

cells, which carry oxygen around the body. The second drug, PT2399, prevents this by blocking a protein called HIF-2 α , which helps cells respond to low oxygen.

The team gave the pill to mice modelling advanced Leigh syndrome, a severe neurological condition that causes progressive loss of mental and movement abilities. The pill more than doubled the mice's survival time from around 62 days to 158 days.

The researchers also tested the pill in mice modelling Friedreich's ataxia, a rare condition that causes progressive damage to the nervous system, resulting in movement difficulties. The team observed that this stopped further declines in the mice's strength and coordination. Finally, when tested in a Parkinson's disease model, the treated mice improved their coordination and balance

([bioRxiv, doi.org/rhrn](https://doi.org/10.1101/2024.08.01.604888)). The effects are comparable to when such animals breathe 11 per cent oxygen, says Mootha.

Research suggests that low oxygen can boost brain growth factors, which aid the formation of new connections between neurons. But Mootha proposes that reducing excess oxygen may prevent cellular damage.

The three conditions he and his team focused on are partly characterised by damaged mitochondria, which provide cells with energy. These may be failing to consume oxygen properly, leaving a local excess that harms other cell components, he says.

Gordon Mitchell at the University of Florida says he is "pretty tickled" by the study, but cautions that it remains to be seen how well the effects translate to people. ■

Animal behaviour

Jaguar mysteriously trekked epic 2100 kilometres

A MALE jaguar has made an unprecedented trek, skirting 2100 kilometres of the southern edge of the Amazon rainforest. The journey expands our knowledge of what these big cats are capable of.

The previous dispersal record for a tagged jaguar was about 60 to 100 kilometres, says Jon Morant at University College Dublin in Ireland. He and his colleagues have been tracking jaguars in Brazil via GPS collars as part of an ongoing project that started in 1999. The researchers wanted to better understand how jaguars use their environments along the Araguaia river, a potential wildlife corridor connecting the Cerrado



LEANDRO SILVEIRA

grasslands with the Amazon.

They captured the male, dubbed Gaspar, as part of this work, fitting him with a collar on 11 November 2024. The 8-year-old jaguar then spent some time in his established

range before setting out on a massive southward trek, skirting the border of the Amazon to inland Cerrado.

The researchers recorded that Gaspar travelled 2122 kilometres,

Gaspar was fitted with a GPS collar – which he took on a surprising adventure

until his collar stopped transmitting locations in late November 2025 (*Ecology*, [doi.org/rhqw](https://doi.org/10.1002/ecy.4588)). The actual distance is probably much more, says Morant.

While Gaspar mostly stuck to forested areas, he also crossed through heavily modified human landscapes, such as farms, ranches and roads. Dispersals, albeit shorter ones, are common in individuals aged 1 to 3 that are looking to establish a new territory, but it is unclear why an older adult like Gaspar made this move. He might have been searching for better food resources, mating opportunities or a better habitat in general, says Morant. ■

Joshua Rapp Learn

Archaeology

Flattened skulls hint at Iron Age parenting

Christa Lesté-Lasserre

FLAT head syndrome, commonly associated with modern parenting practices, especially placing babies to sleep on their backs, may have been common at least 2800 years ago.

Because humans are born with soft heads, their skulls can get shaped by pressure. Today's use of cots and prams tends to create prolonged pressure on the back of the head, which can deform the normally round surface.

But the earliest history of flat head syndrome – also called positional or developmental plagiocephaly – remains unknown. Thus far, researchers have found two plagiocephalic heads in Pakistan dating from 4000 years ago, as well as examples from 4th-century BC Switzerland and the medieval Czech Republic.

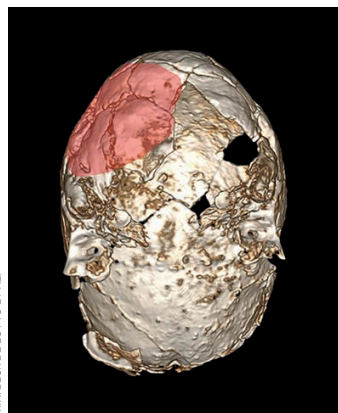
Michael Beck De Lotto at Sapienza University of Rome and his colleagues inspected 26 well-preserved adult skulls from two

"Parents may have placed their babies to sleep on their backs with their heads propped up on pillows"

burial grounds discovered in the 1990s in Matelica, Italy, linked to the Picenes people of the 8th and 9th centuries BC. They found flattened areas on the backs of 11 heads from seven men and four women, making them the earliest known examples of developmental plagiocephaly outside Asia.

The researchers ran CT scans on the skulls and created 2D and 3D virtual models of each one. None of the skulls showed signs of deformation before birth or after death, meaning it must have occurred in the first year of life before head shape solidified, says De Lotto.

Unlike modern flat head



M.A. BECK DE LOTTO ET AL.

CT scans highlighted where the skulls were flattened (in red)

syndrome – which is mostly concentrated across the back of the head – these Iron Age skulls had a variety of flattening patterns, representing different positions (*International Journal of Paleopathology*, doi.org/rhrq).

The head shapes suggest parents may have been placing their babies to sleep on their backs with their heads propped up on pillows, he says. They might also have swaddled their babies or placed them in cradles, although the exact mechanisms remain unclear.

The findings align with an existing "evolutionary mismatch" theory about ancient childcare, says Herbert Renz-Polster, a paediatrician and independent researcher in Germany. As hunter-gatherers moved towards a less mobile lifestyle, he explains, they also transitioned from carrying and co-sleeping with their babies to a parenting practice in which babies were placed in bed alone with "sleep aids" like swaddling. That led to babies spending long periods immobile on their backs with extended pressure on their heads. ■

Palaeontology

Dinosaurs were wiped out by global firestorm

James Woodford

THE asteroid strike 66 million years ago caused a planetary-scale firestorm that burned dinosaurs to a crisp all over the world, according to simulations of the impact.

The so-called Chicxulub asteroid landed in what is today the Gulf of Mexico at the end of the Cretaceous Period.

It was thought that most of the worst effects of heat and fires would have been relatively regional, and global extinctions were mainly caused by a "nuclear winter", where dust blocks out the sun causing dramatic cooling.

Brandon Johnson at Purdue University, Indiana, and his colleagues analysed geological observations and impact simulations, which showed around five times more material was vaporised by the strike than previously thought.

The new work suggests that in the aftermath of the impact, a plume of rock vapour was blasted tens of thousands of kilometres into space and ended up being distributed high above the entirety of the planet.

Just seconds later, the vapour

plume expanded above much of Earth's atmosphere into space, says Johnson, leading to both dust and glassy, metallic beads called spherules, condensing from the vapour.

This immense vapour cloud ultimately turned into 1.6 trillion tonnes of dust, which blanketed the planet, sealing in heat, the study found. The heavier spherules slammed back into the atmosphere (*Journal of Geophysical Research Biogeosciences*, doi.org/rhq4-7).

"As this material re-enters the atmosphere over the coming hours, friction decelerates and heats the spherules, creating an approximately hour-long pulse of thermal radiation," says Johnson.

"This would kill off creatures that were unable to shelter from it and was intense enough to ignite forest litter like grass and pine needles and may have even been enough to ignite trees."

The geologic record suggests the ensuing fires may have lasted for years, he says.

"The Cretaceous animals would have received 17 times the dose of thermal radiation that is 100 per cent lethal to humans," says Johnson. "That should be enough to kill off even thick-skinned dinosaurs." ■

The asteroid strike sparked a worldwide blast of blistering heat



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Food for thought More and more research is linking ultra-processed foods to depression, anxiety and even dementia. **Helen Thomson** tucks into the evidence



Helen Thomson is the author of books including *Unthinkable: An extraordinary journey through the world's strangest brains* and *This Book Could Fix Your Life*. She was previously head of features at *New Scientist*

Helen's week

What I'm reading

The Seven Husbands of Evelyn Hugo by Taylor Jenkins Reid – the perfect soon-to-be-poolside read

What I'm watching

Emma Barnett: Fighting Endometriosis

What I'm working on

Season 2 of Change Your Mind with New Scientist, the fab new podcast I co-host with New Scientist's editor Cat de Lange

BY NOW, we all know that ultra-processed foods aren't particularly good for our bodies. Often high in sugar, salt, saturated fat and additives, UPFs have been linked with an increased risk of heart disease, diabetes and some cancers. But what do they do to our brains?

Lately, I've noticed an increasing number of studies linking UPFs with depression, anxiety and even dementia. I wanted to look at how strong the evidence is, and whether it offered another persuasive reason to eliminate them from my diet.

The immediate problem is that, while many observational studies have found associations between greater intake of UPFs and various brain health problems, direct causal evidence is less forthcoming. The picture is further complicated by how we define UPFs, says Tim Spector at Kings College London, co-founder of nutrition company Zoe. Most countries use the NOVA classification system, which is designed to categorise levels of processing, but not to assess how a food affects health.

That said, evidence is mounting for the harms of UPFs. In 2024, a study involving around 30,000 people who were followed for up to 18 years showed that for every 10 per cent increase in the proportion

"Eating more fibre and oily fish are the two best changes you can make for your brain health"

of UPFs in a person's diet, the risk of cognitive impairment and stroke rose significantly. This association remained even when considering factors such as income, alcohol consumption and physical activity.

Another study followed 10,775 adults in Brazil for around eight years. Those who obtained more than 19.9 per cent of their energy



Many ultra-processed foods are high in salt, fat and sugar, which can disrupt the gut microbiome

from UPFs experienced faster declines in global cognition – an overall measure of mental ability – and executive function, which is the ability to control impulses, regulate emotions and stay focused.

It's not just general cognitive decline, either. In 2025, researchers analysing data from 58,423 people between the ages of 40 and 70 found that increased UPF consumption was associated with a higher risk of dementia, Parkinson's disease and multiple sclerosis.

Other studies have linked UPFs to depression and anxiety, too. In one, researchers followed 31,712 female nurses between 2003 and 2017, who didn't have depression at the start of the study. Those eating more than 8.8 servings a day of UPFs – like artificially sweetened drinks or ready-made meals – had a 49 per cent higher risk of developing depression. Although observational, the study used some advanced statistics to rule out "reverse causality" – the idea that if you're depressed, you may be more tempted to eat less healthy foods.

So what might UPFs be doing that is so bad for the brain? The answer is likely to involve multiple,

overlapping pathways. For instance, many UPFs are high in salt, fat and sugar, all of which are known to disrupt the gut microbiome, shifting it so that it has less diversity and fewer beneficial bacteria. This can damage the gut lining, making it "leakier" and allowing harmful substances into the blood and brain. "High-fat and high-sugar diets also induce low-grade inflammation," says Spector. "We now know that there's a close link between inflammation and mental health, particularly depression."

Laura Bojarskaite at the University of Oslo in Norway points me to a small study published last year that found that just five days of eating an extra 1500 calories from ultra-processed snacks altered men's brain responses to insulin, a hormone that helps cells take up glucose for energy. The effect remained detectable a week after they returned to their normal diets.

Insulin regulation is vital for maintaining cognitive function, while insulin resistance is linked with depression and Alzheimer's. Although the study didn't look at brain health specifically, it provides evidence that UPFs can rapidly modify brain signalling, which Bojarskaite says is a "credible pathway through which a lifelong [UPF-heavy] diet could influence brain ageing".

Bojarskaite says that rather than trying to eliminate every UPF from our diet, we should concentrate on reducing products that combine multiple unfavourable features – like added sugars, high salt and low fibre – and replace these first.

If that still sounds too hard, Ted Dinan at University College Cork in Ireland offered a simpler starting point on a recent episode of the podcast I co-host, *Change Your Mind with New Scientist*: eating more fibre and oily fish are the two best changes you can make for your brain health, he says. ■

Clumpy cosmos The cosmological principle says everything, everywhere should be roughly the same across the universe. Is it time to give up on that idea, asks **Leah Crane**

IN COSMOLOGY, there is one principle to rule them all: the aptly named cosmological principle. It insists that there are no special places in the cosmos – on large-enough scales, everything is roughly the same in all directions, from all perspectives. This seems like it must be false: obviously some places in the universe are different from other places. My office, for instance, bears no resemblance to a black hole.

For it to be useful, we must zoom out – which is why modern statements of the cosmological principle tack on “at sufficiently large scales”. Any supercluster of galaxies is just about the same as any other one. It is a cornerstone of our best model of the cosmos, called the standard model.

Even so, a multitude of cosmologists have called this fundamental rule into question.

There are two parts to this principle, homogeneity (everything is smooth rather than lumpy, on large enough scales)

Even the Lobster Nebula looks smooth when you zoom out far enough

and isotropy (that’s true in every direction). The former faces more credible threats, which generally come in the form of structures of unusual size, leading to names such as the Huge Large Quasar Group or the Giant Arc, all of which are billions of light years across. It’s tough to consider our universe to be smooth when it seems to have such enormous lumps in it. The “at sufficiently large scales” that gets inserted in the cosmological principle can only stretch so far, right?

In the early 2000s, astronomers started finding structures that were just a little bit too big to fit within the standard model. Not everyone agrees on what the limit ought to be, but the proposals are generally a couple hundred megaparsecs, or several hundred million light years – anything bigger than that is a problem, and there do seem to be structures that are bigger. So, homogeneity across the universe is questionable.

Personally, I’m not all that worried about the potential breakage of the cosmological principle itself. Some researchers say a little bit of clumpiness is

actually OK within the standard model, some say the universe has expanded so much since its formation that we can’t actually expect the cosmological principle to hold anymore, and some simply say we have to look at an even larger scale. But if I have to zoom out to such a degree to make a paradigm fit the real universe, is that still a useful paradigm?

The cosmological principle lets us make one huge and necessary assumption: that where we are isn’t special, that what we observe from Earth is true everywhere. If we want to crack on with studying the entire universe, we have to assume some level of homogeneity and isotropy. But just because an assumption is useful that doesn’t make it true.

In science, we assume things all the time that aren’t necessarily true, largely to make calculations easier. Every distance we measure to any object in space (and even the distance scale for the cosmological principle itself) assumes a value for the expansion rate of the universe, even though we don’t quite know what it is. We can accept something as close enough to the truth to be useful, while knowing it’s not quite all the way correct.

So, do I believe in the cosmological principle? No, not really. The cosmos is too huge and too full of variety for me to completely buy into the idea that there are no unique places. It’s infinite enough, at least, that the cosmological principle can be both true enough and untrue. There is life in our corner of the universe, so there is probably life elsewhere as well, because in some ways, the universe is the same everywhere. But it is also different everywhere. There are special places, and we are in one of them, and only by holding both that and the cosmological principle in our heads at once can we truly understand our place in the universe. ■



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

Leah’s week

What I’m reading

The Rime of the Ancient Mariner by Samuel Taylor Coleridge

What I’m watching

A whole lot of Jeopardy reruns, for some reason

What I’m working on

Preparing to go to the Arctic to see a total solar eclipse!



UKIRT, INFRARED, NASA/JPL-CALTECH



Michael Le Page is a reporter at *New Scientist* specialising in genetics, biomedicine and the environment

Michael's week

What I'm reading

I just finished Atmosphere by Taylor Jenkins Reid

What I'm watching

I'm finally getting around to watching The Dinosaurs on Netflix

What I'm working on

I'm already interviewing people for what might be my next column, about muscles

Drugs for 'undruggable' proteins A new type of drug that works in a completely different way has been approved, and it could revolutionise treatment options, says **Michael Le Page**

I THINK we will look back at 2026 as a landmark in medicine, the year in which the first protac drug was approved. While most drugs simply block their targets, protacs utterly demolish them. Per molecule, protacs are far more potent, and they can also do things other drugs just can't.

To understand why protacs are so revolutionary, we need to start with conventional drugs. Almost all the pills you pop contain drugs that consist of small molecules. The shape of these molecules allows them to bind to specific proteins, to block or stimulate them.

Small-molecule drugs have some big advantages. They're cheap to make, can get inside cells and can be taken as a pill because they can also pass through the gut lining and into the bloodstream. But their small size means they're not that specific. They tend to bind to other molecules besides the one they are supposed to target and thus have undesirable side effects.

And in many cases, it simply isn't possible to find a small molecule to block the activity of a protein. The issue is that each drug molecule can't just bind to any part of a target protein. To have an effect, it must bind to the active site of the protein – the workplace – but

"In trials, people with advanced breast cancer survived more than twice as long when given the protac drug"

sometimes small parts of the active site don't have a distinctive enough shape. Such proteins are referred to as undruggable.

That's why many newer drugs consist of large molecules, most commonly proteins known as antibodies. (Any drug whose name ends in "-ab" is an antibody.) The large size of antibodies means they



RICK LEWIS/LAMY

The US Food and Drug Administration approved a protac drug for breast cancer in May

can bind to targets with exquisite precision, making them highly effective and safer than small-molecule drugs. To create them, you get immune cells to generate antibodies to the desired target and then pick the best one. It sounds easy, but it took decades to perfect.

The downside of antibodies is that they are really expensive because they can be made only in living cells. Their large size also means they must be injected because they can't get through the gut. Nor can they get into cells once they're in the bloodstream. So, while antibodies could bind to many undruggable proteins, they can't get into cells to reach them.

The other thing to mention is that both small-molecule drugs and antibodies must be in contact with the target to work. Protacs work differently. Essentially, they stick a "recycle me" label on a protein in a cell. That means just one protac molecule can label and get rid of tens or hundreds of molecules of that protein. And because they're not blocking or stimulating the target protein, they don't have to bind to the active site. Anywhere on the target will do, making many undruggable targets druggable.

Creating protac molecules that were small enough to be useful was a challenge, because each protac must bind to two molecules, whereas conventional small-molecule drugs need bind to only one. Craig Crews, who came up with the idea for protacs with Raymond Deshaies in 1998, succeeded in making them small enough to behave like small molecules, but they are still somewhat larger than conventional drugs. "I call them large small-molecules," Crews told me last month.

By 2013, Crews was confident enough to found a company called Arvinas. For its first products, Arvinas played it safe. Rather than going for undruggable proteins, it targeted hormone receptors in cancer cells. For instance, the growth of some types of breast cancer is driven by receptors that respond to oestrogen. There are already several drugs that work by targeting these receptors, but resistance can develop.

One way that cancers become resistant is by making more receptors, until even the highest tolerable drug doses can't block all the receptor molecules. "Since we're actively degrading the receptor, we don't have that limitation," Crews told me in 2020. In trials, people with advanced breast cancer that had spread around the body survived more than twice as long when given the protac drug vepdegestrant, compared with those given a conventional drug. As a result, vepdegestrant was approved by the US Food and Drug Administration in May.

"The approval is a milestone for the field," Crews told me last month.

I'm hopeful we will soon be seeing all kinds of new treatment based on protacs, ultimately helping billions of us. The approval of vepdegestrant may have received barely a headline, but if it is indeed the first of many, we will look back at it as a major milestone. ■

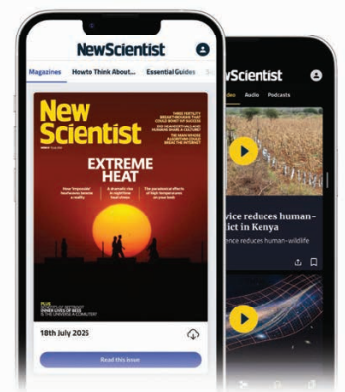
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Net loss



Gaurav Patil **Mangrove Photography Awards**

THIS unusual photograph, shot under ultraviolet light with a 13-second exposure, shows some of the damage caused on land by fishing out at sea.

Gaurav Patil's image of a fishing net that has been carried by ocean currents and become tangled in a mangrove tree on the shore of Nandgaon village, south of Mumbai, India, has won the overall prize in the 2026 Mangrove Photography Awards. The competition is organised by US non-profit organisation Mangrove Action Project to raise awareness of the precarious position of the world's mangrove forests.

Mangroves make up less than 1 per cent of all tropical forests, but provide crucial habitat for wildlife and store up to 10 times more carbon than the same area of inland forest. Despite better recent news after decades of decline, more than half of mangrove ecosystems are thought to be at risk of collapse by 2050.

Hundreds of thousands of tonnes of lost, abandoned and discarded fishing gear litter the oceans, carried around the globe by currents and eventually getting caught up or breaking down into microplastics. This gear can severely damage mangrove ecosystems, entangling marine life and choking mangrove trees.

"This photographer has put life into a subject that normally looks dull but is deeply important for conservation. Ghost nets are a real problem," said judge Dhritiman Mukherjee in an announcement about the prize. ■

Matthew Sparkes

The trouble with life

A provocative book sets out to describe the living world very differently – by insisting on agency and purpose everywhere. **Michael Marshall** explores



**Book
Alive**

Melanie Challenger

Canongate (UK);

Penguin Random House (US)

WHEN you think about it, being alive is a really strange state of being. The vast majority of the matter in the universe is lifeless hydrogen and helium, rocks and dust. Yet, somehow, here we all are: millions of species of microbes and plants and animals, all respiring and eating and trying to reproduce, some of us squawking, and some sleeping, all of us eventually dying. When we consider the sheer implausibility of life in the cosmos, wrote biochemist Jacques Monod in *Chance and Necessity*, “we should feel strange and a little unreal”.

Actually defining what life is has proved extremely tricky, so we tend to fall back on metaphors. One of the most prominent of the past century or so is that living organisms are machines. They have components, moving parts, complicated chemical signalling

pathways to make things happen. In this view, even the brain is a kind of computer, one that responds to stimuli and performs calculations. Moreover, the machines have a purpose, shaped by evolution. In *The Selfish Gene*, Richard Dawkins argued that organisms are machines that exist to pass on their genes, that living things are just complicated by-products of genes copying themselves.

In *Alive: The hidden intelligence of the living world*, writer and broadcaster Melanie Challenger sets out to completely demolish this line of thinking. Living beings aren’t machines, she argues, nor do they exist purely to pass on genes. Instead, what defines living beings is agency and purpose. “Life-forms pursue goals because they are alive, and life is, by its nature, purposeful,” she writes.

The idea that organisms have goals and purposes is “the most obvious” answer to what life is, and also “the most curiously neglected”, argues Challenger.

From René Descartes onwards, the idea that non-human animals have goals, feelings and even thoughts of their own has been

treated with scepticism by zoologists and psychologists. Animal behaviourist C. Lloyd Morgan famously argued that we should never interpret an animal’s behaviour as evidence of a higher psychological process if it could also be explained using a simpler process. “Morgan’s Canon” went on to guide a century of research – even though it isn’t obvious what is meant by higher and lower psychological processes.

Challenger’s suggestion is that we can’t escape the idea of a self, something with agency, to explain the behaviours of living organisms. It’s just that we have removed it from the organisms themselves: either in the form of some separable soul or essence, or a set of genes that determine how organisms behave for their own ends. “Both soul and gene are described as self-like agents, the true initiators of the acts of a life-form,” she writes. In these views of the world, “life-forms themselves are marginalised”.

Instead, we should see living beings as “self-determining”, she argues: “Life-forms use energy to remain locally discontinuous with

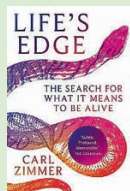


the environment... and what is phenomenal about this act is that it is self-generated.” Challenger develops this idea over six chapters, exploring homeostasis (the mechanisms by which organisms maintain their internal environment), sensory perception, consciousness and intelligence. These can all be explained mechanistically using cells, molecules and physical forces, but they only make sense in the light of the whole organism.

Challenger is trying to reclaim the active nature of life. Even organisms like plants that don’t have brains, and therefore may have little or no conscious experience, are still responsive to their environments and act with purpose for their own ends. There is nothing automaton-like about animals or plants: that’s why the automata of sci-fi are so deeply, gut-level disturbing in contrast.

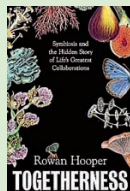
Cards on the table: I think

Three more great reads on the meaning of life



Life's Edge: The search for what it means to be alive
by Carl Zimmer

Despite hundreds of attempts, we still don’t have an agreed definition of life. Science writer Carl Zimmer explores the many tricky edge cases, like viruses, which blur the line between life and non-life.



Togetherness: Symbiosis and the hidden story of life's greatest collaborations
by Rowan Hooper

An ideal companion piece to *Alive*, Rowan Hooper (New Scientist’s podcast editor) shows us the importance of understanding life as a community. Individual organisms are only part of the story.



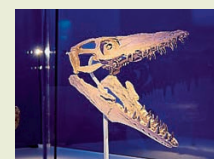
Free Agents: How evolution gave us free will
by Kevin Mitchell

Neuroscientist Kevin Mitchell argues that living beings are “agents acting with purpose”, not mere machines responding to stimuli. His ideas were among the inspirations for Melanie Challenger.



Eleanor Parsons
Magazine editor
London

Peering at the fossilised skeleton, I see something extraordinary. In among the 182-million-year-old ichthyosaur's ribs are the remains of another, smaller reptile, probably another ichthyosaur –



a cannibalistic dinner, or a fossilised pregnancy.

This specimen is on display as part of **Jurassic Oceans: Monsters of the deep** at the Natural History Museum in London until 3 January. The exhibition uses fossils, casts and video to tell the story of some of the fiercest ocean predators that ever lived.

There are the large jaws from a crocodile-like short-necked pliosaur. You can even touch the tooth from a mosasaur (its skull is pictured above), which lived a little later, in the Cretaceous. It is pointy but smooth, with gentle ridges indicating growth lines, if you are wondering how it feels.

I loved the ichthyosaur eye and the fish bone-studded poo from an ichthyosaur or plesiosaur. But my favourite was the fossilised angel shark, looking as if it could still be lying on the seabed, waiting for its prey.

A Brazilian tropical forest supports trillions of individual organisms

is right to stress that individuals have great agency, but finds herself having to neglect or downplay the fact that individuality is fuzzy, and that individuals can only survive in ecosystems.

Consider your body. Yes, you are you and you act for yourself. But you are also home to trillions of microbes, which influence you, and some of which you couldn't survive without. Challenger insists on treating the microbes as distinct from you; each follows its own goals and it just so happens they mostly coincide with yours. But this is, I think, to oversimplify.

She has a similar problem with eusocial insects, in which a single individual reproduces and the rest of the nest is sterile. Eusociality is one of those phenomena that does need explaining at the level of genes, at least to some extent. Challenger doesn't like labelling eusocial ant colonies as "superorganisms", but her justification is weak. She argues that worker ants are still capable of rebelling against the system, so they aren't fully integrated, but the same could be said of some of our cells – that's why we get cancer.

My one other caveat is that her high-flown metaphors and philosophy-speak won't be for everyone. Here's an example: "The activities of organisms are the literal embodiment of what we take the features of our world to mean, radically determined by the organisms themselves." If you have a low tolerance for this, you may find the book tricky, but the effort is worth it: *Alive* will help you see the living world afresh. ■

Michael Marshall is a science writer based in Devon, UK



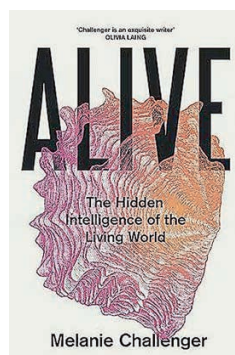
CHIP SOMODEVILLAGE/GETTY IMAGES

Challenger is mostly right. The gene's-eye view of evolution misleads us because it gives too much agency and power to the genes. In reality, genes aren't master controllers of cells, nor do they contain blueprints for entire organisms: they are part of a web of interacting systems that underpin life. Genes are important in cells, but are no more in control than any other component.

I can imagine two readerships for *Alive*, with drastically different responses. One valid reaction is that this is blindingly obvious. It's transparently clear that animals act with purpose, out of sheer vitality and hunger, and joy and will to live. The thing is, the idea of life-as-automata has acquired a lot of power. Challenger argues that it developed alongside the rise of industrialised farming, which exploits and mistreats animals on a staggering scale: if you don't quite believe animals

are sentient, it's easier to accept this globalised abuse. Today, synthetic biologists often treat life as, literally, programmable matter: they are the second readership, who will probably find Challenger's position difficult to accept.

I do think Challenger has one major difficulty: her argument focuses on individual organisms. Whether it's a bacterium or a shark, each acts for its own purposes. She



Into the unknown

An in-depth history of the successes and failures of space exploration reminds us of what faces all who leave our planet, finds **Karmela Padavic-Callaghan**



Book

Out of This World

Peter Bond

Reaktion (UK);

University of Chicago Press (US)

DO RUSSIAN cosmonauts and US astronauts don their spacesuits differently? What was the first musical instrument played on the International Space Station (ISS)? And who was the first person to smuggle pickles into orbit?

In 1957, the Soviet Union launched Sputnik 1, the first artificial satellite. Since then, humanity has explored space by simply going there, a feat replete with challenges, tragedies and oddities. In *Out of This World: Life as an astronaut*, writer Peter Bond chronicles many of these in great detail, offering a well-informed and unfussy view of space travel and life in space alike.

His book is thematic rather than chronological, with the first chapter aptly titled “Learning to Leave Earth”. It’s an overview of early space flights and the development of the rockets and aircraft that made them possible, such as the second world war V-2 rocket – the foundation for the first generation of space launchers.

Space exploration, shows Bond, has always been linked to large nations jockeying for power. This section could have been enriched by more anecdotes and personal details from the pioneers. Instead, *Out of This World* moves quickly and covers a remarkable amount of ground. Bond’s next focus is the process by which different nations’ space agencies, such as NASA, select their astronauts, and how strenuously they must train.

Russian cosmonauts live and train in Star City, their own isolated townlet north-east of Moscow, and



CHIP SOMDEVILL/GETTY IMAGES; NASA; EVERETT COLLECTION/ALAMY

NASA’s recruits primarily undergo training in Houston, Texas. If someone has flown in space, you will probably find their name somewhere in *Out of This World*.

We also hear from the astronauts themselves as Bond quotes their

“The Apollo 7 crew got into a fight with mission control over wearing their helmets when they had colds”

diaries and interviews, providing his book with the necessary sparks of humanity. I was touched to read about the time astronaut Michael Collins spent in the Apollo 11 command module while the rest of the crew walked on the moon for the first time. “Not since Adam has man known such solitude as Mike Collins when he passes around the back of the

Moon,” he wrote in the mission log.

Astronauts also get grumpy on the job just like everyone else. For instance, Bond reveals that in 1968, the crew of Apollo 7 got into a fight with mission control over wearing their helmets while their noses were stuffy from a cold inadvertently brought on board.

While Bond primarily discusses US and Russian missions to space, China’s taikonauts often get the spotlight, too, perhaps pointing towards a more international, though certainly no less politically fraught, future. These tensions are prominent in Bond’s penultimate chapter, which looks at lunar missions. The cold war race to put a man on the moon is an example of the US outdoing the Soviet Union, but space exploration never became politically simple. US efforts to return people to the moon exemplify this.



Clockwise from left: Artemis II’s launch in 2026; the Apollo 13 crew in 1970; Valentina Tereshkova, the first woman in space; Bruce McCandless II’s 1984 untethered spacewalk

At the time of writing, Bond acknowledges that there are many questions hanging over NASA’s Artemis mission, which is meant to accomplish the task. By the time I read *Out of This World*, part of the mission had been triumphantly completed, and part did, in fact, suffer restructuring. Notably, Bond has little to no discussion of debates surrounding ideas of colonising the moon and Mars for private and national profit.

The book ends with a solemn recounting of all the lives lost in space, from well-known incidents such as the Challenger disaster in 1986, which killed seven crew, to

Rewinding ancient history

Tom Hiddleston is the unlikely host of a Pompeii documentary. It is unabashedly cheesy, but somehow it works, says **Josh Bell**



Television

Pompeii: Out of Time Disney+

WHEN the viral trend of asking men how often they think about the Roman Empire was sweeping social media in 2023, it was clearly a mistake that no one posed the question to actor Tom Hiddleston. He apparently thinks about the Roman Empire so often that he has now produced and hosted an entire three-episode National Geographic docuseries about it.

Early in the first episode of *Pompeii: Out of Time*, Hiddleston recounts his formative visit to the preserved remains of the ancient Roman city in 1998 when he was a teenager, showcasing some charming photos of his younger self on the kind of trip where others might spend their time drinking and partying. Instead, Hiddleston says that his experience at Pompeii shaped him so profoundly that it led him to study classics and Latin at university, and even to his decision to become an actor.

While he consults multiple scholars in *Out of Time*, the show plays up Hiddleston's abilities as a performer to provide insights into the people who lived in the towns that were destroyed by the eruption of Mount Vesuvius in AD 79. "I need to combine the historical evidence with what I do as an actor," he says, with all the solemnity of someone who takes his craft very, very seriously.

Hiddleston's unabashed cheesiness is what makes the show work, though. Before introducing his first expert, he touts revolutionary new technology that allows for

the tracking of actual residents of Pompeii, only for it turn out to be a simple spreadsheet created by classics professor Steven L. Tuck. Hiddleston then conjures up the special effects that turn Tuck's data into a three-dimensional holograph, noting cheekily: "I've seen some *Avengers* movies."

His experience playing Loki in the Marvel Cinematic Universe continues to inform *Out of Time*, which counts former Marvel Studios executive Kevin R. Wright among its producers. Hiddleston channels Loki with a little gesture of his thumb and forefinger, deployed multiple times throughout the series to pause or rewind moments when incorporating new information. The series mixes narration and interviews with dramatic re-enactments, and Hiddleston often appears right alongside the actors playing ancient Romans, like Loki travelling through time to witness historical events.

Those dramatisations feature better acting than typical historical recreations, and they are more grounded than director Paul W.S. Anderson's bombastic 2014 action movie *Pompeii*, the most recent high-profile

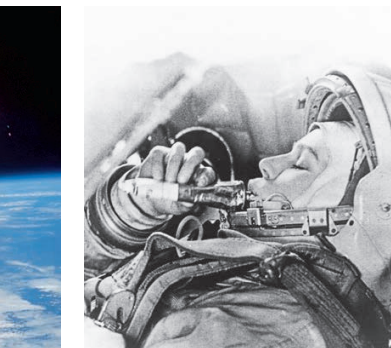
pop-culture take on this topic. Director Tom Barbor-Might and the show's writers create the emotional engagement that Hiddleston is aiming for when he picks out three specific real-life people to focus on: teenage blacksmith's apprentice Avianius (Frankie Treadaway), wealthy businesswoman Julia Felix (Lubna Azabal) and a retired soldier, the Praetorian (Barry Aird).

Initially, Hiddleston teases the idea that this approach will lead to new revelations about what actually happened, but of course that is no truer than anything Loki the trickster god has ever said. Still, that doesn't make *Out of Time* any less entertaining or informative, especially for viewers who don't think about the Roman Empire as frequently as those men on social media. Utilising expertise from historians, archaeologists, geoscientists and one "disaster psychologist", *Out of Time* lays out the scientific and cultural contexts of the events in Pompeii.

Hiddleston does a lot of pensive staring into the middle distance, and his clearly scripted banter with the experts occasionally sounds a bit stilted. It's hard not to laugh when he first unveils his corkboard full of pinned documents, like he is conducting a murder investigation. It's even sillier when his "office" shakes and buckles with the rumblings of the earthquakes in Pompeii.

But Hiddleston also demonstrates genuine, infectious enthusiasm for the subject, and that goes a long way. If he has to make a few Marvel references to get people's attention, that's a small price to pay. ■

Josh Bell is a writer and film critic based in Las Vegas, US



fatalities among early Russian cosmonauts. Bond's writing is never lyrical, but a little more emotion creeps into this last chapter: he is writing to honour the lost lives, and explain how their superiors and support teams failed them. If 350 pages in which he patiently unpacks the many ways space exploration is remarkably challenging aren't enough to curb remaining human hubris, a reminder of how fragile and perishable we are in the face of cosmic vastness might just work.

The next crewed flight to the ISS is planned for next month. I will be awed and anxious as I think about it – and the long history of space flight captured in *Out of This World*. Thanks to Bond, I'll also remember delightful stories like that of Russian cosmonaut Igor Volk, who smuggled pickles onto the Soyuz T-12 mission in July 1984. ■

Geologist Chris Jackson (left) and Tom Hiddleston meet on Mount Vesuvius



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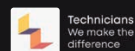
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Editor's pick

Restricting open-source software won't stop misuse

Leader, 25 July

From Sam Edge,
Ringwood, Hampshire, UK

You seem to criticise open-source software on the grounds that it can give everyone access to potentially dangerous technology. However, there is a saying in cryptography that applies equally well here: "Security through obscurity is no security at all." Just as trying to restrict access to books on chemistry and ballistics doesn't stop rogue actors from killing people in large numbers, neither will trying to ban open-source control systems or large language models. In any case, closed-source software can also be reverse engineered, its source code stolen via industrial espionage or simply pirated and used for off-brand purposes.

How to acclimatise to heat, courtesy of a Floridian

18 July, p 16

From Craig MacDougall,
Tampa, Florida, US

The conditions Alec Luhn experienced inside a heat chamber are considered normal for summer afternoons where I live in Florida. Here's a tip from a subtropical climate: to get a sense of how miserable it is going to be on a given day, focus on the dew point, not the relative humidity. The latter starts high in the morning and goes down as the temperature rises, possibly giving the impression that it will feel better in the afternoon. (It won't.)

The dew point – the temperature where the relative humidity is 100 per cent – however, will stay relatively constant. Once it rises to about 21°C (70°F), it feels humid, regardless of the air temperature. I calculated the dew point for Alec's test as about 23°C (73°F). A dew point of 25°C (77°F) or more, which happens around here, is miserable and can be dangerous.

I moved to Tampa from Jacksonville in north-east Florida in 1978. I am acclimated. At age 69, I play tennis twice a week, drink my sports drink and sweat a lot. Not everybody can do that, but I will for as long as I am able.

Shackleton photo hints at a forgotten injustice

18 July, p 18

From Margaret Cuthbert,
Edinburgh, UK

You recently published a dramatic photo of the James Caird, the boat that carried Ernest Shackleton and five of his crew across the Antarctic waters to South Georgia in 1916. That image also highlights a long-standing injustice.

Following the loss of his ship, the *Endurance*, Shackleton had planned for the crew to haul their three lifeboats over the ice and snow until they reached open water. This was met with dismay by carpenter Harry McNish, who foresaw that serious damage to the boats from being pulled over rough terrain was likely to occur. The row ended with Shackleton reportedly levelling a gun at McNish and winning the argument, but within two days, he had to abandon his plans and return to their base.

Eventually, when the ice broke up, they sailed their three lifeboats to Elephant Island. It was there that McNish modified the largest of the three, the *James Caird*, and made it seaworthy for the journey to South Georgia. The photograph you published gives some indication of how extensive McNish's modifications were. This work, carried out in freezing cold and with frostbitten fingers, was a vital contribution to the survival of the explorers, and only McNish had the skills to make it.

However, when Polar Medals were later handed out, McNish was deprived of his due, after Shackleton failed to recommend him for one. This is an injustice that it is not too late to rectify.

Intelligent life wouldn't be power-hungry like us

4 July, p 41

From Dyane Sylvester,
Arnside, Cumbria, UK

Brian Lacki shows a typically anthropomorphic bias in his search for extraterrestrial intelligence by assuming that any "advanced civilisation" will have developed computers and require huge amounts of power. Wouldn't a truly intelligent species be using simple technology requiring minimal power and resources, to ensure that it could exist within the capacity of its home planet?

It's hard to tally economics with the environment

Letters, 18 July

From Tim Mousley,
Caterham, Surrey, UK

The expenditure by the Australian government to protect the Great Barrier Reef, as described in Keith Noble's letter, is no doubt to be applauded. However, one should take care before concluding that this is a very good thing if that is based on the reef supporting 77,000 jobs and making an annual contribution of AUS\$9 billion to the country's economy, as Keith mentions. Unless that economic activity is strictly net zero, it will be directly contributing to the climate change that is the primary factor necessitating protective measures in the first place!

I also wonder how much of this activity could actually be classed as the "useless overconsumption"

Joel Millward-Hopkins mentions in the article "Living the good life" (18 July, p 32), and thus something to be curbed in our efforts to ensure everyone has a reasonable basic quality of life, while keeping within the planet's safe operating space. I fully appreciate the great appeal of the reef for tourism, but it is hard to see that this will have a long-term future, unless, as part of the sum total of all other human activities, the proposed "Great Barrier Reef economic zone" becomes truly sustainable.

Don't forget balance when it comes to brain health

11 July, p 32

From Wai Wong,
Melbourne, Australia

An often neglected measure of brain health is balance. While exercise in general is good for brain health, a regime that targets balance, strength and movement, such as tai chi, improves cognitive function better than approaches focusing on just one area. Various forms of simple and free balance tests are available from trusted sites on the internet. So, it pays to include balance in your brain check-up and exercise routine.

Another option for geothermal in the UK

25 July, p 32

From Larry Stoter,

The Narth, Monmouthshire, UK

Your article on new geothermal methods makes no mention of using abandoned mines. In the UK, there are many such ex-coal mines that could be used as a heat source. While temperatures may not be sufficiently high to generate electricity, they are high enough for district heating schemes. Such schemes are already in action at Gateshead. ■

For the record

■ Iceland's Blue Lagoon is an artificial geothermal spa (25 July, p 32).



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ANDREA DE SANTIS

The prediction machine

A new kind of artificial intelligence is starting to understand cause and effect in the physical world, discovers **Daniel Cossins**

WHAT happens when you knock a glass off a table? Ask ChatGPT and you get a step-by-step explanation: how gravity accelerates the receptacle along a “parabolic trajectory”, why it could shatter “if the impact generates stresses greater than the material can withstand”. Ask my 3-year-old daughter and she’s less bothered with fine details: “It go smash and water everywhere!”

When it comes to the future of artificial intelligence, the difference is instructive. The large language models (LLMs) powering today’s chatbots are trained on vast swathes of text to predict the next word in a sequence. Unlike little Adeline, however, no LLM has ever actually knocked a glass off a table – or thrown spaghetti at a wall, or driven a scooter into a pond – and that may impose a fundamental limitation on their capabilities.

This, essentially, is why some researchers argue that what we need to take AI to the next level isn’t ever-larger LLMs, but “world models”: systems that learn through observation so they can simulate the consequences of actions in the real world.

World models have rapidly become AI’s next frontier, attracting huge buzz from industry and business thanks to their promise in autonomous robotics. What makes the world-model approach especially intriguing, though, is that it also ostensibly offers a route to artificial general intelligence (AGI), or machines with human-level reasoning that can be applied across a range of tasks.

The problem is that it is tricky to parse substance from bluster. The term “world model” is confusingly elastic, for starters – for some, problematically so. It has become “a kind of shorthand for all the things that current AI systems can’t do well”, says Melanie

Mitchell at the Santa Fe Institute in New Mexico. It is unclear exactly what these systems should model, never mind whether internal representations of physical reality will be sufficient for the kind of generalisable intelligence that means my 3-year-old intuitively understands what happens when she swipes a glass, even if she can’t say why.

To make sense of world models as they apply in AI, it helps to understand the concept’s roots in cognitive science. AI researchers themselves typically trace it back to 1943, when psychologist Kenneth Craik wrote that the human mind “carries a small-scale model of external reality and of its own possible actions”, allowing us “to try out various alternatives” and “react to future situations before they arise”.

That idea has evolved in the decades since, most notably with the theory of predictive processing. This posits that perception – possibly even consciousness itself – relies on the brain constantly generating predictions about the external world and updating them in response to incoming sensory data.

But the point remains. “The key idea is

“LLMs lack the mental map that allows us to imagine different scenarios”

that intelligence involves building models of the world in our heads so we can simulate outcomes and avoid costly mistakes,” says Josh Tenenbaum, a cognitive scientist and AI researcher at the Massachusetts Institute of Technology. “So ‘our ideas die in our stead’, as Craik put it.”

It doesn’t take a genius to see why that has piqued the interest of AI researchers. LLMs have proved astonishingly capable, and they can certainly give the impression they understand things as we do. But language is a description of reality, rather than reality itself, and their lack of direct experience means that even the most powerful language models struggle when it comes to “understanding” physical phenomena in the real world.

LLMs often perform poorly when they are asked to reason about spatial concepts and things that might happen in the physical world, says Mitchell. “If you’ve ever uploaded a map to one of these models and asked it questions about it, you’ll know that they will often have a lot of problems with reasoning.” Indeed, in a 2024 study, when researchers trained language models on a database of turn-by-turn directions for taxi trips around New York City, they found that the system could provide reasonable routes from one point to another – but failed miserably when asked to take the odd detour.

The reason why is that the LLMs have only descriptions of journeys, and therefore lack the sort of mental map that allows us to imagine what would happen in different scenarios. And navigation is just one example. LLMs demonstrate similar shortcomings in any scenario where you need to simulate the physical world – safely loading a dishwasher, say, or folding laundry. “They’re not ➤



Google DeepMind's Genie 3 creates worlds that users can explore from text-based prompts

designed for it, which is why people are interested in alternatives like world models," says Tenenbaum.

Probably the most influential proponent is Yann LeCun, a computer scientist at New York University and, until recently, chief scientist of foundational AI research at Meta. His argument, first made in a 2022 paper, is essentially that if we want to build truly intelligent systems that can reason, plan and act effectively in the real world, we need world models.

"I cannot imagine we can build agentic systems without those systems having an

ability to predict, in advance, what the consequences of their actions are going to be," LeCun told artificial intelligence forum AI House Davos in January. The key to that, he reckons, is systems that learn the rules of the world from observation.

The idea has caught on. In December 2025, LeCun left Meta to found AMI Labs, raising just north of \$1 billion to build world-model systems. A year earlier, Fei-Fei Li at Stanford University in California started World Labs, with \$230 million of investment, to develop AI with "spatial intelligence". Many of the established AI firms, most notably Google

DeepMind, are now also actively pursuing world models in one form or another.

The reason for the influx of money is primarily the promise that world models hold for advancing robotics (see "What are AI world models good for?", below). However, it is early days and the existing prototypes are modest in their applications. With Marble, for instance, World Labs has built a system that generates coherent 3D scenes from text prompts. Similarly, DeepMind's Genie 3 creates convincing interactive virtual environments – "snowy mountain at dusk", say – in which you can move around for several minutes and even prompt events like rain.

In both cases, the companies describe their systems as "world models". But Marble is really a 3D video generator and Genie 3 a video-game simulator, albeit one producing simulations in which agents could plausibly act, observe consequences and learn.

Arguably, a proper world model would be something that exists inside an agent such that it can predict the consequences of its decisions, imagine the future and plan ahead before taking actions – and that is what DeepMind is pushing towards with its Dreamer 4 system,

What are AI world models good for?

For anyone wondering what the rise of world models in AI means for us, the applications researchers have in mind are illuminating. In short, world models are unlikely to produce another ChatGPT moment, when millions of people suddenly discovered a powerful tool they could use in their everyday lives. The promise isn't better chatbots, or really anything that consumers will notice any time soon, but rather a new generation of AI systems whose earliest impact could come in the form of autonomous robots capable of working in factories and warehouses, before possibly making their way into our homes.

The rationale is straightforward: rather than learning by repeatedly trying and failing for real, which is dangerous, or learning responses for every situation from exhaustive training data, which is expensive, robots controlled by AI world models could predict what would happen across a vast range of scenarios and

choose the safest and most effective action.

"There's huge potential for robotics to change everything," says Danijar Hafner at Google DeepMind in San Francisco, who works on world models.

Beyond robots, world models are also touted as a way to accelerate scientific advances, particularly in materials science and drug discovery, where the challenge

lies in exploring vast numbers of candidate molecules or atomic arrangements for novel compounds. By learning the underlying physics, they could simulate countless possibilities – how molecules interact with proteins, say, or which hypothetical compounds best capture carbon dioxide – before anything is made or tested in the lab.

"The key capability is planning in imagination space because, once you have this abstract predictor, you can say, for example, if you want to develop a drug, 'OK, what if I add this chemical or do this series of actions', and you can actually predict what will happen without having to do it in the real world," says Randall Balestrero at Brown University in Rhode Island. "It just makes things cheaper and faster."

World models may help with humanoid robotics



released in September 2025. It learns an internal predictive model of its environment, training mostly on data from the video game *Minecraft*, and uses that to train an agent that repeatedly “dreams” the consequences of possible actions to improve its behaviour.

“The biggest difference [from Genie 3] is that Dreamer 4 is an agent, not just a world model,” says Danijar Hafner at DeepMind in San Francisco, who leads the Dreamer 4 team. “It predicts actions and improves them through iterative self-improvement, using planning and [imagined] trial and error.”

Playing games

The power of this approach is apparent in Hafner and his colleagues’ demonstration that Dreamer 4 can figure out how to collect diamonds in *Minecraft*, a complex task involving thousands of different actions – gathering resources, crafting tools, navigating the landscape – without being shown how to play. “The system has to understand its environment and generalise, because each new episode starts in a randomly generated world,” says Hafner.

That is an important step, not least because this is precisely the kind of world model that could facilitate autonomous robots capable of folding laundry, say, or loading the dishwasher. “I think it’s going to solve robotics,” says Hafner. “What’s missing now is execution: data, compute, scaling. But we have the recipe, so, like with language models, it’s about scaling and details.”

Who would bet against DeepMind, given its impressive track record? After all, its researchers have won a Nobel prize for work on protein folding. But while Dreamer 4 demonstrates that agents with internal world models can reason and plan, it leaves a deeper question unresolved: what exactly should these systems learn about the world, or, more specifically, at what level of detail? This has become a key fault line in the field, with two distinct approaches emerging.

Many of the existing strategies are attempting to generate predictions on condition of action, as the researchers put it, by reconstructing future observations as faithfully to the training data as possible. But LeCun reckons that is the wrong approach, or at least not the best. His argument is based on the fact that humans don’t mentally simulate the world in any great detail, and certainly not pixel by pixel. When we imagine a glass falling

from a table and smashing to pieces, for example, we don’t predict the position of every shard of glass, every water droplet. Instead, LeCun argues, we run highly compressed models that capture only the aspects that matter.

This is why LeCun advocates for a different tack, which he calls joint-embedding predictive architecture (JEPA). In this framework, world models infer abstract representations of what is relevant for reasoning, planning and action. “Generative models try to reconstruct pixels, whereas JEPA learns in a latent space and only predicts what is useful,” says Randall Balestriero at Brown University in Rhode Island, who has worked with LeCun on JEPA-based world models. “It ignores irrelevant details and focuses only on what matters for the agent.”

LeCun and his investors appear to be betting that the JEPA approach will offer a swifter route to real-world applications, largely because it requires less training data. The most concrete publicly available demonstration of this technique so far is a system called V-JEPA 2, released by Meta in June 2025. Trained on video inputs, V-JEPA learns by masking certain regions of footage – obscuring a moving ball,

say, over multiple consecutive frames – and repeatedly predicting not pixels, but abstract representations of what was hidden to learn a compact internal model of how the ball moves. What LeCun and his colleagues have shown, then, is that their system can model the causal structure of the physical world without having to reconstruct it in detail.

Which isn’t to say that JEPA is necessarily any better than generative world models. Its advocates argue that it will be, of course. “Without abstraction, AI systems will stay limited to narrow tasks,” says Balestriero. But V-JEPA 2 is yet to clearly demonstrate that its abstract representations are sufficiently meaningful to enable an agent operating in an open-ended environment to reason and plan. “The biggest missing piece is the question of, how do we know that the abstraction is actually useful,” says Balestriero. “This is where there is a huge amount of active research right now, to understand: what do you capture, or how do you encode something very rich about the world that is useful for planning downstream.”

Hafner, for his part, isn’t convinced that more compressed representations of reality are better. “Yann is right about many things, ➤





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even if maybe he expresses them more controversially than necessary, and the JEPA approach is very promising,” he says. “But I don’t think that representations should be compressed and tiny. Ultimately, you want to learn strong representations, and what we did with Dreamer 4 [which trains with pixels but predicts in abstract space] is incredibly robust.”

Intelligent thinking

More broadly, it is also far from clear at this stage if any of the world models in development – whether they learn and predict by reconstructing the world in high-fidelity or by inferring abstract representations – will ultimately be enough to get us to AGI.

Now, it’s fair to say that AGI is another elastic term, and that claims about world models as a route towards it exist on a spectrum, with some of the most ambitious suggesting that learned simulations of physical reality could become the foundation of generally capable reasoning agents. When it released Genie 3, for instance, DeepMind insisted world models are “a key stepping stone on the path to AGI, since they make it possible to train AI agents in an unlimited curriculum of rich simulation environments”. Indeed, Hafner argues that “if you have systems that are able to represent the rules governing the world, then you’re approaching something like AGI because that’s understanding, that’s a key part of intelligence”.

For his part, LeCun talks about them as a vital component of broader systems, rather than the whole story. Yet it is worth exploring the extent to which the kinds of world models in development would approximate human intelligence, because it can reveal what else might be required. Hafner says the most immediate requirement is temporal abstraction – that is, being able to reason not just about what will happen in the immediate future, but as things continue to play out. “You cannot just simulate everything at a sub-second, frame-by-frame level, because humans do not reason like that,” he says. “This is one of the open frontiers.”

Tenenbaum goes further. Human world models aren’t just engines for predictions, he says, “they are much richer than that”. Human reasoning depends on various forms of causal abstraction and hypothesis-driven inference –

“A limitation of AI systems today is a lack of awareness of their own cognitive state”

Our minds have models that let us predict what will happen next

not to mention models of other minds – which together allow us to flexibly recombine knowledge across different situations. “A key open question in all this is whether scaling up these world models will recover that richness, and my view is that it likely won’t,” says Tenenbaum.

Mitchell makes a similar, if slightly broader, point. “I think the ability to have a kind of compressed, simulatable representation of aspects of the world is very important, and this notion of world models is probably going to result in useful improvements,” she says. “But I think there are probably lots of other aspects of intelligence that matter.”

Another limitation of AI systems today, says Mitchell, is a lack of metacognition – an awareness of their own cognitive state, of what they know and don’t know, and how uncertain they are. “Is that fixable with a world model? Well, it depends what kind of world model, obviously,” she says. “But I’m a little worried that the notion of ‘world model’ is going to be used as the term for the difference between what we have now and ‘AGI’.”

All of which suggests that world models as currently conceived may well be necessary for human-level machine intelligence, but not necessarily sufficient. Indeed, while it looks increasingly likely that they will be powerful and genuinely useful in robotics, and possibly scientific simulation too, it is far from a sure bet that they will replicate the way world models work in human cognition, never mind human-level intelligence more broadly. “One of the big misconceptions is that intelligence is a single thing, that there is a single world model in the brain,” says Tenenbaum. “What we actually have is the ability to run many different models depending on the context, task and goal.”

Ultimately, then, the task of replicating what my 3-year-old daughter’s brain is capable of when it comes to modelling and predicting the physical world – even if it doesn’t stop her knocking glasses of water off the table – is not one to be underestimated. ■



Daniel Cossins is a journalist and former head of features at New Scientist

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CSI: Microbiome

Every crime scene contains hidden microbial clues, but can we use them to solve cases, asks **Matthew Ponsford**

IN 2015, two intruders broke into Jose Lopez's home in Hollywood, Florida, and stole a TV. But this wasn't your standard-issue burglary. The "thieves" were deputies from the local sheriff's office, and Lopez, a biologist at Nova Southeastern University, was in on the whole thing as part of a project to see whether police can identify criminals from the microbes they leave at the scene.

Having analysed microbial traces left on surfaces and isolated bacterial DNA, the researchers could match them to the deputies. But when they tried to pick the intruders out of a database of 10,000 microbiome samples, the signatures proved insufficiently unique. The technique, they concluded in a 2020 paper, "cannot be used as a reliable trace evidence standard for criminal investigations".

Let's call that cause for reasonable doubt. Forensic scientists have long argued that the billions of bacteria, viruses and fungi in and on our bodies could become a valuable source of evidence. The problem has been proving that "microbiome forensics" is reliable enough for real investigations.

In recent years, however, researchers have refined their techniques, working with police to better establish what these methods can and can't tell us. They have also developed a way to analyse the post-mortem microbiome to estimate time of death – an approach that is being explored in relation to a controversial murder case in Italy.

"It's a massive frontier in forensic science right now," says David Carter at Chaminade University of Honolulu in Hawaii. The question is which of these techniques will prove useful – and whether the evidence they produce will ever stand up in court.

It's not difficult to see why forensic scientists see the human microbiome as an untapped source of information. "Imagine if I told you that there was a type of physical evidence that was guaranteed to be associated with every death scene – no matter where it was, when it was," says Carter, alluding to the many cases where fingerprints and DNA aren't retrievable. In those circumstances, the microbes we constantly shed onto other people and any



PETER REYNOLDS



surfaces we come into contact with could give clues because the ecosystems on our skin, for instance, vary hugely from person to person.

The field of forensic microbiology has really only existed since the 1990s, when advances in sequencing technology transformed what was possible in terms of analysing microbial DNA to isolate signature bacterial species. As sequencing got faster and cheaper, researchers could start testing the idea that the highly individual mixture of microbes we carry around – our microbial “fingerprints” – might be useful in identifying people.

For a study published in 2010, for example, Rob Knight, now at the University of California, San Diego, and his colleagues showed that the cocktail of bacteria deposited on a personal keyboard or mouse could identify the owner out of a database of 270 people. Other studies, meanwhile, showed that people leave a unique microbial signature in their homes.

This seemed promising. Yet when researchers tested the “touch microbiome” approach under more realistic conditions – including in those mock burglaries – it fell well short of the reliability required of forensic evidence.

The results prompted Jack Gilbert, then director of the Microbiome Center at the University of Chicago, who had led the burglary studies and others, to warn the US Department of Justice against adopting the technique in 2018. “I stipulated that I had no confidence that this could be used to identify individuals with enough rigour to definitively state that it was them and not somebody else,” says Gilbert. “I cannot prove, without a shadow of a doubt, that the bacteria that I found didn’t come from another human being.”

The setback didn’t end interest in forensic microbiology, though. Other researchers have since been exploring not only the extent to which better sequencing techniques and larger datasets can make a difference, but also whether other forms of microbiome analysis might play a role in criminal investigations.

Noemi Procopio, a forensic scientist at the University of Lancashire, UK, is investigating one such possibility. She argues that touch microbiome techniques might already hold

“investigative intelligence” that could give police crucial clues in cases where conventional forensic evidence is missing.

Her current research project began with the frustrations of Andy Nixon, a veteran crime-scene specialist for West Midlands Police in the UK, who is often confronted with murder cases where there is what he calls a “forensic void”. Many of the most vexing cases involve strangulation, says Nixon, because “the neck is too soft and elastic to preserve conventional fingerprints, and touch alone rarely leaves usable fragments of DNA – even when attackers use such extreme violence”.

Investigative toolkit

To see whether microbial traces might help, in 2025, Procopio and Nixon recruited 100 new officers from West Midlands Police to test how reliably their touch microbiomes could be traced back to them. The participants pressed their fingers onto acetate sheets, which were left around for days or weeks in a room where passers-by could walk through, as real-world microbial fingerprints might be. To start with, Procopio and her colleagues focused on rare bacterial species, which sometimes identified individuals but often became undetectable through sequencing within 48 hours, which is likely to be because they are overwhelmed by other species from the environment.

Next, the researchers analysed the overall structure of the microbial community in the samples to see whether it could offer a more reliable signature. “Maybe we have the same bacteria, but I have more of that, less of that, something unique,” says Procopio. In yet-to-be-published research, they found that this allowed them to match the sample to the individual with much greater accuracy, and that this signal remained a month later.

Crucially, Procopio isn’t claiming that such techniques will be a replacement for DNA analysis, sufficient alone to place a suspect at a crime scene. Instead, she sees them as “complementary” additions to the investigative toolkit. In fact, she agrees with Gilbert that “it will be very difficult, at least ➤

at this stage, to achieve the type of statistical weight typically associated with human DNA identification". But in cases where investigators draw a forensic blank, they might get a lead if the overall structure of a microbial community matches a sample taken from a known suspect.

Knight says this reflects how forensic evidence is often used in practice. The most common form of forensic finding is not one conclusive method of identification, but "class evidence" that narrows the suspect pool. Knight points to a 1982 case involving child murders in Atlanta, Georgia, where investigators found a mixture of microscopic fibres – yellowish-green nylon and violet acetate – on several murder victims and also in an unusual carpet owned by suspect Wayne Williams. They were able to explain to a jury the long odds of such a carpet being found in a suspect's home: 1 in 7792, based on sales records. "No individual fibre was conclusive, but the aggregate was very convincing," says Knight. "Treating microbes in this context is reasonable."

Microbial traces could have a similar role.

Fingerprints and DNA aren't always present at crime scenes

"Microbiome profiling could reveal clues about an unknown murderer"

"A technique doesn't have to be perfect to be useful," says Knight. "It's about stacking multiple class characteristics so that the probability of a false match approaches zero."

The microbial communities we carry around with us might also point in directions that investigators weren't looking. That's because our microbiomes are shaped to a great extent by our lifestyles and our interactions with others over the course of our lives, from where we live and who we spend time with to the foods we eat. In 2023, for instance, Procopio and her colleagues showed that microbiome

analysis can distinguish the residents of two neighbouring Italian regions, Lombardy and Piedmont, based on their oral microbiome. "This is definitely something that can be useful," says Procopio.

The challenge here has to do with reference data. For the moment, we don't have datasets of diverse individuals' microbiomes that are sufficiently large to draw useful conclusions. As with DNA, big databases make better insights possible. But Procopio reckons we could eventually use microbiome profiling to reveal clues about the lifestyle of an unknown murderer, for instance – whether they work in an office or on a farm, say, whether they have particular health problems or even whether they have pets.

Then again, for all the intrigue around efforts to use microbes to identify perpetrators from a crime scene, the most promising way to use the microbiome in forensics is in revealing when – and, in some cases, how – someone died.

Procopio is among a group of researchers seeking to use the bacteria that come and go as bodies decompose to develop microbial clocks that could offer a reliable estimate of the time since death, days or even weeks after a body is discovered. Few illustrate the potential better than one of the most controversial recent murder investigations in Italy: the case of Liliana Resinovich.

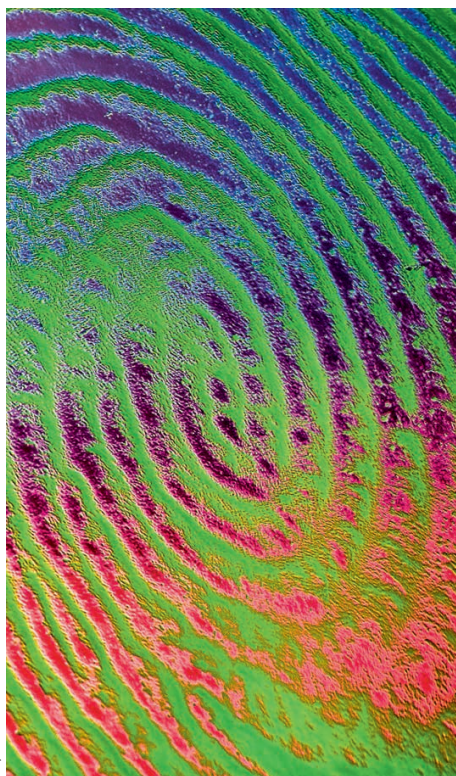
In January 2022, almost a month after the 63-year-old was reported missing, Resinovich's body was found on the grounds of a former psychiatric hospital in Trieste. She was found with plastic bags around her head and body, yet forensic pathologists found no obvious signs she had been attacked; their first report concluded that she had died, possibly by suicide, within the previous 48 hours.

But later, following protests by Resinovich's family, her body was re-examined. This new forensic assessment concluded not only that she had been killed by asphyxiation, owing to the identification of signs of trauma on the face and head, but also that Resinovich had been killed around the time of her disappearance – citing evidence including the undigested contents of her last known meal from the morning she vanished.

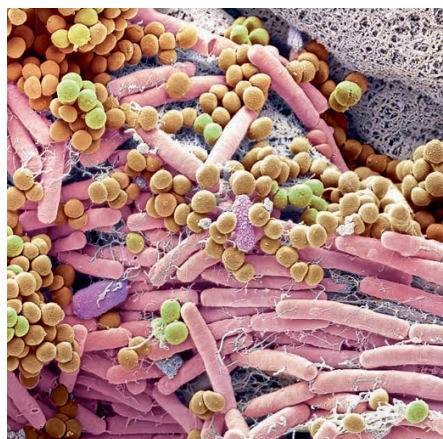
"Someone says she was dead for 48 hours, then the next forensic expert said she'd been dead for 23 days," says Procopio. "It's a massive gap." Crucially, it leaves open the question of what really happened: did Resinovich die two days before her body was found, as the first report suggested? Or was she killed around the time she went missing and kept somewhere cold, possibly even frozen, before her body was



SCOTT OLSON/GETTY IMAGES



STEVE GSCHEISSNER/SCIENCE PHOTO LIBRARY



We all leave a unique bacterial signature in our environment, often from our fingers

moved to the place where she was discovered – a hypothesis proposed to explain why it appeared unusually well preserved for a body left outdoors for three weeks?

Despite what detective dramas might suggest, conventional forensic tools can pinpoint the time of death only when a body is discovered quickly. For the first 24 hours, a forensic pathologist can usually calculate a reliable “post-mortem interval” using a temperature reading from a rectal thermometer, says Procopio, while colouration, rigor mortis and cues from insects that lay eggs in the body’s orifices can help in the first few days. But uncertainty increases as the body enters more advanced states of decay, she adds, especially if it is outdoors.

This is precisely the kind of uncertainty that microbial clocks are designed to address, says Procopio. In the past decade, studies on human remains at “body farms” across the US have shown that decomposition proceeds in a particular way: different bacteria arrive, flourish and decline in predictable patterns. By tracking these microbial changes, researchers can estimate how long a body has been decomposing, potentially unearthing vital clues about when – and how – someone died.

In the Resinovich case, a mouth swab taken

around the time of her body’s discovery preserved a snapshot of her oral microbiome. If her body had been frozen or kept somewhere cold before it was found, the microbial community in that sample should contain evidence of alterations consistent with a freeze-thaw cycle. “It would leave a detectable signature,” says Knight. Procopio adds that other clues might come from insects, because a study published in March showed that they introduce certain decomposing microbes to a body at different times depending on whether it was exposed outdoors from the moment of death or was moved, from inside to outside.

In Procopio’s view, the microbiome can resolve the uncertainty between the freezer hypothesis and the suicide hypothesis. All the evidence so far is “clearly going in one direction and not in the other”, she says. But for the evidence to be admissible in court, judges require compelling proof that microbial clocks are reliable. Which is why Procopio and her colleagues are now recreating the two scenarios at a body farm in northern Michigan, where climatic conditions resemble those in northern Italy. There, four donated cadavers are kept under different conditions, allowing the researchers to track how their microbiomes change over time with a view to presenting

a clear and admissible finding to the public prosecutor in charge of the Resinovich case.

On the broader question of whether microbiome forensics will ever produce evidence that leads to a criminal conviction, the answer depends on the application. In most countries, judges act as gatekeepers, with the power to decide if a new form of scientific evidence should be allowed in courts, often following guidelines similar to those set down in the US starting in 1993. Under the Daubert standard, as it became known, judges consider whether a technique has been independently tested and peer-reviewed and has a known error rate before admitting it as evidence.

On all counts, microbial clocks to estimate time of death appear ready to be used in court, says Carter. Research led by Jessica Metcalf at Colorado State University shows that a reliable post-mortem interval judgement can be made with an error rate of three days if a body is discovered in 10 days, though that gets larger the longer someone has been dead. “I feel that it meets those criteria, but it would really be a judge that would determine that,” says Carter.

The prospects for using microbiome analysis to identify suspects are more uncertain. To offer an alternative to DNA matching in the identification of suspects, it would have to achieve similarly exacting evidentiary standards – roughly a million-to-1 chance of a false match. The difficulty here is that the skin microbiome remains such a dynamic and ever-changing ecosystem that Gilbert doubts it will be useful any time soon. “The microbiome contains 500 species, maybe 5000 to 6000 strains that are constantly fluctuating in abundance, constantly undergoing genetic evolution, constantly shifting in the proportional representation and constantly being exchanged between people,” says Gilbert. “You’re dealing with biology, and biology is horribly complex.”

Others are more optimistic. Knight argues that sequencing technology has moved on in critical ways since 2018. More advanced methods can detect less obvious genetic differences between microbes, he says, revealing “personalised and persistent strains” that older approaches could not. “I wouldn’t give up on the trace evidence topic,” says Knight. “It’s challenging, but technology is advancing rapidly.” ■



Matthew Ponsford is a journalist based in London

"A grief attack is, essentially, a full-human-experience attack"

A few years ago, psychologist **Sherman Lee** experienced a "grief attack" and set out to study them. He tells Vanessa Nirode just how powerful and all-consuming they can be



KLAWE RZECZY

ONCE, while driving his car, Sherman Lee started sobbing so violently that he lost control of his muscles and had to pull over for fear of crashing. His whole body was subsumed in grief over a beloved pet who had died a month previously. He'd had panic attacks before, but this seemed different; he wasn't just breathless, but filled with intense despair.

Looking back now, Lee says the episode felt like a grief attack, a term that was coined decades ago and is widely recognised within psychology, but hadn't been rigorously researched. Last year, Lee, a psychologist at Christopher Newport University in Virginia and an expert on grief, co-published a study of almost 250 people who had experienced grief attacks to better understand how to define them.

Lee's research fits into a growing understanding of grief as a complex and nonlinear experience. The "five stages of grief" concept has long been debunked, and psychologists now emphasise that grief can last for years, affect both body and mind, and permeate every aspect of life. It is both intensely distressing and one of the most profound and intrinsically human experiences.

Speaking to *New Scientist*, Lee explains what he has uncovered about grief attacks, and the importance of understanding the myriad expressions of grief.

Vanessa Nirode: What are the different ways grief can manifest?

Sherman Lee: Name any facet of a person's life and I can show you where grief will express itself. Biologically, grief is shown in sleep behaviour or eating disturbances. A grieving person can have lower immunity because of stress. If a couple's been together for a very long period of time, there's a good chance the widow or the widower will follow soon after.

Psychologically, grief can produce strong emotions like yearning, sadness or anger. People become preoccupied with the person they lost, especially if it was a tragic death. A lot of people have hallucinations. In one large study of more than 10,000 people who've experienced grief, 50 per cent of participants

reported a sensation of a presence; one-third perceived hearing their voice.

Socially, people may avoid anything that triggers their memory of the person. Their lives get very small. They may avoid activities they used to do with the deceased. Or they may turn to coping through some form of substance abuse.

Spiritually, you can be angry at God, not believe in the things you used to believe in – a very big existential crisis.

This concept of a grief attack may not be familiar to many of us, but I believe it has been around for a while.

Therese Rando is a pioneer in grief therapy. She first explored the subject of grief attacks in 1991 [though she called them "sudden upsurges of grief" at the time] and has written extensively about it based on clinical observations. In contrast, my colleagues and I identified and scientifically validated the symptoms using data drawn from large numbers of people.

So, what exactly is a grief attack?

We were able to identify four main characteristics: panic (which manifests with dizziness, shortness of breath and fear), yearning, despair and incoherent thinking. We also created a tool to recognise and evaluate the symptoms. [Grief attacks] are different from "standard" grief, as they include physical symptoms as well as emotional ones and at an intensity that usually comes on suddenly. We don't yet know how common they are in terms of frequency, but they are mentioned, often by different names such as "pangs" or "spasms", in many books and articles that I've read. I think all this gives us an indicator that it's relatively common.

The most significant thing is that this is a real condition, and as such can be scientifically studied and, if necessary, treated.

How are grief attacks different from panic attacks, and why make the distinction?

From a basic science perspective, it brings together two systems that are often studied separately: the fear system and the attachment system. Grief attacks look like a unique storm of these two systems occurring at around ➤

the same time, with sweating and shaking as manifestations of the fear system, and yearning thoughts as part of the attachment system.

When you have a grief attack, along with typical panic attack symptoms like shortness of breath and dizziness, you also experience acute grief symptoms such as yearning, irresistible crying and thoughts about the deceased. The intensity of these two things together makes it a unique class of human experience.

Do we know why some people experience them and others don't?

I would postulate that two main things might contribute.

Firstly, a person [might experience grief attacks if they have] anxiety sensitivity, which is the fear that anxiety symptoms like a racing heart are physically harmful. For instance, if your heart races or you can't breathe, some people interpret that as a threat to their life, so they get really scared and panicky. I happen to fall in this spectrum. We know that people who have anxiety sensitivity are five times more likely to be diagnosed with a panic disorder and, because grief attacks contain a panic attack component, it would follow that they are also more likely to experience grief attacks.

The second factor is stress build-up, which can trigger panic attacks and make grief symptoms worse. If a person has compounding stress in their life, they are probably more likely to have a grief attack.

How long are people deeply affected by grief and grief attacks?

I think when we say "deeply affected", what most people mean is how long grief is dysfunctional or extremely distressing. Grief researchers give it about six months. The latest *Diagnostic and Statistical Manual of Mental Disorders* (DSM) gives a whole year. After that, we start talking about prolonged grief disorder.

The way I look at it, though, "deeply affected" means changing you in a fundamental way. I think it's lifelong. Take C.S. Lewis. He wrote a whole book about his experience of losing his wife. Many people can function, laugh and have fulfilling lives so that when you talk to them, you wouldn't know that they lost something significant, but every time they paint or write, it's there.

[Grief attacks] can occur anywhere along a course of one's life post-loss, though they



ROBERT HARDING/ALAMY

"Those who allow the grief attack to come and go fare better than those trying to distract themselves"

seem to [be] more frequent early on in the grief process.

Is there anything people can do to manage the experience of a grief attack?

We asked people how they coped, though we didn't directly do any experiments. Our research suggests that those who allow the experience to come and go fare better than those trying to distract themselves or focus on some activity. It's what mindfulness teaches us: don't judge it, don't fight it, just allow the experience to come because it will leave in a few minutes.

What do we know about how grief affects the brain and what happens in our brains during a grief attack?

Cognitive tests show that the more complicated and intense the grief experience is, the more impairment and disruption we see in memory and attention. A few studies show smaller brain volume in people with very severe grief. Also, chronic stress leads to neuronal loss, which could be reflected in brain volume. It also hits the brain area that deals with rewards and addictions, as well as regions associated with physical pain.



The loss of a loved one can lead to sudden panic-attack-like episodes



PLAINPICTURE/TAMBOLY



MARCUS BASTEL/MILLENNIUMIMAGES, UK

Grief attacks can include feelings of intense yearning and despair

During a grief attack, multiple areas of the brain activate at the same time. Because of the fear aspect, the amygdala is involved, similar to a fight-or-flight response. The periaqueductal grey [an area of the brain that regulates pain modulation and flight-or-freeze responses] kicks in because you yearn for that person to be back. The brain reward system's nucleus accumbens, which searches for the person in a craving sort of way, gets triggered. And then there's the anterior cingulate cortex, the pain centre of the brain, where the experience of pain and emotion come together. A grief attack is, essentially, a full-human-experience attack.

How can you know if grief or grief attacks are becoming worrying, as opposed to a natural process?

I think what we mean by "natural" is good: what is good or healthy grieving? Which, in a weird way, assumes that good has to be pain-free. You love someone and the natural consequence of that love is the pain that comes from disconnection. You have to deal with that pain until it subsides.

While grief attacks are disruptive enough to be scary, I wouldn't say they're worrisome

or directly physically dangerous. After mine, I was scared enough that I didn't want to drive [for] the rest of the day, but I did have enough control to pull over. I think most people [in our study] were the same way. Psychologically, they can feel like you're losing control, which is scary, but not necessarily dangerous. At the same time, mental events are disruptive and real. We shouldn't ignore them and people should ask for support if they need it.

You should seek a professional whenever you find that grief is too much to handle, when it impairs your ability to function.

It sounds like relatively few of us will experience a grief attack, but almost all of us will feel grief at some point in our lives. What is your advice for people in that situation?

For a lot of people, closure is important: rituals, a funeral, being able to have final words. Talking to people about the loss is helpful when trying to make sense and gain perspective. There is evidence that shows that physical movement, exercise and sport are helpful for those mourning a loss. As well as combating loneliness and depression, exercise and sport can help with sleep problems, especially if you get exhausted

enough to override your overthinking mind. Also, if you're doing a sport, you're not at home looking at pictures; you're getting a temporary distraction. We all need a break from pain.

When you decide to seek out a professional, grief therapy is tailored for you individually. Because grief is a big thing. It's never one thing. Many people might suggest cognitive behavioural therapy, which deals with the thoughts and actions that give you problems. Let's say what bothers you are the grief attacks. Then I would suggest acceptance-based therapies, which aim to teach you to let them happen and accept them, thus building psychological flexibility and a way to keep yourself grounded in the present.

All of these are great therapies and approaches, but it's hard to give a silver bullet for [grief]. It has many parts. I suggest trying to figure out the problems that you are having within that big thing. ■



Vanessa Nirode is a journalist who writes about health and wellness

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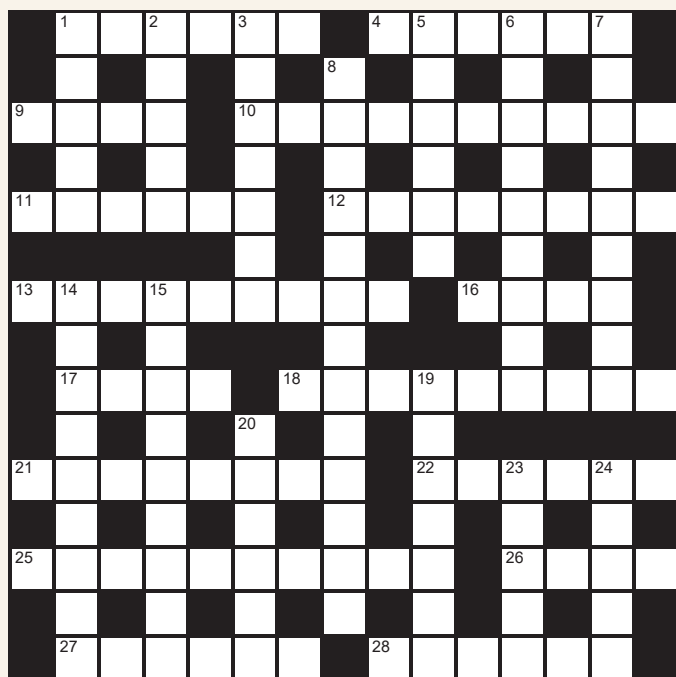
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Quick crossword #214 Set by Richard Smyth



Scribble zone

Cryptic crossword next week

ACROSS

- 1 Automotons (6)
- 4 Medical imaging procedure (1,1,4)
- 9 Notion, invention (4)
- 10 Amphetamine trade name (10)
- 11 Lymphoid organ in the throat (6)
- 12 Lynn ____, US evolutionary biologist (8)
- 13 Cluster of boils (9)
- 16 Skin condition that causes pimples (4)
- 17 Circle (4)
- 18 1 million millimetres (9)
- 21 Scuba brand co-developed by Jacques Cousteau (4-4)
- 22 Ag (6)
- 25 Geological era that began around 540 million years ago (10)
- 26 Accessible (4)
- 27 Phenomena of flowing water (6)
- 28 Reciprocal function, in trigonometry (6)

DOWN

- 1 Broadcast technology associated with Guglielmo Marconi (5)
- 2 Alloy of Cu and Zn (5)
- 3 Cell protein (7)
- 5 Supposition or hypothesis (6)
- 6 Blood cell, perhaps (9)
- 7 Of a system, having outputs that are disproportionate to inputs (9)
- 8 Taxonomic grouping to which *Homo sapiens* belongs (6,7)
- 14 Even (3,6)
- 15 A virus, toxin or bacterium, for example? (9)
- 19 Small bone of the middle ear (7)
- 20 Wrinkled (6)
- 23 Dopamine precursor (1-4)
- 24 Discharge from the body (5)

Quick quiz #364

set by Chelsea Whyte

1 Hong Wang became the third woman to ever win the Fields medal, the most prestigious prize in mathematics. What did she win it for solving?

2 Which ingredient of the cosmos was recently found to perhaps not exist?

3 Which marine animal were orcas seen ramming, causing them to explode into thousands of fragments?

4 An agricultural start-up developed a way to increase yields of soya beans, peppers and cannabis. What did it use to stimulate plant growth?

5 What discovery in Cloggs cave in Australia suggests the Gunaikurnai people have been conducting elaborate rituals there for more than 1000 generations?

Block Universe

created by Puzzlr

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

							4	
6					8			
			15					
		6						
								9
		6			3			
4				6	6			
		3						
			4				2	
2	2	4				3		
2				4				

Answers to this week's puzzles on page 47



Our games are now playable online
newscientist.com/games

Branching out

My family tree doubles at every past ancestor generation, branching back into the past. At what point does it decrease to reflect the size of the smaller historical population?

Hillary Shaw

Newport, Shropshire, UK

Global population was around 2 billion in 1930, 1 billion in 1820, 0.5 billion in 1640 and 0.25 billion in 900. Meanwhile, if your parents were born in 1950, and 10 doublings equal 1000 ancestors, theoretically you would have 2000 ancestors from 1700 (assume average maternal age 25), 2 million from 1450 and 2 billion from 1200. So, these two series cross around the year 1300.

However, your family tree numbers stabilise much later and smaller than that because, before railways, many people lived in isolated communities and married distant relatives.

As an extreme example, the Scottish archipelago of St Kilda had around 100 people for several centuries before mass emigration kicked in around 1800 – about the minimum number to avoid excessive inbreeding and genetic problems.

On the British mainland, before railways, there were travelling

“In the 1700s, chances are that most of your ancestors came from a village of a few 100. Before that, it’s almost all inbreeding”

merchants, justices, preachers, soldiers and beggars, but people would marry in a similar social class, religion, et cetera.

In the cities, especially port cities, you might marry an outsider, but pre-railway villages were almost as isolated as St Kilda and of similar population size.

Around 1650, it took seven days to travel between York and London, due to atrocious roads, which would have been quagmires



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This week's new questions

Fish-eye view Humans can see water but not air. So can fish see air? *Kayla Zelenietz-Mills, age 13, Ottawa, Canada*

Feeling negative Would it be possible to have anti-black holes, and how could we tell if we were looking at one? *David Oxnam, Toppesfield, Essex, UK*

in winter, dust bowls in summer.

In 1700, just 15 per cent of the British population lived in urban areas, which were small. London then had 650,000 inhabitants, but other cities were much smaller: Bristol had 20,000, Manchester 10,000 and Liverpool 5000 people. So, chances are that most of your ancestors came from a village of a few hundred in the 1700s. Before that, it's almost all inbreeding.

Simon McLeish

Lechlade, Gloucestershire, UK

It is actually more to do with the availability of unrelated partners than the wider population size. The availability of the bicycle has been cited as one factor that made it easier to find less closely related prospective partners. Parish records in Dorset, UK, show that,

between 1887 and 1916, the proportion of marriages between people in the same village dropped from 77 to 41 per cent.

The royal families of Europe often married close relations for centuries to preserve the purity of the royal blood. The Habsburgs were the best known example, with the “Habsburg lip” a physical trait seen in many portraits of those related to the dynasty.

Robin Maguire

Hobart, Tasmania, Australia

The answer will vary when factors such as geography or social practices limit potential marriage partners to a particular segment of the population.

For an extreme example, consider the Ptolemaic dynasty of Egyptian rulers. After the death

of Alexander the Great in 323 BC, the Macedonian general Ptolemy I Soter appropriated the throne of Egypt and his descendants kept power in the family through the practice of intermarriage.

The final ruler in the Ptolemaic line was Queen Cleopatra VII (born in 69 BC), the paramour of Julius Caesar and subsequently of Mark Antony. Going back through her family tree, she had about the usual number of direct forebears in the late 100s BC, but all of these were exclusively descended from the irreducible minimum of just two ancestors in the late 200s, King Ptolemy V Epiphanes and his consort, Queen Cleopatra I. There were six incestuous liaisons along the way. This unusual background did not seem to do the final Cleopatra any harm: she was almost as famous for her learning as for her vivacity.

John Davies

Haverbreaks, Lancaster, UK

Your family tree's size just stops doubling when it reaches the size of the earlier population, and you discover that two of your great-to-the-X-grandparents are the same individual!

Anthony Woodward

Portland, Oregon, US

It never does. Tracing your ancestors backward in time for 8 million years, approximately 32,000 hominin generations, they will become the last common ancestors of chimpanzees and hominins.

Energy savings

How does energy use by the body differ when I walk, jog or run for 1 kilometre?

Eric Kvaalen

Les Essarts-le-Roi, France

An article in *Nature* gives a graph showing oxygen consumption as a function of speed for walking



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Tom Gauld
for New Scientist



and running (“Endurance running and the evolution of Homo”, 2004).

For walking, the curve is U-shaped, with a minimum of about 165 millilitre O₂ per kilogram body weight per kilometre at around 1.3 metres per second. Running (which includes jogging) is a straight line that decreases from around 210 ml O₂/kg/km at 2 m/s to around 200 at 6 m/s.

This means that if you want to go a certain distance in a given, fairly long amount of time while consuming the lowest possible amount of oxygen, then you should walk.

However, when the allotted time is less than a certain value, corresponding to a slightly fast walk, then you should alternate between running as fast as you can and walking at that slightly fast walking speed.

Note, however, that this is talking about total oxygen consumption, not extra oxygen consumption over normal basal rate. To minimise extra oxygen

“My theory is that, because dogs don’t climb and have no aerial predators, they tend to not have much concept of ‘up’”

consumption, the optimum is a slower walk than that for total consumption.

Hear that?

Why don’t dogs look up when a low-flying plane or helicopter passes overhead? I’ve never seen one do this. (continued)

Dyane Silvester

Arnside, Cumbria, UK

As a former dog owner, and now regular dog-sitter, my theory is that, because dogs don’t climb and, as a species, have no aerial predators, they tend not to have much concept of “up” (except where it’s upward-sloping ground).

If you drop something from a height, most dogs will look for it

on the floor rather than realise that there was a table between the object and the floor.

I did, however, have one Alsatian who, if I appeared at an upstairs window when she was in the garden, could immediately locate and arrive at the room I was in, despite having never been able to see out of any upstairs windows in our house. She also noticed and watched birds and low-flying aircraft.

I did manage to stump her once: by climbing out of the skylight and appearing on the roof. She never worked that one out!

David Lewis

London, UK

Although unusual, a friend’s late spaniel would look at aircraft flying above her in the park. She would then bark and chase them. Fortunately, she never caught one!

C. H. Johnson

Colyton, Devon, UK

Because they know planes and helicopters don’t bring their food or any doggy treats. ■

Answers

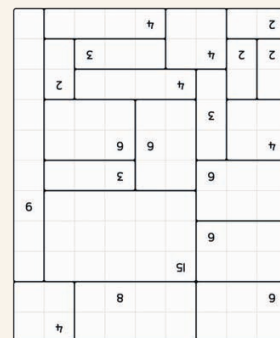
DOWN 1 Radio, **2** Brass, **3** Tubulin, **5** Theory, **6** Corpse, **7** Nonlinear, **8** Animal kingdom, **14** All square, **15** Biohazard, **19** Ossicle, **20** Rugose, **23** L-dopa, **24** Eggst

ACROSS 1 Robots, **4** CT scan, **9** Idea, **10** Benzidine, **11** Tonsil, **12** Margulis, **13** Caruncle, **16** Acne, **17** Loop, **18** Kilometre, **21** Aqua-Lung, **22** Silver, **25** Palaeozoic, **26** Open, **27** Eddies, **28** Secant

#214 Quick crossword

1 The kakeya conjecture
2 Dark energy
3 Sunfish
4 Sound waves
5 Ash from burnt grass

Quick quiz #364



Block Universe Solution

Bloons and doubloons

This edition of Feedback is an exercise in time travel – in that every item is something from absolutely ages ago that we somehow missed. We would feel guilty, but it is the summer holidays (in the northern hemisphere, anyway) and many readers will have half an eye on their errant children, so we thought we could get away with it.

So, cast your minds back to 2008. This, obviously, was the year of the 20th Canadian Conference on Computational Geometry, held in Montreal. A large amount of research was presented at this conference, but reporter Matthew Sparkes recently stumbled across a theoretical study by Erik Demaine, Martin Demaine and Vi Hart. It presents “a general mathematical and algorithmic theory for balloon-twisting structures”.

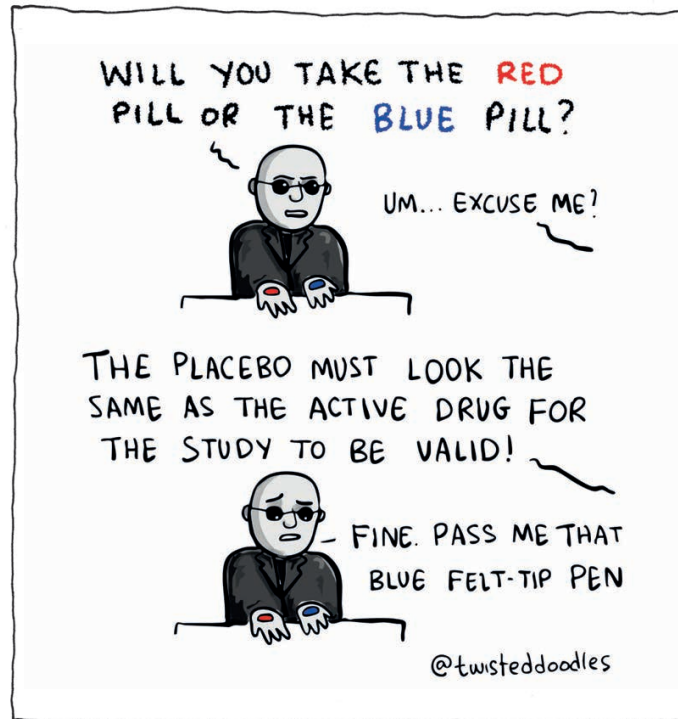
If you didn't grasp that, allow us to clarify: it's about the geometry of balloon animals. The authors develop a mathematical framework that allows them to calculate how many balloons you need to generate a particular shape, whether it is a dog (one) or some complicated polyhedron like a dodecahedron (10). These, naturally, are referred to as “Platonic balloons”.

Throughout the paper, the authors use the term “bloon” to refer to a mathematical entity equivalent to a balloon. Feedback wasn't clear why this neologism was necessary, until we realised that they were therefore able to refer to a balloon of twice the usual length as a “doubloon”.

Curious to know what the authors had been up to since, Feedback went a-searching. Hart became a science populariser on YouTube, then a senior manager at Microsoft. Meanwhile, Martin and Erik are father-and-son researchers and artists, both fascinated by the mathematics of folding.

Erik, a professor at the Massachusetts Institute of Technology, has been in *New Scientist* a lot. Recent papers include “Overlapping unfoldings of cones and convex polyhedra” and “Tetris

Twisteddoodles for New Scientist



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or New Scientist, 9 Derry Street, London, W8 5HY

Consideration of items sent in the post will be delayed

is hard with just one piece type”.
More from Erik, please.

Testing times

Continuing on the topic of being very late to things, reader Derek Long flagged a paper from 2018, “Parachute use to prevent death and major trauma when jumping from aircraft: randomized controlled trial”. It reports on a study called “PARTicipation in RANdomized trials Compromised by widely Held beliefs aboUt lack of Treatment Equipoise (PARACHUTE)”.

(Side note: that is a truly excellent scientific acronym. We haven't had any of those in a while.)

The problem posed is one of evidence. “Parachutes are routinely used to prevent death or major traumatic injury among individuals jumping from aircraft.

However, evidence supporting the efficacy of parachutes is weak and guideline recommendations for their use are principally based on biological plausibility and expert opinion.” If readers haven't yet twigged: the paper is satirical, poking fun at the idea that even the most common-sense interventions should be tested in a full randomised controlled trial.

As the authors write: “In seminal work published in the BMJ in 2003, a systematic search by Smith and Pell for randomized clinical trials evaluating the efficacy of parachutes during gravitational challenge yielded no published studies.”

Feedback actually ran across that review back in 2004. The authors noted they were “unable to identify any randomised controlled trials of parachute intervention” and suggested

that “everyone might benefit if the most radical protagonists of evidence based medicine organised and participated in a double blind, randomised, placebo controlled, crossover trial of the parachute”. Oof.

Fifteen years later, they did do a trial. This showed that “parachute use did not significantly reduce death or major injury”, with the slight caveat that “the trial was only able to enroll participants on small stationary aircraft on the ground”. This was helpfully illustrated by a photo of one of the participants jumping, parachute-less, out of a grounded plane. As the authors say: “Our findings should give momentary pause to experts who advocate for routine use of parachutes for jumps from aircraft in recreational or military settings.”

Witty Zwicky

Some concepts can't be traced back to their origins. One such is the spherical cow joke, which illustrates the difficulties of working with highly simplified and abstract models of complicated, real-world situations. It involves a physicist who figures out how to improve productivity on a dairy farm, but their solution only works for spherical cows in a vacuum. Nobody seems to know who came up with this: the oldest references place it in the 1960s, but the origin stories are all vague and one reference replaces the cows with chickens.

However, another sphere-based physicist joke seems to be older. Feedback has just learned, many decades after the fact, about an insult deployed by Fritz Zwicky, who, in the 1930s, produced some of the first evidence for dark matter. A noted curmudgeon, Zwicky was fond of referring to people he disliked as “spherical bastards”. Such a person is a bastard no matter which way you look at them.

Feedback will be using that from now on. But we also want to know the etymology (if that is quite the term) of spherical bastards, chickens and cows. Any insights welcome. ■

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