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A TIME TRAVELLER'S GUIDE TO THE SOLAR SYSTEM

LANDMARK GENETIC INSIGHT INTO CHRONIC FATIGUE SYNDROME

THE EPIC FIGHTBACK AGAINST WEB-SCRAPING AI

THE NEW RULES OF AGEING

A revolutionary understanding of how to be healthy and happy in our later years

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PLUS LITHIUM'S ROLE IN ALZHEIMER'S / THE MATHEMATICAL SECRETS OF 'GUESS WHO?' / **17 NEW COCKATOO DANCE MOVES** / INTROVERTS, EXTROVERTS – AND OTROVERTS?


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SPARKLING WATER
WATER DOWN NOTHING
O SUGAR
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This week's issue

On the cover

28 The new rules of ageing
A revolutionary understanding of how to be healthy and happy in our later years

Vol 267 No 3556
Cover image: Stephan Schmitz

32 A time traveller's guide to the solar system

10 Landmark genetic insight into chronic fatigue syndrome

38 The epic fightback against web-scraping AI

6 Lithium's role in Alzheimer's
10 The mathematical secrets of 'Guess Who?' 15 17 new cockatoo dance moves 19 Introverts, extroverts – and otroverts?

28 Features

"Health isn't like life and death; it's a continuum"

News

7 Superheavy chemistry
Fresh findings could end up rearranging the periodic table

8 Allergy hope
An asthma drug could prevent severe allergic reactions

9 Interstellar investigation
The latest observations are telling us more about the mysterious comet 3I/ATLAS

Views

19 Comment
There is a previously unrecognised personality type, says Rami Kaminski

20 The columnist
Graham Lawton gets to the heart of a tree's microbiome

22 Aperture
Water's vital role pictured

24 Culture
In praise of a call to use nature's power to still our minds

27 Letters
Heated views on the need for a new global warming limit

SOPA IMAGES LIMITED/ALAMY

13 No laughing matter Laughter therapy really could reduce anxiety

Features

28 The ageing revolution
A new lens on what it means to age well is reshaping our view of our golden years

32 Travel the solar system
Go on a tour of the six most mysterious moments in the life of our solar system

38 Hiding from AI
People are finding creative ways to trick AI bots

The back pages

44 The science of exercise
What's the best activity to improve your sleep?

45 Puzzles
Try our crossword, quick quiz and logic puzzle

46 *Almost* the last word
Why do humans find flowers so appealing?

47 Tom Gauld for *New Scientist*
A cartoonist's take on the world

48 Feedback
Want to get ahead in science? It's all in the acronyms

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A golden age of ageing

A new measure says today's older people are the healthiest ever, but that might not last

ONE of the more depressing prospects of old age is years of poor health towards the end. The familiar story is that, while people are living longer, our healthspans haven't risen to the same extent, meaning those who reach old age experience more years of illness.

It is heartening, then, that a new way of assessing our later years reveals a different picture (see page 28), shifting the focus from chronic disease diagnoses to whether a person is able to live their life in a way they value – described as "intrinsic capacity". When looked at this way, people born in the 1950s in wealthy nations seem set to live the longest and healthiest lives of any generation yet.

We don't yet know, however, if people born after this will enjoy a similar trend, as rises in obesity, pollution and sedentary lifestyles could reverse past gains.

It is estimated that in 2023, more than three quarters of the US population had at least one chronic condition and over half of all middle-aged adults had two or more. But when thinking in terms of intrinsic capacity, being diagnosed with an illness need not mark the end of good health, provided there are ways to manage the condition.

> **"People born in the 1950s in rich nations look set to live the longest and healthiest lives yet"**

It is unfortunate, then, that the idea of a chronic disease epidemic is cited as the motivation behind the Make America Healthy Again campaign, fronted by Robert F. Kennedy Jr, the US health secretary, who last week cut research funding for mRNA vaccine technology. That funding could have helped lengthen lives and lessen the impact of disease.

However, there are still reasons for optimism. GLP-1 drugs, for example, have provided a powerful new way to manage obesity and, as we reported last week, are now being investigated as a way to slow ageing. This week, preliminary findings in mice suggest a new approach for lessening the impact of Alzheimer's disease (see page 6).

Such advances should remind politicians that if spending more years in better health is our goal, biomedical research is our ally, not our enemy. ▮

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News

Space monster
We have discovered the most massive black hole yet **p8**

Jiggling molecule
Tiny atomic motions have been observed in great detail **p12**

Stepping stones
Primitive tools hint at ancient human sea crossing **p14**

Super glue
Sticky material is so strong it can be used underwater **p14**

Deepfake detector
There's a better way to identify manipulated videos online **p17**

CMSA

Space

China's lunar lander gets put to the test

China has taken one big step towards putting astronauts on the moon by successfully completing takeoff and landing tests for its lunar lander at a site in Hualai county, Hebei province, on 6 August. Called Lanyue, which means "embracing the moon" in Mandarin, the craft is designed to ferry crew from lunar orbit to the moon's surface and back, a feat the country hopes to accomplish before 2030.

Health

Low lithium linked to Alzheimer's

Human tissue samples and mouse experiments suggest lithium levels in the brain may play a key role in Alzheimer's disease, finds **Grace Wade**

PEOPLE with Alzheimer's disease have lower levels of lithium in their brains, and giving lithium to mice with symptoms of the condition reverses cognitive decline. The findings suggest lithium deficiency could be a driver of Alzheimer's disease and that low-dose lithium medications could help treat it.

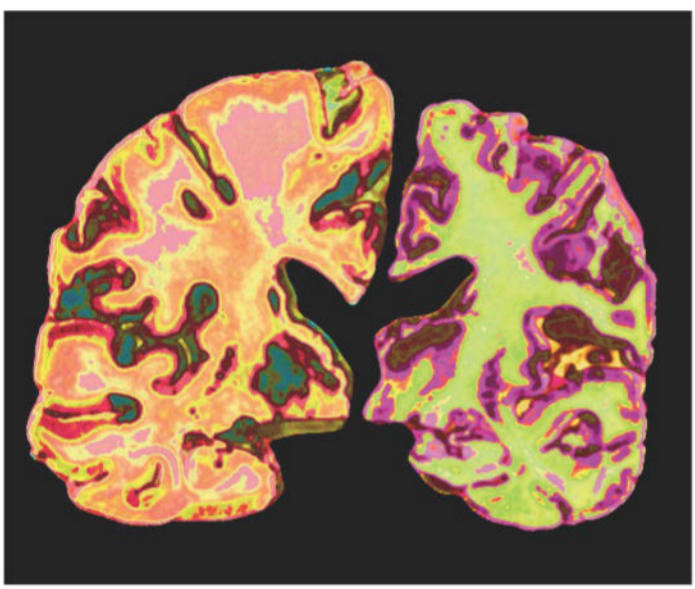
Since the 1990s, many researchers have believed that clumps of proteins in the brain, called amyloid plaques, are the primary driver of Alzheimer's. The idea spurred the development of drugs that can clear amyloid from the brain. But these medications don't stop the condition's progression – they only slow it.

Numerous studies have hinted at a link between lithium and Alzheimer's disease. A 2022 study found that people prescribed lithium had almost half the risk of developing Alzheimer's over the study's follow-up period compared with those who hadn't been, and another study last year showed an association between lithium in drinking water and decreased dementia risk.

But other factors might explain the associations, says Bruce Yankner at Harvard University. For example, it could be that instead of lithium, another metal in drinking water, such as magnesium, is responsible for lowering dementia risk, he says.

Yankner and his colleagues analysed levels of 27 metals in the brains of 285 people after they died, 94 of whom were diagnosed with Alzheimer's disease and 58 of whom had mild cognitive impairment, a precursor to the condition. The other participants showed no signs of cognitive decline at the time of their deaths.

Lithium levels in the prefrontal cortex – a brain region crucial for memory and decision-making – were about 36 per cent lower, on average, in people with Alzheimer's disease than in those without any cognitive decline. For those with mild cognitive impairment, lithium levels were about 23 per cent lower. "We suspect that's due to a number of environmental factors: dietary intake, genetics and so forth," says Yankner.



JESSICA WILSON/SCIENCE HISTORY IMAGES/ALAMY

A slice of the human brain with Alzheimer's (right) and without (left)

Yet there seemed to be another reason, too. In those with Alzheimer's disease, amyloid plaques contained nearly three times more lithium than plaque-free regions of their brain. "We have two things going on. There is impaired uptake of lithium [in the brain] very early on and then, as the disease progresses, the lithium that is in the brain is further diminished by being bound to amyloid," says Yankner.

To understand how this influences cognition, the team reduced the lithium intake of 22 mice – which were genetically engineered to develop Alzheimer's-like symptoms – by 92 per cent. After about eight months, the animals performed significantly worse on multiple memory tests compared with 16 genetically engineered mice on a standard diet. Their brains also contained nearly two and a half times as many amyloid plaques.

Genetic analysis of brain cells from the lithium-deficient mice showed increased activity in genes related to neurodegeneration and Alzheimer's. They also had more brain inflammation, fewer connections between neurons and immune cells that were less able to clear away amyloid plaques, all changes also seen in people with Alzheimer's disease (*Nature*, doi.org/g9wc8r).

> **"Lithium deficiency may be the missing piece that ties together our understanding of Alzheimer's disease"**

These results suggest that lithium deficiency may be the missing puzzle piece that ties together our understanding of Alzheimer's, says Yankner.

But Rudolph Tanzi at Massachusetts General Hospital is sceptical of the idea that lithium deficiency could cause Alzheimer's. He points to past research in human organoids – "mini-brains" grown in a lab – that shows amyloid plaques lead to neurodegeneration irrespective of lithium levels. "I would view lithium deficiency as a way to possibly exacerbate existing Alzheimer's pathology, but not actually cause the disease," he says.

Towards a treatment

Still, the finding raises the possibility of using lithium supplements to treat the condition. The team screened different lithium compounds for their ability to bind to amyloid and found that lithium orotate – a naturally occurring compound in the body formed by combining lithium with orotic acid – appeared to be the least likely to get trapped within plaques. Mice with Alzheimer's symptoms that were treated with this compound for nine months showed significantly reduced plaques, and they performed as well as normal mice on memory tests.

High doses of different lithium compounds are already used to treat some psychiatric conditions, such as bipolar disorder. However, this can result in kidney and thyroid toxicity, says Yankner. But such doses are in concentrations far higher than those used to treat the mice in this study, he says.

While lithium orotate is already available as a dietary supplement in many countries, people shouldn't start self-mediating with the compound, Tanzi warns. Clinical trials are still needed to understand how low-dose lithium orotate may affect people, he says. ▮

Chemistry

Superheavy chemistry could rearrange the periodic table

Karmela Padavic-Callaghan

RESEARCHERS have directly observed the heaviest atom yet participating in a chemical reaction and forming a molecule. The finding pushes "superheavy" chemistry, which involves extremely massive radioactive elements, to a new level – and further experiments could lead to a rearrangement of the periodic table.

Some exotic chemical elements are hard to experiment with, which makes it difficult to determine their proper placement within the periodic table. For instance, the radioactive element copernicium is placed among a group called the transition metals, but behaves more like noble gases, which belong in a different section.

This problem may affect elements at the table's very bottom, too – heavy and radioactive atoms called actinides, says Jennifer Pore at the Lawrence Berkeley National Laboratory in California. To check the properties of actinides, she and her colleagues carried out a chemical reaction that created a molecule containing the heaviest actinide, nobelium, which is element 102.

To make the element, the researchers used a particle accelerator that smashed a beam of very energetic calcium atoms into a chunk of lead. Nobelium

"Some exotic chemical elements are hard to experiment with and to place on the periodic table"

atoms emerged in the aftermath of this collision and reacted with nitrogen and water molecules in the air. A fast-acting detector, similar to a particle-sensing machine called a mass spectrometer, then identified the resulting molecules more precisely than in any past attempt to do superheavy chemistry.

Next, the team reran their experiment with a chunk of thulium instead of lead. This created an actinide called actinium, which is element 89. By comparing how easy it was for water to stick to actinium versus nobelium, the researchers confirmed that the two elements behave similarly enough to belong in the same row of the periodic table (*Nature*, doi.org/p2gz).

Nobelium is not only properly placed on the periodic table; it has also become the heaviest element that researchers have directly observed forming a new molecule, although the heaviest element ever created is still oganesson, element 118. And the procedure used to create molecules that contain nobelium, then precisely identify them, could lead to new breakthroughs.

Already, the findings are making an impact. Pore and her team thought that they would have to add extra molecules into the experiment for actinium and nobelium to react with. However, the superheavies reacted with substances that were already present: nitrogen and water in the air. Anastasia Borschevsky at the University of Groningen in the Netherlands says this may force scientists to re-examine previous superheavy experiments in which researchers assumed that they were looking at atoms – because they may have also been observing molecules containing those atoms.

For Pore, the next challenge is doing chemistry with even heavier elements, such as dubnium, which is element 105. To do so, the researchers may have to speed up their procedure, because the heavier elements get, the less time they spend in a stable state before decaying into a different element.

"If things go well, we want to do the bigger guys at the end [of the periodic table]. We don't have any [heaviness] limits with this technique," says Pore. Unlike nobelium, some of those bigger elements might need to find new places on the periodic table. ▮

Entomology

Covert viruses may be messing with honeybee flight

A PAIR of seemingly innocuous viral infections in adult honeybees may be meddling with the insects' flight. One virus makes them fly faster, while the other pumps the brakes.

Honeybees routinely battle infectious fungi, bacteria, mites and viruses – some of which can wipe out whole colonies. But not all pathogens are equally destructive. For instance, when deformed wing virus (DWV) and sacbrood virus (SBV) infect the bees early in their development, they produce lethal symptoms – malformed wings and larvae burdened with fluid-filled sacs, respectively. However, infections in adult bees are generally considered asymptomatic, even though the viruses are associated with increased deaths and reduced colony size. Michelle Flenniken at Montana State University and her colleagues wondered if the viruses weren't so benign after all.

The team gathered insights into the bees' health via their flight performance, infecting bees with DWV or SBV. Three days later, they attached the bees to the arm of a device shaped like a tiny tetherball set, which restricted the bees to flying in a circle. In all, 240 bees took a spin and the team measured the speed, duration and distance of their flights.

Flenniken and her colleagues found that bees with high DWV levels fly distances 49 per cent shorter than bees without the virus, despite having similar flying durations. Bees with SBV get a 53 per cent range boost (*Science Advances*, doi.org/p2gt).

ANTHONY BROWN/ALAMY

Honeybees have to contend with many viral infections

"It's surprising that DWV and SBV, which are very closely related and both members of the family Iflaviridae, have such opposite impacts on the honeybees' flight performance," says Eugene Ryabov at the James Hutton Institute in the UK.

By tampering with flight and the honeybees' ability to travel for nectar, viruses like DWV may even hobble the insects' pollination relationships with any nearby plants, in addition to making it more difficult for the bees to feed themselves. ▮

Jake Buehler

Health

Asthma drug could prevent fatal allergic reactions

Jay Kakade

NORTHWESTERN UNIVERSITY

Stephanie Eisenbarth used peanuts to study food allergies

A COMMON asthma drug has been shown to shield mice from anaphylaxis – a potentially life-threatening allergic reaction. The medication, called zileuton, has long been used to treat asthma and is now being trialled in humans as a possible treatment for severe allergic reactions to food.

Although many people have food allergies, it is difficult to predict an individual's risk of anaphylaxis when they are exposed to an allergen. Researchers have been working to understand why some people with positive blood tests for food allergens show no symptoms, while others experience severe, sometimes life-threatening reactions.

"Our goal is to find ways to make people with symptomatic food allergy tolerate exposure to allergens," says Stephanie Eisenbarth at Northwestern University in Illinois.

She and her colleagues used groups of five to 10 mice that had been sensitised to peanut allergens such that they were expected to experience anaphylaxis with exposure to peanuts. Each mouse was given a single oral dose of zileuton about an hour before being fed peanut extract. A control group wasn't given the drug. Then the researchers watched the zileuton-dosed mice for signs of anaphylaxis, such as a drop in body temperature and increased heart rate, and found that nearly every zileuton-treated mouse remained symptom-free. The control group showed clear signs of anaphylaxis (*Science*, doi.org/g9wgvp).

"We could take mice that normally respond to food allergens and make them unresponsive"

Most of the proteins we eat are broken down, but a few are actively transported across the gut and into the bloodstream intact. In severely allergic people, these trigger immune cells and cause anaphylaxis.

During an allergic reaction, the body also releases chemicals called leukotrienes. In the mice, the researchers found that leukotrienes control how many intact proteins pass through the gut. They also found that a gene called *DPEP1* is involved in regulating the breakdown of leukotrienes.

One of zileuton's effects is to block 5-lipoxygenase, an enzyme needed to produce leukotrienes. Giving the drug to the mice reduced leukotriene levels, allowing *DPEP1* to keep the remaining leukotrienes in check, preventing allergen absorption and stalling anaphylaxis in sensitive mice. A single oral dose of zileuton led to a 95 per cent fall in anaphylaxis rates.

"We could take mice that normally respond to food allergens and make them unresponsive. We are now testing whether the same drug, which is already used clinically for asthma, can reduce allergen absorption in the gut in people with food allergy. If so, this could provide a treatment to prevent anaphylaxis," says Eisenbarth.

Jorge Emiliano Gómez Medellín at the University of Chicago says this simple pill may provide significant relief from accidental exposure to food allergens. He adds that while zileuton may prevent the absorption of these, it wouldn't be able to alter a person's sensitivity to them in the long term.

"Nonetheless, zileuton has the potential to become an important asset in our fight against food allergies," he says. ▮

Space

We've discovered the most massive black hole yet

Alex Wilkins

A GARGANTUAN black hole hiding in a galaxy 5 billion light years away is the most massive that we have directly measured. It is more than 10,000 times as massive as the supermassive black hole at the centre of the Milky Way, and around 36 billion times the mass of our sun.

The ultramassive black hole is around 5 billion light years away in the Cosmic Horseshoe, one of the most massive known galaxies. The Cosmic Horseshoe is also the largest known galactic lens, a galaxy that can magnify the light behind it due to its enormous gravitational pull. While previous studies suggested an extremely massive black hole could be at the centre of this galaxy, researchers struggled to put an exact number on it.

To pin down the black hole's mass more accurately, Thomas Collett at the University of Portsmouth in the UK and his team measured how fast stars were swirling around it, since their speed depends on the mass of the black hole. To put constraints on the potential mass, they also measured how much light was being bent by the black hole's gravity, an effect called gravitational lensing (*Monthly Notices of the Royal Astronomical Society*, doi.org/g9wgq9).

Although the object's mass is unusually large, it fits with previous work by Collett and his team, which involved studying how dark matter is distributed through its home galaxy by constructing a model to match the data from the light they observed. They couldn't find a model that fitted – unless the Cosmic Horseshoe had an extremely massive black hole at its centre.

However, one puzzling feature remains: the black hole has stopped growing and is lying dormant. "For it to be as big as it is, it had to have been accreting for basically the entirety of the universe. It's weird that now it's off," says Collett. ▮

Astronomy

A closer look at new interstellar visitor

The latest observations of comet 3I/ATLAS give clues to its origins in a distant star system, but some mysteries still remain, finds **Alex Wilkins**

TELESCOPES trained on the interstellar comet 3I/ATLAS have found it looks much like comets in the outer reaches of our solar system. However, puzzling features, such as a surprisingly large amount of water coming off it even while far from the sun, might give us clues about the ancient star system it came from.

Objects from other systems passing through ours are extremely rare: 3I/ATLAS, discovered in July, is only the third known interstellar visitor after the objects 'Oumuamua in 2017 and Borisov in 2019. There is only a window of a few months to observe the newcomer, which is barrelling towards the sun at around 60 kilometres per second, before it loops around it and is flung out of the solar system forever.

So far, scientists have used its speed to infer that it might have come from a star system billions of years older than our own. Early observations also suggested a size of around 20 kilometres wide, but there has been little information on the vast plume of water or gases, or both, that it leaves in its wake, called its tail, which can tell us about the composition of the comet itself.

Toni Santana-Ros at the University of Barcelona in Spain and his colleagues have now used several ground-based telescopes to observe the comet and its tail,and found that it contains a relatively low to moderate amount of dust (arXiv, doi.org/p2g3). The amount of dust also appears to be growing as it gets closer to the sun and warms up, which is similar to the behaviour of comets from the outer solar system. "It's a regular object. There is nothing especially weird on it," says Santana-Ros.

Astronomers have also used the Hubble Space Telescope to observe the comet, finding that it may be smaller than we thought, possibly 320 metres to 5.6 kilometres wide (arXiv, doi.org/g9wgqv).

Comets often contain ice, which is vaporised as they get close to the sun, producing water vapour in the tail. Using the Neil Gehrels Swift Observatory satellite, Zexi Xing at Auburn University, Alabama, and her colleagues have detected water in the comet's tail, at distances much further from the sun than is typical. To create the amount of water detected, around 20 per cent of the comet's surface would need to be producing it, more than in typical solar system comets (arXiv, doi.org/p2g4).

60 km/s

How fast comet 3I/ATLAS is moving towards our sun

Producing this much water so far from the sun could fit with the idea that 3I/ATLAS comes from a star system much older than our sun, says Cyrielle Opitom at the University of Edinburgh, UK. This is because older star systems tend to have more water relative to other substances. "It might be that it has more water than other molecules just because it was formed earlier. It could be indicative of that, but I think it's still too early to say."

Astronomers are also digging through older data to see whether telescopes may have accidentally picked up the comet. Adina Feinstein at Michigan State University and her colleagues found that the Transiting Exoplanet Survey Satellite (TESS) space telescope, which is looking for planets around other stars, picked up the comet by chance between 7 May and 3 June. "It just happened to be that, at this perfect time, TESS [was] staring right where 3I/ATLAS was," says Feinstein.

They found that it was surprisingly bright during this time, implying it was releasing either water or gases from its surface at distances far from the sun (arXiv, doi.org/p2g5). "It hadn't quite crossed over into the region in our solar system where you would expect water to start reacting," says Feinstein.

NASA, ESA, DAVID JEWITT (UCLA)/JOSEPH DEPASQUALE (STSCI)

3I/ATLAS crossing space, seen as a fuzzy dot by the Hubble Space Telescope

More clues to come

In this far-off zone, it is relatively unlikely that this was water and more likely to have been gases like carbon monoxide, says Opitom. "That happens all the time with comets from the solar system. They can be active very far away because of these volatiles."

But the fact that it was active so far from the sun might suggest it is a comet that hasn't been exposed to much starlight in its life, which is consistent with an origin in the outer reaches of its own star system, says Matthew Genge at Imperial College London.

"What it all ultimately suggests is this is a comet that was perturbed out of the outskirts of another solar system," says Genge. It will be difficult to know exactly what caused its exit, but it may have been a passing star's gravity that set it towards us, he says.

We will soon get even more detailed observations of 3I/ATLAS, says Opitom, as the James Webb Space Telescope has just completed observations of it, which will be analysed in the coming weeks.

The comet will reach its closest point to the sun in October, when it will be exposed to the highest intensity of sunlight, allowing astronomers to measure the gases that it produces. This could tell us exactly what molecules are in its active tail, and so also in the comet itself, and also the ratios of various molecules, which might hint at how 3I/ATLAS originally formed, says Opitom.

Health

Genetic signal seen in chronic fatigue

DNA analysis has linked eight regions of the human genome to chronic fatigue syndrome

Michael Marshall

GENETIC factors that could contribute to people's risk of developing chronic fatigue syndrome (CFS), also known as myalgic encephalomyelitis (ME), have been identified.

"Our study provides the first robust evidence of genetic contributions to ME," says Sonya Chowdhury at the charity Action for ME in the UK.

In the long run, the findings could contribute to the development of new diagnostic tools and treatments for ME/CFS, which has been recognised for decades and is marked chiefly by post-exertional malaise, a severe and debilitating response to even mild exertion.

Already, the results provide "validity and credibility" for people with the condition, says Chowdhury. "They've been to doctors and been disbelieved and told it's not a real illness," she says.

"This will be huge for the patient population," says Andy Devereux-Cooke, co-founder of the Science for ME forum, who has had the condition for 45 years.

"This provides validity for people with the condition, who have been told it's not a real illness"

The study, called DecodeME, compared DNA samples from just over 15,500 people with ME/CFS and nearly 260,000 without, all of whom were from the UK and of European ancestry.

"We have found eight genetic signals," says Chris Ponting at the University of Edinburgh in the UK. The eight genome regions involved look significantly different in people with ME/CFS, indicating that genetic variants there contribute to the risk of developing it. The University of Edinburgh announced the findings in a press briefing, but they haven't yet been published in a journal or on a preprint server.

Within these eight regions, the team identified 43 protein-coding genes, of which 29 looked especially promising. "When we dig down into these eight different genetic signals, we find genes that are related to both the immune system and the nervous system," says Ponting. "Overall, the activities of the genes in these signals are enriched in the brain's tissues. They are more likely to be active in the brain than elsewhere, pointing to a nervous system involvement."

The researchers also identified an immune system-related gene called *RABGAP1L* as a probable contributor to ME/CFS risk. This fits with the testimony of most people with the condition, who say that an initial infection, often one that seemed mild, preceded the onset of their symptoms.

"My thought has always been that there is something different about the immune system in people with ME/CFS," says Jackie Cliff at Brunel University of London.

The work didn't find any differences in genetic risk between men and women, even though ME/CFS is much more common in women. However, the team hasn't yet analysed the X and Y chromosomes.

The next step is to study in more detail the eight regions of the genome that have been highlighted, to try to figure out how the genetic alterations are translated into molecular and cellular processes in people with and without ME/CFS. ▮

Mathematics

The secret formula to help you win at Guess Who?

YOU can maximise your chances of winning the board game Guess Who? if you follow a strategy devised by a group of mathematicians.

In the game, two players each secretly choose a person from a set of 24 unique characters. The players then take turns asking their opponent a yes or no question, or trying to guess the opponent's secret character.

Many people play a version of the game where you win by narrowing your opponent's characters down to one person. However, the official rules say you can only win by affirmatively guessing the secret character, rather than simply eliminating all the incorrect choices on the board.

SHUTTERSTOCK/JAYANTHI PHOTOGRAPHY

In Guess Who? players must secretly pick a character from a set of 24

David Stewart at the University of Manchester, UK, and his colleagues have now devised a method to win more often using the official rules. They found that, most of the time, you should use two pronged or bipartite questions to split your suspects into even or uneven groups, depending on how many remaining suspects both you and your opponent have. Using this strategy, the first player will win, on average, around 65 per cent of the time (arXiv, doi.org/p2g7). However, there are scenarios where you and your opponent have certain numbers of people left when you should take a different approach.

To find the optimal strategy, Stewart and his colleagues worked backwards from the simplest possible scenarios, such as each player having two characters left, and calculated the best strategy for each case, working their way up to far more complicated scenarios.

The team found that if you have either four, six or 10 players left on your board, and your opponent has four left on theirs, you should follow special rules, such as asking questions that split your four options into one and three. Although this is a more risky strategy, in these scenarios, the reward outweighs the risk. ▮

Alex Wilkins

Genetics

Older eggs don't rack up mutations in their mitochondria

Meagan Mulcair

HUMAN eggs appear to be protected against a certain type of age-related mutation. In a small study, researchers found no signs that mutations accumulate in the mitochondrial DNA of egg cells as women get older, which may give us clues as to how they can stay fresh for decades.

"When we think about age-related mutations, we think about older people having more mutations than younger people," says Kateryna Makova at Penn State University. "But expectation is not necessarily the truth."

Mitochondria, which supply most of the energy to most of our body's cells, are only passed down from mothers to their children. Although

"We think about older people having more mutations. But expectation is not necessarily the truth"

mutations in mitochondrial DNA are usually harmless, they sometimes lead to complications, which particularly affect muscle and nerve cells given their high energy needs.

Studies have shown that older mothers pass on more chromosomal mutations, prompting the widespread assumption that this also occurs among mutations to mitochondrial DNA. To study this, Makova and her colleagues used a DNA-sequencing method to identify any new mutations in 80 eggs collected from 22 women, aged 20 to 42.

They found that mitochondrial mutations in the women's eggs actually didn't increase as they aged (*Science Advances*, doi.org/g9wghr). The same wasn't true for the mitochondria in their salivary and blood cells. "I think that we evolved a mechanism to somehow lower our mutation burden, because we can reproduce later in life," says Makova.

Archaeology

Human bones show signs of ancient cannibalism

Luke Taylor

MARIA D. GUILLÉN/IPHES-CERCA; BELOW: IPHES-CERCA

The bone fragments were found in El Mirador cave in northern Spain

BUTCHERED human remains found in a cave in northern Spain suggest that Neolithic people may have eaten their enemies after killing them in combat.

Francesc Marginedas at the Catalan Institute of Human Paleoecology and Social Evolution (IPHES) in Tarragona, Spain, and his colleagues studied 650 fragments of human remains belonging to 11 people, which were found in El Mirador cave in the Atapuerca mountains and date back 5700 years.

All of the bones had signs that these individuals had been eaten by fellow humans. Some had chop marks, indicating that the people's skin was cut off with stone tools, while others were translucent with slightly rounded edges, suggesting they had been boiled. Some of the longer bones had been broken open with stones, probably to extract and eat the marrow, while smaller ones like metatarsals and ribs featured human teeth marks (*Scientific Reports*, doi.org/pz8k).

The study adds to evidence that cannibalism was more common than previously thought throughout human history.

El Mirador is at least the fifth site with strong evidence of cannibalism in Spain in the Neolithic period, when people switched from foraging to farming, says Marginedas.

Why humans ate each other so much is less certain. At some sites, evidence including skull cups suggests that cannibalism may have had a ceremonial purpose. At others, it appears to have been a means of survival during extreme famine.

Marginedas and his colleagues say the evidence at El Mirador instead points to war. An abundance of animal remains and no signs of nutritional stress in the humans indicate this early farming community didn't face famine, they say. They found no telltale signs of ritual, with the human remains mixed in with animal bones.

Cut marks were discovered on this ancient foot bone

The age of the individuals ranged from under 7 to more than 50 years old, suggesting a whole family had been wiped out in conflict. Radiocarbon dating revealed that all 11 people were probably killed and eaten in a matter of days.

The researchers say this mirrors signs of conflict and cannibalism also seen at two other Neolithic sites: Fontbrégoua cave in France and Herxheim in Germany. This period increasingly looks like it was defined by violence, as communities clashed with neighbours or newly arrived settlers over territory.

Marginedas and his colleagues are less sure why these people then ate their adversaries, but ethnographical studies of humans eating each other in war throughout history suggest cannibalism was a form of "ultimate elimination".

Silvia Bello at the Natural History Museum in London agrees the deaths were probably the result of conflict, but isn't convinced they were eaten as a form of humiliation. While the cannibalism may indeed have been fuelled by aggression, it could still have been ceremonial, she says.

"I think it could be more complicated. Even if it was warfare, the fact that they eat them still has a sort of ritualistic meaning," she says.

Environment

Europe could face intense heatwaves that last weeks

Madeleine Cuff

NICK PALEOLOGOS/BLOOMBERG VIA GETTY IMAGES

Wildfires, like ones in Greece in 2024, could become more common

IN TODAY'S climate, Europe could be hit with a summer of rolling heatwaves and severe drought that would leave much of the continent suffering weeks of deadly temperatures and water shortages.

That is the finding of new research that seeks to define the "worst-case scenario" for heat and drought possible during the summer months in central and western Europe under the current climate.

Laura Suarez-Gutierrez at ETH Zurich in Switzerland and her colleagues started with seven simulations of heatwaves in climate models. They then deliberately made tiny tweaks to the starting atmospheric state in the models and reran them 1000 times for each simulation to assess alternative outcomes, such as the heatwaves becoming more severe, a technique known as ensemble boosting.

"They generate lots of events with a very, very tiny change in the initial state of the model each time," says Vikki Thompson at the Royal Netherlands Meteorological Institute. "These worst cases that they're presenting are things that this model suggests could happen right now."

In many cases, no heatwave emerged from the simulations, but in some cases, the simulations produced

45°C

Temperatures could stay this high for more than a month

heatwaves and droughts far more severe than anything seen in the historical record (*Research Square*, doi.org/pz8v).

Under the most extreme scenarios, temperatures of up to 45°C (113°F) could linger for more than a month in parts of the continent, accompanied by extreme drought. Such an event would outstrip by a large margin the 2003 or 2018 heat and drought events, currently the worst on record in Europe, for duration and intensity, according to the researchers.

More worryingly still, the modelling suggests the worst heatwaves tend to occur immediately after a previous heatwave, potentially condemning Europe to a summer of rolling heat extremes with little respite for humans or ecosystems. This raises the risk of wildfires, drought, and energy and food shortages, the researchers warn.

"Our findings expose the potential for unprecedented compound heat, fire weather and soil drought conditions well beyond historical extremes in the recent past," Suarez-Gutierrez and her colleagues write in the study.

This pattern of successive heatwaves and persistent drought could be partly driven by extreme heat drying out soils, says Pascal Yiou at the Laboratory for Climate and Environmental Sciences in France. One heatwave may cause the soils to dry out, contributing to further heat extremes, he says. "Dryness of the soils actually generates weather systems that can last for a long time."

Yiou, who works with Suarez-Gutierrez but wasn't involved in this research, stresses that these worst-case scenarios are unlikely outcomes in the current climate, but they are possible.

"This work is about creating the perfect conditions for an extreme event," says Jana Sillmann at the Centre for International Climate Research in Norway. Doing this can help decision-makers stress-test their response plans, to ensure they can cope with, for example, a series of record-breaking heatwaves occurring over a single summer, she says. ▮

Quantum physics

Jiggling molecule measured in extraordinary detail

Karmela Padavic-Callaghan

FOR the first time, a powerful X-ray laser has revealed minuscule atomic motions in a molecule that should otherwise be still – were it not for the quirks of quantum mechanics.

Heisenberg's uncertainty principle forbids researchers from simultaneously and precisely measuring a particle's position and momentum. This means a quantum particle can never be completely still, because both its position and momentum would then be known too precisely. Instead, even when atoms have very little energy, they jiggle, albeit very slightly.

But in complex molecules, where atoms move in a variety of ways, measuring this tiny jiggle is extremely difficult. Now, Till Jahnke at the European XFEL, a laser facility in Germany, and his colleagues have captured it in a molecule made from 11 atoms of carbon, hydrogen, nitrogen and iodine (*Science*, doi.org/pz8f).

The crucial instrument, says Jahnke, was the "beast of a laser" that barraged molecules with bursts of powerful X-rays.

Each X-ray burst tore electrons away from the molecule. This made its atoms positively charged, so they explosively repelled one another. By examining the aftermath of these explosions, the researchers could reconstruct the atoms' quantum fluctuations at their lowest energy in unprecedented detail.

Specifically, they found the jiggle seems to follow a choreography, where some atoms' motions are synchronised. This wasn't totally unexpected, and could be predicted from the molecule's structure. But the researchers were surprised by how well they could measure it, says team member Ludger Inhester at the German Electron Synchrotron.

Next, they want to study how quantum fluctuations affect molecules during chemical reactions, and how electrons jiggle. ▮

Space

How we might explore a black hole

An ambitious plan involves sending a probe weighing just a few grams propelled by light

James Woodford

AN INTERSTELLAR probe sent to a black hole could complete its journey and send data back to Earth in less than a century – if we can find a black hole close enough.

Cosimo Bambi at Fudan University in Shanghai, China, has developed a blueprint for such a mission, using technology that may be available in the next 20 to 30 years.

Getting up close to a black hole would allow us to test Albert Einstein's theory of general relativity and reveal what happens to the fundamental constants of physics in an extreme gravity field.

The closest known black hole to us is about 1500 light years away, much too far for us to send a craft there. But in the Milky Way, there is thought to be roughly one black hole for every 100 normal stars. That means there is likely to be a black hole somewhere within 20 to 25 light years of us, says Bambi.

Spotting one, however, will be tricky. As black holes don't emit light, astronomers must detect them by observing their effects on stars or how they distort light.

"Getting up close to a black hole would allow us to test Albert Einstein's theory of general relativity"

To reach one within 25 light years of our solar system, technological developments will be needed, but it "should be feasible", says Bambi. The journey could be made in under a century with a nanocraft weighing about a gram that carried a 10-square-metre sail, which would allow it to be propelled by light. This craft could be accelerated to around a third of the speed of light with a blast from a very powerful laser (*iScience*, doi.org/g9wgjx).

But a laser with the power required would probably cost around €1 trillion today, Bambi estimates.

In order to test the predictions of general relativity, it may be necessary to dispatch two miniature spacecraft, or for the main nanocraft to release a second probe once it nears the black hole. The second nanocraft would approach the black hole while the primary vehicle would remain at a distance, collecting data to be sent back to Earth.

Geraint Lewis at the University of Sydney says Bambi's plan is ambitious, but it doesn't address how to decelerate the nanocraft once it arrives at the black hole. Bambi says the simplest solution isn't to try to slow the vehicle down, but rather for the mothership to release probes that can relay data back to the main craft, which, in turn, can transmit the information back to Earth.

Sam Baron at the University of Melbourne in Australia says Bambi's blueprint is one of the most "speculative" research papers he has ever read – but a century ago, the construction of the Large Hadron Collider would have seemed like science fiction.

It won't be possible for humans to visit a black hole in such a way, says Bambi, as our bodies wouldn't be able to cope with the 10,000 *g* acceleration forces the nanocraft will have to endure. That is, unless we find a space-time-warping wormhole to use as a shortcut.

"In my proposal, unfortunately, there is no wormhole," he says.

Health

Laughter really could be the best medicine

IT SEEMS that laughter therapy is no joke. Structured interventions that aim to tickle our funny bone, like laughter yoga or hospital clowns, really do appear to reduce anxiety and improve life satisfaction.

Yelsyn-Mauricio Porras-Jiménez at the University of Jaén in Spain wanted to understand how we can better support people's overall health – "not just the physical, but also the spiritual and emotional", he says. "In the midst of searching for how to truly implement this comprehensive care, I came across laughter therapy."

Porras-Jiménez and his colleagues carried out a meta-analysis of 33 studies done in the US, Europe, Asia and the Middle East. Many of the participants were nursing students, but they also included individuals undergoing end-of-life care, surgery or in vitro fertilisation, and people with depression or burnout.

All of the studies were made up of two groups: one received some form of laughter therapy – such as doing laughter yoga, which combines the physical activity with laughter exercises; being visited by a clown; watching funny films; or taking part in guided group laughing sessions – while the second group acted as the control, receiving either no intervention or carrying on with their usual care.

The researchers found that laughter therapy was consistently linked to reduced anxiety and improved life satisfaction. If you were to measure anxiety on a scale of 0 to 100, says Porras-Jiménez, the control group would have an average score of about 60, while the laughter therapy group would be 8 to 10 points lower (*Journal of Happiness Studies*, doi.org/pz7g). For life satisfaction, the control group would score about 50 and the laughter therapy group 10 to 12 points higher, he says.

But the participants couldn't be blinded to the fact that they were receiving laughter therapy, so the findings might be due to the placebo effect, says Sophie Scott at University College London.

Elizabeth Hlavinka

SUNIL GHOSH/HINDUSTAN TIMES/SHUTTERSTOCK

This yoga session will have you rolling on floor, and it could also reduce anxiety

Ancient humans

Stone tools shake up 'hobbit' history

Artefacts on the island of Sulawesi may tell us more about the mysterious *Homo floresiensis*

James Woodford

SEVEN stone tools found on the Indonesian island of Sulawesi are the earliest evidence ever discovered of ancient humans making a sea crossing, dating back up to 1.4 million years.

They may also provide clues to how a tiny human species, nicknamed "hobbits", ended up on the nearby island of Flores.

The first of the artefacts was found embedded in a sandstone outcrop at a site called Calio by Budianto Hakim at the National Research and Innovation Agency in Indonesia in 2019, and a full excavation uncovered six more tools in the same outcrop.

In the same deposit as the stone tools, Hakim and his colleagues found part of the upper jaw, with teeth, of an extinct giant pig known as *Celebochoerus*, along with a tooth fragment from an unidentifiable species of juvenile elephant.

While the researchers couldn't directly date the stone tools themselves, they could estimate an age of between 1.04 million and 1.48 million years old by analysing the sediments and the fossil pig's teeth (*Nature*, doi.org/g9wctg). Until now, evidence of hominins on Sulawesi went back only 194,000 years.

At least one of the newly discovered artefacts is a flake that was struck off a larger flake and then had its edges trimmed, says team member Adam Brumm at Griffith University in Brisbane, Australia. While non-human primates like chimpanzees have been known to use stones like a hammer to break open nuts, they don't carefully work flakes to produce tools.

"This is a very early kind of human intelligence from a species that no longer exists," says Brumm.

The remains of a metre-tall hominin named *Homo floresiensis* were discovered on Flores in 2003. Archaeological evidence shows that hominins were on that island more than 1 million years ago, but it has been a mystery as to how an early human species could have made their way there.

Both Flores and Sulawesi had large expanses of sea separating them from mainland South-East Asia, even during the periods of lowest sea levels. Brumm says the distances between the mainland and Sulawesi were too great to swim and it is almost certain these early hominins weren't capable of building ocean-going vessels.

"It may have been some sort of freak geological event, like a tsunami, for example, washing some hominins out to sea clinging to floating trees or vegetation mats of some kind, and then winding up on these islands in large enough numbers to give rise to these isolated populations," he says.

The late archaeologist Mike Morwood, who led the team that identified *Homo floresiensis*, was the first to suggest that Sulawesi was an important place to search for potential ancestors of the so-called hobbits, says Kira Westaway at Macquarie University in Sydney, Australia. This is due to the path of the Indonesian throughflow, a strong current that flows from Sulawesi to Flores.

"But I think that even Mike would be pleasantly surprised by the antiquity of the stone tools found at this site," she says. "It could be argued that seven tools is not a large enough assemblage to support large claims, but it certainly represents an early hominin presence." ▮

BRIN, BUDIANTO HAKIM ET AL.

An excavation on the Indonesian island of Sulawesi (left) and one of the seven stone tools uncovered there (below)

Chemistry

Super-strong adhesive can be used underwater

A RUBBER duck that was stuck to a seaside rock for more than a year has proved the strength of a new sticky material. The adhesive could be used in deep-sea robots or as surgical glue for medical procedures.

"We developed a super-adhesive hydrogel that works extremely well even underwater – something very few materials can achieve," says Hailong Fan at Shenzhen University in China. Hydrogels are stretchy and soft materials.

Fan, then at Hokkaido University in Japan, and his colleagues analysed 24,000 sticky protein sequences from many different organisms to identify the stickiest combinations of amino acids, the building blocks of proteins. They used that information to create 180 different types of adhesive hydrogel. Then, they trained artificial intelligence models on the hydrogels' material properties to predict even better recipes for super-sticky materials.

This process let the team develop a new class of versatile and sticky hydrogel. The material bonds to surfaces even when it has been unstuck and restuck multiple times or immersed in seawater, says Fan. It exceeded 1 megapascal of adhesion strength underwater – about 10 times stronger than most soft, sticky materials under the same conditions (*Nature*, doi.org/pz4d).

As well as sticking a rubber duck to a rock, the researchers used the hydrogel to instantly seal a leaking water pipe. This suggests it could help repair underwater structures or make robotics water-resistant.

"The material bonds to surfaces even when it has been unstuck and restuck multiple times"

The material was also biocompatible, which the researchers proved by implanting it under the skin of mice. This could make it useful for biomedical applications, such as surgical glue.

The hydrogel's stickiness is remarkable, says Zhao Qin at Syracuse University in New York state. But he notes that the material must be relatively thick to perform well. He hopes to see it tested in more real-world situations. ▮

Jeremy Hsu

Animal behaviour

Cockatoos like to move it, move it

Chris Simms

ANDREW ANGELOV/ALAMY

***Birdie Song* anyone? White cockatoos are known to dance**

THE headbang, the side-to-side and the body roll are some of at least 30 dance moves used by captive cockatoos.

These birds have been grabbing the limelight online ever since Snowball, a sulphur-crested cockatoo (*Cacatua galerita*), became an internet sensation back in 2009. Then, in 2019, Aniruddh Patel at Tufts University in Massachusetts and his team showed Snowball had invented 14 different movements and even combined some of them.

To investigate how common such behaviour is, Natasha Lubke at Charles Sturt University in Australia and her colleagues analysed 45 videos posted on social media of dancing cockatoos. They included five different species: sulphur-crested, white (*Cacatua alba*), salmon-crested (*Cacatua moluccensis*), Tanimbar corellas (*Cacatua goffiniana*) and little corellas (*Cacatua sanguinea*).

The team identified 30 distinct dance moves each done by at least two birds, 17 of which hadn't previously been scientifically described (*PLoS One*, doi.org/g9wc4b).

Lubke and her colleagues also experimentally investigated dancing in two sulphur-crested cockatoos, two pink cockatoos (*Lophochroa leadbeateri*) and two galahs (*Eolophus roseicapilla*) at the Wagga Wagga Zoo & Aviary in Australia.

They played the birds a house music track – *The Nights* by Avicii – a financial podcast called *She's On the Money* or white noise, and found the birds danced regardless of whether music was being played.

Many of the dance moves are similar to the courtship displays of wild parrots, which hints they may have originated as courtship behaviour, says Lubke.

Based on video evidence, she and her colleagues conclude dancing behaviour is present in at least 10 out of the 21 species of cockatoo.

But which of these is the best dancer? "From the zoo study, the Major Mitchell [pink] cockatoos definitely looked like they danced a bit more and were more engaged than the other species," says Lubke. ▮

Health

Psychotherapy relieves lower back pain

Christa Lesté-Lasserre

A SHORT-TERM course of a type of psychotherapy was nearly three times more effective at relieving chronic lower back pain than standard treatments, even years later.

Cognitive functional therapy (CFT) provides people with personalised programmes that teach them to manage their pain through movement and lifestyle changes. In 2023, researchers found it relieved chronic lower back pain for at least a year after just eight sessions.

Now, the researchers have found those sessions continued to bring about relief three years later – almost tripling the improvement in pain and its associated disability levels compared with the care people were already on, such as painkillers or physical therapy.

"It seems to produce a lasting difference in patients who are very disabled from back pain, many of whom were, for all practical purposes, treatment resistant," says Jan Hartvigsen at the University of Southern Denmark.

> **"It seems to produce a lasting difference in people who were treatment resistant"**

Back pain is a leading cause of disability globally, with treatments often providing only short-term relief. For the earlier work, Hartvigsen and his colleagues recruited 492 people with chronic lower back pain, defined as rating at least 4 on a pain scale of 0 to 10 and that had been moderately to severely limiting their physical activity for three months or more.

The researchers had one-third of the participants continue with their typical care routine. The other two-thirds stopped their regular care to engage in seven CFT sessions over 12 weeks, with a final session at 26 weeks.

During those sessions, physiotherapists examined each individual's posture, thoughts about pain, emotions and lifestyle factors. They aimed to help the participants view their pain differently, retrain their movement patterns and adopt healthier diets, rest strategies, stress management and exercise plans.

Half of those in the CFT group also had biofeedback, a sensor-based technique that allows them to track movement patterns in real time to help retrain their posture and motion.

At one year, both pain intensity and disability levels – measured according to the Roland Morris Disability Questionnaire – improved about three to four times as much in the CFT groups compared with those receiving usual care. Biofeedback only slightly increased the efficacy of CFT.

In the three-year follow-up, Hartvigsen's team obtained updated feedback from 312 of the participants, who were evenly distributed across the treatment groups.

They found those who received CFT still had a nearly three-fold improvement in both pain and disability compared with the usual care group (*The Lancet Rheumatology*, doi.org/pz39). Plus, about three times as many people in the CFT groups had disability scores so low on the questionnaire their pain was no longer considered functionally disabling.

However, participants were all free to seek additional care after the first year, but whether they did wasn't recorded. ▮

Health

You can lose more weight by cutting out processed food

Chris Simms

ANNE JAPAUD/GETTY IMAGES

Ready-meal lasagnes are one example of ultra-processed foods

IT SEEMS you can lose twice as much weight if you eat a diet based around minimally processed, homemade food, compared with ultra-processed meals and snacks.

Food is generally considered to be ultra-processed if it includes ingredients that are never or rarely used in kitchens, such as high-fructose corn syrup, or additives, such as flavourings and thickeners.

Many studies have linked eating ultra-processed food to adverse health outcomes, such as type 2 diabetes and weight gain, but these studies have been observational. Ultra-processed food also tends to be high in sugar, salt or fat, sparking a debate over whether it is the ingredients that make ultra-processed food unhealthy or if there is something intrinsically detrimental about the processing itself.

To better understand this in the context of weight loss, Samuel Dicken at University College London and his colleagues randomly assigned 55 people who were overweight or had obesity to eat a diet of either ultra-processed or minimally processed foods.

They made sure that both diets aligned with the UK Eatwell Guide, which encourages a healthy, balanced diet that includes at least five portions of fruit and vegetables a day and several sources of protein, such as beans, fish, eggs and meat. The two diets were also matched so they contained roughly the same levels of fat, sugar, salt and carbohydrate.

> "A minimally processed diet also saw more fat loss and a greater reduction in craving"

Food was delivered to the participants, making it the first trial to compare such diets in real-world conditions, rather than in a hospital or lab. With the ultra-processed group, this involved things like breakfast cereals, protein bars, chicken sandwiches and ready-meal lasagnes, but versions that were low in fat and salt.

The minimally processed diet featured homemade foods like overnight oats, chicken salad, bread made from scratch and spaghetti bolognese. Both groups were given enough food for about 4000 calories a day and were told to eat as much as they wanted. The researchers set it up so that half of the participants were on one diet for eight weeks, half on the other, and then they switched after a four-week break.

The participants were told the study was investigating the health effects of balanced meals made in different ways, rather than looking for weight loss specifically, but both diets still led to people shedding pounds: the minimally processed food diet resulted in a 2 per cent average reduction in weight, and the ultra-processed diet led to a 1 per cent reduction (*Nature Medicine*, doi.org/pz36).

"We saw more weight loss on the minimally processed diet, and it's not just that – we also saw greater fat loss and also a greater reduction in craving," says Dicken.

The researchers also found that the minimally processed diet reduced the amount of fat in their bodies and its levels in blood. Perhaps surprisingly, the ultra-processed diet resulted in lower levels of low-density lipoprotein, or "bad" cholesterol.

However, Ciarán Forde at Wageningen University in the Netherlands says the ultra-processed diet was more calorie-dense than the minimally processed one, which could have driven the difference in weight loss. ▮

Environment

Coal plants could be used to store green energy

Jeremy Hsu

DOZENS of retired coal-fired power plants could find new life providing backup or emergency power for the electricity grid – except this time without the need for fossil fuels.

The concept involves creating a huge dirt pile near a coal plant and placing industrial heaters inside. During the grid's low-demand periods, these machines would convert cheap electricity into heat, which would remain stored within the dirt at a temperature of about 600°C. In times of high demand, the heat could be transferred out of the dirt via pipes of heated liquid.

The coal plant's turbine blades and connected generator could then turn that heat into backup energy. The heat would transform water into steam, which would spin the turbine blades to produce electricity (*Findings*, doi.org/pz3w). "Instead of taking the coal to heat up the water to produce the steam, you use the heat from this energy stored in the dirt," says Ken Caldeira at Stanford University in California.

Energy storage like this is necessary to supplement renewable power sources, such as wind and solar, which only provide energy intermittently. Dirt is also cheaper and more abundant than other types of long-term energy storage.

However, this approach could have other costs. "Reducing piping and electrical costs are essential in such systems and may be a challenge," says Andrew Maxson at the Electric Power Research Institute, a non-profit research organisation headquartered in California.

Most dirt includes naturally heat-resistant materials, such as silicon dioxide and aluminium oxide, which make it "pretty robust to heating", says Austin Vernon at Standard Thermal in Oklahoma. His start-up is looking to commercialise this "heat battery" technology, especially at sites with nearby solar or wind-power sources. ▮

Artificial intelligence

A better way to detect deepfakes

An AI model can identify manipulated videos with a high level of accuracy

Jeremy Hsu

A UNIVERSAL deepfake detector has achieved the best accuracy yet in spotting multiple types of videos manipulated or completely generated by artificial intelligence. The technology may help flag non-consensual AI-generated pornography, deepfake scams or election misinformation videos.

The widespread availability of cheap AI-powered deepfake-creation tools has fuelled the out-of-control online spread of synthetic videos. Many depict women – including celebrities and even schoolgirls – in non-consensual pornography. And deepfakes have also been used to influence political elections, as well as to enhance financial scams targeting both ordinary consumers and company executives.

But most AI models trained to detect synthetic video focus on faces – which means they are most effective at spotting one specific type of deepfake, where a real person's face is swapped into an existing video. "We need one model that will be able to detect face-manipulated videos as well as background-manipulated or fully AI-generated videos," says Rohit Kundu at the University of California, Riverside.

"The detector is able to spot inconsistencies in lighting conditions or background details in deepfake videos"

Kundu and his colleagues trained their AI-powered universal detector to monitor multiple background elements of videos, as well as people's faces. It can spot subtle signs of spatial and temporal inconsistencies in deepfakes. As a result, it can detect inconsistent lighting conditions on people who were artificially inserted into face-swap videos, discrepancies in the background details of completely AI-generated videos and even signs of AI manipulation in synthetic videos that don't contain any human faces. The detector also flags realistic-looking scenes from video games that aren't necessarily AI-generated but that may be used in disinformation campaigns.

"Most existing methods handle AI-generated face videos – such as face-swaps, lip-syncing videos or face reenactments that animate a face from a single image," says Siwei Lyu at the University at Buffalo in New York. "This method has a broader applicability range."

The universal detector achieved between 95 per cent and 99 per cent accuracy at identifying four sets of test videos involving face-manipulated deepfakes (arXiv, doi.org/g9t9jb). That is better than all other published methods for detecting this type of deepfake. When monitoring completely synthetic videos, it also had more accurate results than any other detector evaluated to date.

Several Google researchers also participated in developing the new detector. Google didn't respond to questions about whether this detection method could help spot deepfakes on its platforms, such as YouTube. But the company is among those supporting a watermarking tool that makes it easier to identify content generated by their AI systems.

The universal detector could also be improved in the future. For instance, it would be helpful if it could detect deepfakes deployed during live video conferencing calls, a trick some scammers have already begun using. ▮

Palaeontology

Skulls reveal which dinosaur had the strongest bite

A CLOSER look at the skulls of gigantic dinosaurs reveals some preferred to shred their prey, while others crushed bones.

Andre Rowe and Emily Rayfield at the University of Bristol in the UK looked at the skulls of 18 species of theropods from across the Mesozoic Era. This diverse group of dinosaurs, which includes *Tyrannosaurus*, *Giganotosaurus* and *Spinosaurus*, walked on their hind legs and had large heads and big, sharp teeth.

Despite the dinosaurs' similarities, however, their behaviour shouldn't be thought of as "one size fits all", says Eric Snively at Oklahoma State University. *Giganotosaurus*'s thin, serrated teeth, "like a cross between a great white shark and a Komodo dragon", were suited for slashing big swathes of flesh from prey, says Snively. Meanwhile, the semi-aquatic *Spinosaurus* was "like a fin-backed heron with the body of a Wiener dog, and teeth like a crocodile", better adapted to eating very large fish, he says.

ROGER HARRIS/SCIENCE PHOTO LIBRARY/GETTY IMAGES

Tyrannosaurus rex had a thick skull, which helped power its bone-crunching bite

After taking 3D scans of the surfaces of the skulls, the researchers investigated the dinosaurs' bite mechanics using a method for modelling stress in bridges. By comparing how each dinosaur's muscles attached to the skull bones with modern relatives like birds and crocodiles, they found *Giganotosaurus* and *Spinosaurus* had a much weaker bite than the evolutionarily younger *Tyrannosaurus*, which used its shorter, thicker skull to attack its prey with "bone-crunching" force (*Current Biology*, doi.org/pz35).

"The feeding strategies of these top predators are more complex than we thought in the past," says Fion Waisum Ma at Beipiao Pterosaur Museum of China. "*T. rex* lived later during the Late Cretaceous Period, when hunting was highly competitive," she says. This may have inspired its "unique feeding strategy". ▮

Meagan Mulcair

TRIP

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Views

The columnist
Graham Lawton gets to the heart of a tree's microbiome p20

Aperture
Water's vital role pictured, from desert well to holy spring p22

Culture
In praise of a call to use nature's power to still our minds p24

Culture
Running the rule over a sunny take on solar power's potential p26

Letters
Heated views on the need for a new global warming limit p27

Comment

The power of one

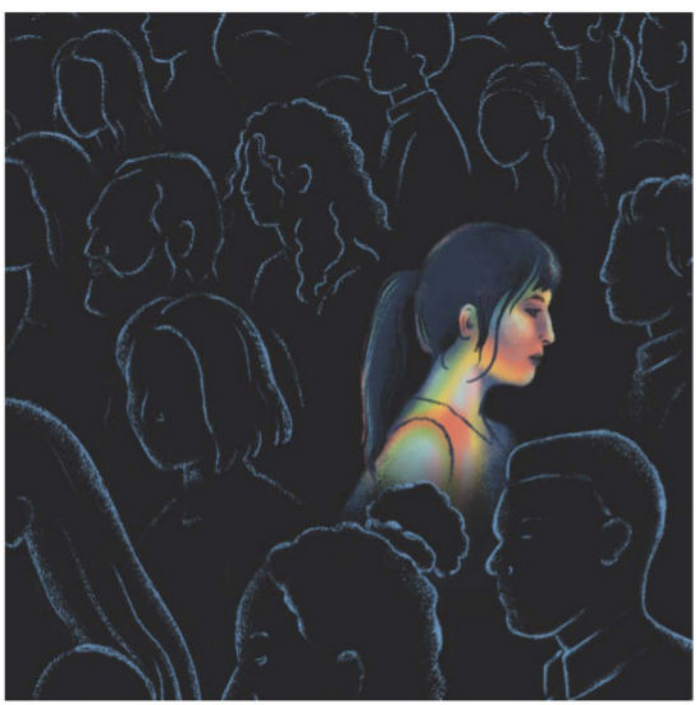
There is a previously unrecognised personality type – the otrovert, says psychiatrist **Rami Kaminski**, and it has a lot to teach us

WHEN I was growing up, it was customary for children to join the scouts once they reached fifth grade, around the age of 9 or 10. My parents bought me the scout uniform with the matching scarf and leather loop to fasten it around the collar, and I still remember feeling special and grown-up as I wore the uniform to the local scouts chapter.

We all formed a circle, sitting cross-legged on the ground as the group leader sat on a small stool and addressed us very seriously. When he finished talking about what it meant to be a junior scout, he told us to stand to attention as he recited the scouting pledge, and we repeated it solemnly after him.

As I said the words out loud, I knew for the first time that I was different. While the other kids seemed awed by this initiation – by the sacred bond forged with their fellow inductees and all those who had come before them – I felt nothing. They were just words.

Most people find it hard to imagine what it is like to not feel any particular affinity or loyalty towards any group. This is so unusual that it is understood by some as a psychological problem to be treated. However, over my 40 years as a clinical psychiatrist I have realised that for many of my patients (and for me) disinterest in group membership and assimilation isn't a psychological problem – it is simply a personality type that hasn't been recognised before.



ELAINE KNOX

Otroverts is the term I use for those who don't feel the obligation to merge their identities with others. We are all born as otroverts, before the cultural conditioning of childhood cements our affiliations with various identities and groups.

Being unable to adopt a group identity can have social consequences in a culture that is designed for joining. However, it can also be quite advantageous. When you don't belong to any group, you aren't subject to the group's implicit rules or swayed by its influence. This confers two beneficial traits: originality and emotional independence.

Being outside the hive, so to speak, allows you to think and create freely: to come up with unique ideas, untainted by groupthink or by what has come before. Able to distinguish between the gravitational pull of the group consensus and your own inner, personal centre of gravity, you are free to think whatever you want and to be flexible when situations change, without fear of subverting collective notions about what makes an idea "good".

Given that you can't be cast out of a group to which you don't belong, you have no fear of such social rejection. You don't seek external validation, nor do you rely on others for emotional support. You don't feel the need to convince anyone of anything, least of all your own worth.

Our communal society often conflates belonging with connection. However, while it is true that people who struggle to connect might find it hard to achieve a sense of belonging, it isn't true that not belonging means no connections at all. In fact, without the noise of popular culture, gossip, family conflicts or political tribes (all disinteresting to otroverts), you are free to focus on deepening bonds with the people you feel genuinely close to.

History is full of independent thinkers who aren't emotionally dependent on any group and can therefore see the fanaticism of a hive mind long before most people do: George Orwell comes to mind.

Sadly, it often seems that people need to emerge from the ashes of self-destructive groupthink before they realise that individual thinkers can be right.

Perhaps we can learn from otroverts that, while there are many reasons to praise community, we should also be acutely aware of its darker side – tribalism. ▮

Rami Kaminski is a psychiatrist and author of *The Gift of Not Belonging*

No planet B

Heart of an oak Groundbreaking new research reveals something that should have been obvious all along: trees have a vast, diverse microbiome in their interiors, says **Graham Lawton**

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

Graham's week

What I'm reading
I'm visiting the Carpathian mountains in Romania next month, so I'm reading up on them.

What I'm watching
Bookish. *I love Mark Gatiss and his new drama is brilliant.*

What I'm working on
I'm tracking my food intake in detail again – and measuring the pH of my urine – for a forthcoming article.

This column appears monthly

A COUPLE of years ago, I spent an enjoyable afternoon in an ancient forest near London learning about old trees and their vital importance to biodiversity. My host, Cardiff University mycologist Lynne Boddy, told me that once a tree has been alive for a few hundred years, the inner part of its trunk starts rotting away as it is slowly eaten by fungi. This "heart rot" is a natural part of a tree's life cycle and provides an irreplaceable habitat for insects, birds and mammals. But heart rot itself is dying out, as there are no longer enough old trees to pick up the mantle when the ancient ones die. Boddy and others are on a mission to rescue heart rot by prematurely ageing young trees.

It didn't occur to me at the time, but heart rot fungi are part of a tree's microbiome, analogous to the rich assemblage of bacteria, archaea, fungi, protists and viruses that live inside our bodily cavities. Indeed, back then, nobody was really thinking in those terms. But thanks to groundbreaking new research in *Nature*, we now know that trees have a microbiome as diverse and fascinating as our own, and one that is probably just as essential to their biology.

We already knew that the surfaces of trees – trunks, roots, leaves and so on – host a diverse microbiome. But what the new research shows is that their interiors do too. Inside the wood of each tree on Earth are vast numbers of microorganisms, many of them new to science.

It is one of those discoveries that is both obvious and profound. Obvious because microbiomes are everywhere in nature, including inside smaller plants, so why not in trees? Profound because it reveals a previously unknown microbial ecosystem sat right under our noses, and also because it recasts trees – arguably the most important living things on Earth – in a new light: not as discrete organisms, but as holobionts.

In other words, like us, they are a collective entity composed of the host and its microorganisms. And if trees' microbiomes are indeed as integral to their biology as is the case with human microbiomes, we may be able to turn that to our advantage in the battle to save biodiversity and fix the climate.

The researchers behind the new work sampled wood from the trunks, branches and roots of 150 living trees representing 16 species in the forests of the north-eastern US. They carried out what they call a microbial census and found that the wood inside a tree hosts huge numbers of microorganisms, comprised not just of heart rot fungi, but also many other microorganisms, including other fungi, bacteria and archaea, some of which live only inside trees. What's more, each tree species harbours a distinct microbiome within its interior.

> **"If trees' microbiomes are integral to their biology, that could help in the battle to save biodiversity"**

Or make that two microbiomes. Tree trunks are composed of two different types of wood, the outer sapwood and inner heartwood. The sapwood is alive and its main function is to conduct water from the roots up to the leaves; the heartwood is dead and mainly provides structural support (this is the part eventually eaten away by heart rot). The researchers found that microbial communities in the two types of wood are starkly different from each other.

Even though they only sampled a small number of species, it is likely that all trees, everywhere, host these microbiomes in their wood. The 16 species in their study represent 11 genera, all with a global distribution.

What are the microbes doing there? As yet, we don't know, but the researchers say they probably play a role in supporting the health of trees and that of the wider forest. They probably also contribute to some of the critical ecosystem services that trees provide, as habitats for other plants and animals, as producers of clean water and as carbon storage. The wood in the world's trees holds roughly 600 gigatonnes of carbon, says the new paper, about 60 years' worth of current global emissions. They could hold more, and to have any chance of limiting global warming to 2°C above pre-industrial levels, we need healthy and expanding forests. A deeper understanding of trees' microbiomes could help deliver that, the researchers say.

This holds true more generally as well. Microorganisms are often-neglected elements of biodiversity, but they are the foundation stone of global ecosystems. They are the principal decomposers of organic matter and keep critical biogeochemical cycles turning, supplying the biosphere with carbon, hydrogen, nitrogen, oxygen, phosphorus and sulphur. They also form symbioses with the vast majority of plant species. Not for nothing have they been called the planet's life support system. Yet there are worrying signs that Earth's microbiome is in decline.

It is too early to say whether that is also true of tree microbiomes. But now we know they have one, we need to make sure they keep it. ▮

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M'HAMMED KILITO

WELLCOME COLLECTION

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Thirsty Earth

Wellcome Collection

A MAN gazes at the water level in a well in Morocco as the dunes of the Sahara desert extend to the horizon in the main image shown here, taken by M'hammed Kilito.

The stark shot is part of the photographer's ongoing project entitled Before It's Gone, which documents the degradation of Morocco's oases. These have declined by two-thirds in the past century due to human activities and climate change.

Despite this, Kilito sees these places as a model of sustainability, with date palms that create a humid microclimate and retain water in the soil, helping to prevent desertification. He aims to tell the stories of the scientists, farmers and locals fighting to preserve oases as Morocco experiences a drought that started in 2018.

His work is included in a major new exhibition at the Wellcome Collection in London – Thirst: In Search of Freshwater. This documents how essential water is to humanity's survival. Moving from ancient Mesopotamia – a Sumerian poem about a war over water written in cuneiform on a tablet sits near Kilito's photos – to the modern day, it features more than 125 objects, a mix of artworks, historical artefacts, new research and meteorological records.

Among them is a painting from the 1700s, *The Life-Giving Spring* (immediate left, top), showing a spring in Istanbul, Turkey, reputed to have healing powers. Below it is a map from the display with tiny dots near its centre, just above two bends in the river, showing cholera deaths in and around London's East End amid the city's final outbreak of the disease in 1866 – largely due to contaminated water.

The exhibition is on now and runs until 1 February 2026.

Alison Flood

The nature revolution

How do we fight to restore the attention that is sucked out of us by modern life? **Kate Douglas** discovers plans for a "nature revolution"

LUKE HAYES/MILLENNIUM IMAGES, UK

Time spent in green spaces boosts working memory and attention

Book

Nature and the Mind

Marc Berman

Vermilion, UK; S&S/Simon Element, US

MARC BERMAN is out to start a revolution. I am already a convert to his cause – and you may be too, having read in *New Scientist* about the extraordinary benefits of a nature walk, the healing power of plants and the magic of urban green spaces.

If so, perhaps you will think there is nothing to be gained from a book about Berman's research. You would be wrong. *Nature and the Mind* is for everyone from the adept to the uninitiated – it isn't simply written to educate and entertain, it is a call to action.

This is the story of how an anxious boy, warned off studying medicine by his mother, a nurse, and law by his father, a lawyer, enrolled as an undergraduate in engineering and then went on to establish the revolutionary field of environmental neuroscience.

At its heart is a chance encounter with psychologists Steve and Rachel Kaplan at the University of Michigan and their big idea – attention restoration theory, or ART. This posits that interactions with nature improve our attention in ways that allow us to function better, and the Kaplans already had plenty of evidence to back this up by the time Berman met them as a graduate student.

His audacious plan, however, was to measure these effects: to use brain imaging, behavioural experimentation, computational neuroscience and statistical models to quantify the person, the environment and their interactions.

In his book, Berman recounts the reaction when he proposed his first experiment, which would entail giving people tasks to assess their attention level before and after taking a stroll in nature. "That's crazy. That's not gonna work," said his supervisor, cognitive neuroscientist John Jonides, also at the University of Michigan.

Nevertheless, Berman ploughed on. And what he discovered was astonishing. A mere 50-minute walk in the park boosted people's working memory and attention by 20 per cent, and the effect was the same whatever the weather, whether they enjoyed the experience or not – they didn't even need to walk, simply being in nature was enough.

"The author advocates for a revolution to 'naturize' our homes, schools, offices and cities"

That is an impressive improvement, but why would we want to restore our attention? Well, as Berman points out, attention is the common resource for most cognitive and emotional functions, yet we live in an attention-grabbing world that depletes it. So, by replenishing this precious commodity, nature is like a superpower, able to make you smarter, happier, less stressed, more productive and caring.

Some of Berman's findings are mind-blowing. For instance, clinically depressed people got five times the benefit from a walk in the park than the volunteers in his original study. And having just 10 extra trees on an average-sized block in Toronto increased people's feelings of health by 1 per cent, the same effect as if everyone were seven years younger or they were given $10,000 each.

Other studies are wonderfully creative. In one of them, his team used the JPEG standard for digital image compression to explore how the human brain processes information in natural landscapes compared with urban ones. This led to the discovery that when urban and natural images appeared to have similar levels of complexity, the latter were less taxing on the brain. The team has also developed an app that gives "restoration scores" for routes in your neighbourhood.

Berman's research answers big questions. How does nature restore attention? What aspects of a scene are restorative? How can architecture tap into these effects? It also addresses little questions, including the hidden appeal of fonts like Garamond (it is down to the curves in serif typefaces) and why Jackson Pollock's paintings are so captivating (it is the fractals).

But, above all, he wants his work to do good – and here is that call to action. He advocates for a "nature revolution" using the lessons from environmental neuroscience to "naturize" homes, schools, offices and cities.

"We have to... fundamentally change how we design all built spaces," he writes. "The nature revolution requires that people take this work seriously on a massive scale."

Micro to macro

From DNA sequencing to rainbows, the world of microfluidics is well-served by a new book, says **Karmela Padavic-Callaghan**

Book

How the World Flows

Albert Folch

Oxford University Press, on sale now

WHAT do rainbows, inkjet printers, human skin, pregnancy tests and fish gills have in common?

To answer this question, we must travel to what Albert Folch, a bioengineering professor at the University of Washington, calls the "Lilliputian world of fluids". Here we encounter the science of microfluidics, which deals with liquids at the smallest of scales, from tiny veins in the human body to microchannels etched onto chips in the lab.

Folch's new book *How the World Flows: Microfluidics from raindrops to covid tests*, is a dazzling exploration of the myriad ways that microfluidics underpins our world. This book owes a debt, which Folch acknowleges, to his neurobiologist wife. She encouraged him to write not just about microfluidic chips, which have, as he shows, proved invaluable for research in chemistry, biology and medicine, but also the microfluidic "devices" created by nature.

This means his book paints a larger picture, addressing examples as current and technological as handheld devices for sequencing DNA, and as ancient as how the world's biggest trees get nutrients all the way up to their leaves. In passing, Folch also explains phenomena such as the capillarity of paper, which allows us to write on it, and why candles have wicks – not to mention how car engines work, which gives the book an almost encyclopaedic character.

At the same time, each of the 18 chapters, all fairly succinct and accompanied by a summary, opens with a personal story of a figure from history: an inventor, an athlete and a chef, for example, which makes them approachable.

The physics in *How the World Flows* are the bread and butter of what you may encounter in a college class on fluids – viscosity, surface tension, gravity and so on – but rather than being couched in notoriously difficult equations, they are explained simply and consistently given a real-world context.

At times, I found myself wishing for more nitty-gritty details of the devices and processes that Folch focuses on. Meanwhile, the space given to more recent inventions, such as chip-sized devices that emulate whole organs, sometimes seemed slightly small compared with the plethora of historical information.

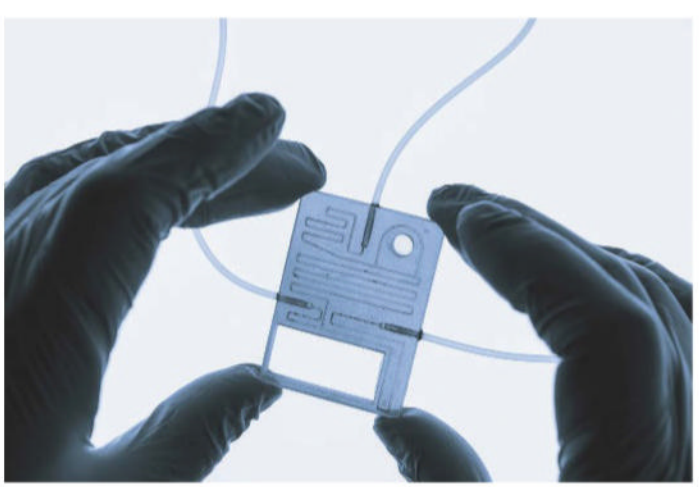
Yet, as I read on, I felt that I was learning a tremendous number of facts, many about everyday life, that I had simply not thought about deeply. Microfluidics, it turns out, is key to understanding how sweating helped us become bipedal, why lakes don't just drain into the earth beneath them, and how every vertebrate can hear the calls of their kin. There was even a section on the incredibly intricate engineering of a mosquito's mouth parts!

Folch writes with an undeniable enthusiasm and warmth, but occasionally falls into tropes of popular science writing that don't always serve the book's overall tone well. For instance, much of the work by the scientists featured in his book is introduced alongside stories of their childhood, a stylistic device that can veer from relatable to hagiographic.

And I did wince whenever the book emphasised how remarkable it is that anyone without a rigorous education could have advanced microfluidics – what was intended as a compliment also conveyed a sense of elitism.

That aside, it is a strength of *How the World Flows* that it includes a truly diverse cast of characters, again underscoring the point that microfluidics really is an essential part of our world's construction.

Above all, this feels like a book that could convince you to become an engineer if you read it at a young enough age. It could also remind you at any age of the sheer intricacy and wonder of any object when you put it under a microscope. It overflows with curiosity. ▮



Microfluidics makes it possible for devices like this chip to simulate biological organs

WLADIMIR BULGAR/SCIENCE PHOTO LIBRARY

New Scientist *recommends*

Alison Flood
Culture editor
London

I recently rewatched **28 Days Later** before going to see its sequel, *28 Years Later*, because I wondered if Danny Boyle's 2002 zombie apocalypse would live up to my fond memories.

It really did, from that stunning opener, in which Cillian Murphy stumbles through an

eerily empty London in a hospital gown, to the horror of Christopher Eccleston turning into a baddie in an eyebrow-raising few weeks.

I've also just reread John Wyndham's **The Day of the Triffids**, above, which kicks off similarly: a man escapes disaster through hospitalisation, and wakes to devastation. Googling, I discovered that, according to *The Guardian*, the writer of *28 Days Later* was partly inspired by Wyndham. So, was the very similar opening of *The Walking Dead* also inspired by either of the above? Not according to various comics industry reports...

I'm way behind the times in any event – and the bottom line is that a classic zombie film and a classic sci-fi novel are still very, very good – and start the same way.

Rays of hope?

For environmentalist Bill McKibben, the rapid adoption of solar power could quell our worst climate fears. Is he right, asks **James Dinneen**

Book

Here Comes the Sun
Bill McKibben
W. W. Norton (UK, 16 September; US, 19 August)

STR/AFP VIA GETTY IMAGES

A solar future for this Sichuan pepper field in Bijie, China

THE sun is rising on solar power. According to Ember, an energy think tank, solar energy has been the world's fastest growing source of electricity for the past 20 years, and it is accelerating.

In 2022, solar power capacity surpassed 1 terawatt for the first time. Just two years later, it had doubled, generating 7 per cent of the world's electricity. When you include wind turbines (which capture the sun's energy via a different mechanism), the sun generated 15 per cent of Earth's electricity last year.

This solar energy boom isn't due to countries suddenly getting serious about their climate commitments. In fact, according to another Ember report, most renewable energy targets still lag far behind the tripling that is needed this decade to stay on track for net-zero emissions.

The real reason solar power is taking off is because it has become the cheapest way of generating electricity almost everywhere.

In *Here Comes the Sun: A last chance for the climate and a fresh chance for civilization,* long-time climate activist and environmentalist Bill McKibben makes the case that this shift leaves the world "on the edge of one of those rare and enormous transformations in human history" where we transition from one dominant energy source, fossil fuels, to another, the sun. "We are on the verge of turning to the heavens for energy instead of to hell," writes McKibben.

What follows is a stirring and closely argued account of how cheap solar energy now offers us a chance of not only tackling climate change on time, but of remaking our economies and our relationship to the natural world.

This is hardly the first book to argue for a rapid transition to renewable energy. But it is

"An energy transition led by solar power might be inevitable, but it may not happen fast enough"

visionary in the way it goes beyond the technical and economic dimensions of the energy transition to explore what a sun-powered society might really look like.

"All of a sudden this entirely necessary conversion is also the greatest bargain of all time, one that could upend our conventional economics of scarcity and replace it with something we don't yet fully understand," he writes.

That this sunny optimism comes from McKibben, whose first book was entitled *The End of Nature* and who was among the first to raise the alarm about climate change, makes it much more powerful.

Instead of detailing the damage caused by climate change and how it could all get worse, he emphasises the benefits that could come from more solar power, such as lower and more stable energy prices and less dependence on petrostates.

On a spiritual level, he hints at how this shift could restore our sense of awe for the sun and its power.

McKibben is also alive to sceptics of renewable energy and offers balanced answers on how to address trade-offs of the energy transition, such as rising demand for minerals and land, and lost jobs in the fossil fuel industry. These are supported not only by numbers, but an eclectic suite of anecdotes from the early days of the energy transition around the world. I was delighted to learn, for instance, that the Kentucky Coal Mining Museum has switched to solar power to save energy costs.

However, there are plenty of reasons to doubt that all of these sun-powered dreams will come to pass as quickly as McKibben suggests they could. Remember, most of the extraordinary expansion of solar energy is happening in China. There is no guarantee that countries lacking China's unique combination of manufacturing prowess, central planning and authoritarian politics can match that blistering pace. It might not even be sustainable there.

In the US, solar power has seen record growth for several years, but now it faces the Trump administration's hostility to renewable energy. After losing the tax credits that evened out the playing field with subsidised fossil fuels, there is certainly more headwind. Local opposition to renewables projects also makes future expansion challenging.

As McKibben accepts, two things can be true at the same time: an energy transition led by solar power might be inevitable, and the reduction in emissions might not happen fast enough to avoid the ever more dangerous consequences of global warming. "It's not going to be easy, but it's what must happen," he writes. "We have to bring burning to a halt – or we will burn."

I agree. Personally, I'd rather bask in the sun.

Editor's pick

Here's the climate target the world really needs

26 July, p 8

From David Flint, London, UK

We all know the aim to "pursue efforts" to keep global warming to 1.5°C is a lost cause. Your article asks whether the new target should be 1.7°C, 2°C or even stay at 1.5°C, but with a new meaning. None is the right target. It should be 1°C.

To set a higher target is to accept that the current state of the world's climate and the changes now baked in are tolerable. They aren't. A 1°C target, however, would restore a lot of the damage already done and make extreme weather less likely.

That should be our long-term target. But we also need to limit the temperature rise as we exceed 1.5°C and fall back to 1°C. That limit, surely less than 2°C, needs to be set to minimise the risk of passing a tipping point, and we must be willing to use extraordinary methods, such as geoengineering, to keep below it.

From Larry Stoter, The Narth, Monmouthshire, UK

The majority of climatologists have, since at least the 1992 Rio Earth Summit, been well aware of climate change – that it is real, happening now and mainly a consequence of human activity. Nations, political leaders, businesses and many individuals have widely ignored the warnings. Why does anybody think this will change? It won't, or at least not until devastating impacts hit large areas of the planet, which isn't going to happen for some years yet. Realistically, 1.5°C of warming isn't going to be averted – nor is 1.7°C, nor 2°C. We will be lucky to limit global warming to 2.5°C.

From Geoff Harding, Sydney, Australia

For governments to officially accept that 1.5°C is no longer achievable and that a higher limit must be set would almost certainly have negative consequences. Any excuse to relax decarbonisation efforts or to continue business as usual will result in greater climate catastrophes and is unacceptable.

Some music really hits the wrong note

26 July, p 21

From Richard Mellish, London, UK

Stefan Koelsch highlights benefits that music can deliver, but we shouldn't ignore its downsides. We don't all have the same tastes. A genre that one person enjoys will infuriate another. Consider, for example, the thumping bass coming from a car in a traffic queue. Loud canned music has driven me out of shops. Some film soundtracks mask dialogue.

From Maureen Clason, Stratford-upon-Avon, Warwickshire, UK

Music in general is soothing and puts me into a better state of mind. However, two types drive me nuts: the Muzak in shops, or the radio stations they play, which are usually so loud that it is impossible to think about what you are there for; and the music played over the phone while on hold. The sooner they get rid of these the better!

No need for a bounce to get another big bang?

26 July, p 10

From Ian Napier, Adelaide, Australia

The big bounce theory has never held any attraction for me. Our universe is expanding as a result of the big bang, and as the fragments of it get further dispersed, the gravitational force acting on them falls. Rather more attractive is a belief that these fragments will all find their way into an infinite space populated by fragments of an infinite number of other universes. Given time, these fragments from many different universes will accumulate to such a degree that they become part of another big bang.

Neanderthal funerals indicate complex brain

26 July, p 38

From Sam Edge, Ringwood, Hampshire, UK

I was fascinated by the possible funerary practices in hominins previously not considered sophisticated enough for such behaviours. The question as to whether Neanderthals developed their practices or learned them from us is interesting and probably impossible to answer. Either way, it doesn't detract from the fact that they would need sophisticated cognitive abilities just to choose to engage in such seemingly unproductive rituals.

From Andrew Whiteley, Consett, County Durham, UK

This piece leaves me wondering what the motivations may be behind ancient funerary practices. They may well reflect belief in, and ritual worship of, some sort of god or gods, and a belief in, or at any rate a desire for, life beyond death.

The barefoot answer to navigating tick country

21 June, p 36

From John Ford, Amersham, Buckinghamshire, UK

I have walked in tick-infested areas for years. My solution may sound counterintuitive, but it seems to work. I wear a short-sleeved shirt and shorts and go barefoot when possible. With no creases and folds to hide in, I can spot ticks immediately and remove them before they become attached.

We may have free will, but we have ceded power

Letters, 12 July

From Peter Cundall, Minneapolis, Minnesota, US

Howie Firth, proposing we have free will, asks why "we" fail to better sustain the life of our planet. Even if most people desire a better future, the fate of the planet is controlled by politicians and corporations over which we have almost no control. They have a vested interest in maximising control and profit. We, the people, don't have the power that Firth mentions.

And now for one-sided isometrics in bed

Letters, 6 July

From Mary Rose, Hindmarsh Island, South Australia

Further to Clive Bashford's letter about doing isometric exercises in bed – I do that, too, but concentrate on my left side as, during the day, I do a fair amount of physical work using my right side.

The magic of a really reliable pressure cooker

26 July, p 28

From Steve Tunnicliff, Long Clawson, Leicestershire, UK

On your contents page, you promoted a book-related article with the phrase "*The Prestige* is still magic". My mind's eye conjured the image of the Prestige pressure cooker I bought back in 1970. It is kind of old tech, but it still works; it must be magic.

For the record

Libor Šmejkal is now at the Max Planck Institute for the Physics of Complex Systems in Dresden, Germany. Anna Hellenes and Atasi Chakraborty are in Jairo Sinova's group at Johannes Gutenberg University Mainz, Germany (19 July, p 36). A corrected graphic is also online at shorturl.at/CrH3N.

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STEPHAN SCHMITZ

The ageing revolution

A new lens on what it means to age well is reshaping our view of our golden years, finds **Graham Lawton**

On 16 October 2029, I will – hopefully – become a member of the world's fastest-growing demographic. By then, 1.4 billion people, a sixth of the world's population, will be aged 60 or over. Assuming I make it, I can then expect to live for another 24 years.

I am the beneficiary of a global trend that started more than a century ago. A baby boy born in England in 1900 could expect to live to 44. By the time I was born, in 1969, that had risen to nearly 69. A baby boy born in England today can expect to live to 87, and a baby girl can expect to reach 90. Other places around the world, including lower-income countries, have also seen rises in average life expectancy, buoyed by improved sanitation, nutrition and access to healthcare and education.

For the first time in history, every person born today has a reasonable chance of celebrating their 60th birthday. But before we break out the cake and candles, we need to consider whether we will be able to blow them out.

For now, I'm in reasonably good health – but the longer my fellow soon-to-be sexagenarians and I live, the more likely we are to develop one or more age-related conditions. So are increases in life expectancy matched by increases in health expectancy? Or have we created a "nursing home world"?

These are surprisingly difficult questions to answer. But now, thanks to a new understanding of what health in later life looks like, we might finally have some answers. And not only is it positive news – mostly – we might also have a good idea of how we can stay healthier longer.

Gerontologists – researchers who study ageing – have long recognised that increasing average lifespan doesn't automatically increase the number of healthy years of life. All those hard-won gains in life expectancy might merely extend the period of ill health, at great expense to individuals and healthcare systems.

"We all know that populations around the world are ageing rapidly," says John Beard, professor of ageing at Columbia University in New York. "But what we're not so clear on is, are those extra years being experienced in good health, better than previous generations, the same, or worse?" To answer that question, around 30 years ago, scientists working on ageing started using a concept called healthspan, which is defined as the number of years that a person lives in good health free from chronic illness or disabilities of ageing.

Assessing whether the beneficiaries of the longevity boom also enjoy an increased healthspan can yield depressing results. Last year, for example, Andre Terzic and Armin Garmany at the Mayo Clinic in Rochester, Minnesota, published an analysis of 20 years of data from 183 countries in the World Health Organization's Global Health Observatory. Using a measure of healthspan called health-adjusted life expectancy, they calculated the average discrepancy between lifespan and healthspan, what they called the "healthspan-lifespan gap". They found that while average lifespans rose by 6.5 years between 2000 and 2019, from 66 to 72.5, healthspans didn't keep pace, rising by only 5.4 years to 63.3. In other words, the healthspan-lifespan gap grew from 8.5 years to 9.6 years.

The largest gaps were in higher-income countries: 12.4 years in the US, 12.1 in Australia, 11.8 in New Zealand and 11.3 in the UK. Across the board, women lived longer than men, but also had a larger gap by more than two years. "These results underscore that around the world, while people live longer, they live a greater number of years burdened by disease," the authors concluded.

That might sound like the issue is settled, but according to Beard and others, the focus on healthspan distorts the true picture. As a concept, healthspan suffers from a lack of clarity – for one thing, it seems to assume that only diseases of age diminish healthspan, without considering childhood or lifelong conditions. For another, it's too binary: "With healthspan, you're either healthy or you're not healthy," he says. "But health is not like life and death: life and death is black and white; health is a continuum."

Studies like these, he says, tend to assume that healthspan ends abruptly with the diagnosis of a major age-related condition. But that fails to capture what impact the condition is having on quality of life. "The problem is, a diagnosis doesn't really tell you much about people's experience," says Beard. "Three ›

people can have the same condition and each have a very different experience."

There are also medical interventions that can dramatically reduce the health effects of an age-related condition without curing it. "The one I often use is arthritis of the hip," says Beard. "If people have a hip replacement, they've still got arthritis of the hip, but they can get around and do what they want to do."

Other studies have looked at health experience from a different angle: functionality. In other words, regardless of the presence or absence of disease, can people still get on with their daily lives?

"When we get older, sure, there are bad things that happen to our bodies," says S. Jay Olshansky, a researcher on ageing at the University of Illinois Chicago. "But many folks that make it to older ages have found ways to adapt to these changes."

70 is the new 50

That is a better way of assessing health, but studies that use functionality as a metric have a weakness, says Beard. "Most of those studies have only looked at very severe losses of functioning, using tests that were designed to decide whether people needed care," he says, meaning they tend to underestimate the loss of functionality from less severe illness and disability.

What has also been missing is a concerted effort to measure day-to-day functioning in all older adults and how it compares with that of previous generations, says Beard. "So that's what we tried to do."

Over the past few years, he and his colleagues have pioneered a new approach to the problem using a concept called "intrinsic capacity". The idea first surfaced in 2015 in the WHO's World Report on Ageing and Health, and it is fundamentally different from what has gone before. Based not on the presence or absence of disease or disability, it instead assesses a person's ability to do things and live life in a way they personally value. So, for example, somebody with minor hearing loss may not be diagnosed with an age-related disease but may be less able to interact socially than they would like. Their intrinsic capacity, therefore, would be lowered. Alternatively, someone diagnosed with a disease of old age, such as osteoarthritis – and so technically at the end of their healthspan – may be perfectly able to live a fulfilling life.

When it was first developed, the concept was only nebulously defined, but Beard and others have since put it on a firm scientific footing. It can now be measured objectively as a composite of people's functional level in five domains: locomotion, cognition, vision and hearing, psychological health and general vitality. "These come from objective measures, clinical tests of each of these domains," says Beard.

Clinicians and researchers using this model assign scores to the individual domains, weigh them appropriately and, from there, determine an overall numerical score. That makes intrinsic capacity a useful tool for measuring how well individual people are ageing: it has been validated as a predictor of mortality from respiratory disease, for example.

Perhaps more importantly, it also tells us how well we are ageing collectively, finally providing an answer to the big question: are increases in lifespan also delivering increases in how long we stay healthy?

To find out, Beard and his colleagues reanalysed figures from two existing datasets. One was the English Longitudinal Study of Ageing, which followed four cohorts of adults who were born in 1920, 1930, 1940 and 1950 and recorded information that could be converted into scores of intrinsic capacity. The other was the China Health and Retirement Longitudinal Study, a similar project following three

"Health isn't like life and death; it's a continuum"

KAREN HAIBARA/AFP VIA GETTY IMAGES

Building and maintaining muscle mass can help you stay healthy longer

REUTERS/GIL MONTANO

The number of years spent feeling sharp is increasing

cohorts born in 1930, 1940 and 1950.

The aim of the analysis was to find out whether people in later cohorts entered older ages with higher intrinsic capacity and retained it for longer, on average. What they found blew their minds. "I was expecting there wouldn't be much change, if anything," says Beard. "But I have to say I was surprised. We found very stark improvements for almost all dimensions."

In the English cohorts, they found that somebody born in 1950 had higher intrinsic capacity at 68, on average, than a 62-year-old who was born in 1940, for example. The data from China told a similar story. And that is only comparing people born 10 years apart. If you compare the English 1950 cohort to the 1920 one, the differences are even starker. "It's more like 70 is the new 50-something," says Beard. "I can tell you that with absolute certainty."

The data also showed some evidence of a phenomenon called compression of morbidity, which refers to the conditions of old age being squeezed into the final year or two of life, rather than piling up slowly over a decade or more. "Clearly, we don't want people living for a long period of their life in poor health where they can't do what they need to do. But if you enter older age with a higher peak, there's further to fall, and you can maintain a good level of functioning for a longer period of time," he says.

The reasons for this gain aren't hard to fathom – they are essentially the same as the reasons for increases in lifespan. These include higher-quality nutrition, especially in early life, as well as sanitation, better education, expanded access to medical care and lifestyle factors such as declining rates of smoking. The result is that the peak in a person's intrinsic capacity, which for all cohorts occurred at around age 30, is higher for later generations than earlier ones. After that, it is mostly downhill, although cognitive capacity can continue to increase, and other domains can be improved with the right interventions. The most important takeaway, however, is that the higher the peak – the more intrinsic capacity at around age 30 – the longer it takes to descend.

Good news? Not so fast. The results only apply to the cohorts in the studies and can't be generalised, although Beard says he expects to find similar improvements in datasets from other places. There are around 25 such studies from all over the world waiting to be analysed, he says.

It is also possible that the lower healthspan in older cohorts reflects early-life exposure to major upheavals, says Beard, such as the great depression, the second world war or the Chinese civil war, which ended in 1949. "It may be that the people born in 1950 had better nutrition, better learning environments, better everything," he says.

Living longer, better

Crucially, the results also don't tell us what has happened to cohorts born after 1950. It is probable that the gains have slowed, stopped or even reversed as improvements in conditions such as access to education and healthcare have plateaued or dropped off, says Beard. "The explanations lie in the broader environment, and that's important because, why would it continue to improve?" he says. "There may be a ceiling that we have probably attained. I look at my kids and I don't think their nutrition is any better than mine was."

There are also factors such as increased obesity, sedentarism and pollution that may be pushing the intrinsic capacity gains back – trends in life expectancy certainly appear to be going that way. It is possible that people born in the 1950s in higher-income countries may be a golden generation who will live the longest, healthiest lives in human history. Only time will tell: people born in 1960 are now knocking on the door of old age, so trends in that cohort will start to appear soon.

While we wait for more data on the fate of our collective intrinsic capacity, there are ways to boost your individual score. You can start by estimating it using the WHO's downloadable Integrated Care for Older People (ICOPE) screening tool. It includes a basic checklist for assessing intrinsic capacity, including a series of questions and tests on the five domains. To a medical professional, failure on any of these would lead to further in-depth assessment, but this tool gives anyone a rough indication of their intrinsic capacity, says Beard.

After you have your assessment results, you can get to work improving your score. Even though many determinants of intrinsic capacity are laid down in early life, "it's never too late", says Beard. "There are no surprises – eat a healthy diet, maintain a healthy weight, don't smoke, address stress. The field where there's probably the most evidence is physical activity, both aerobic to maintain your fitness but also building and maintaining muscle mass, particularly as you get older." Physical strength and fitness not only help maintain balance, which protects against falls, but also seem to reduce inflammation and the risk of chronic disease. (I know what I want for my 60th birthday: a set of dumbbells.)

Whether the trend continues or not, the recognition that our later years are becoming healthier is great news, and not only for me and the 1.4 billion people turning 60 with me. "That is a really excellent message to support combating ageism," says Yuka Sumi, who runs the WHO's ICOPE programme in Geneva, Switzerland. "Many in society think older people are care-dependent and frail and a burden. And not only the society, older people themselves. But actually our older population is getting healthier and healthier. The older person is a social asset and they contribute to society."

Understanding our later years in terms of intrinsic capacity can and is changing how we approach ageing. "In my view, the concept of intrinsic capacity is revolutionary in our understanding of ageing," says Olshansky.

"We now have the privilege of living into our 70s, 80s, 90s and beyond in ways that previous generations never had an opportunity to experience," he says. "When we get older, sure, there are bad things that happen to our bodies. But we've found ways to push them aside so that they're no longer relevant." ▮

Graham Lawton is a staff writer at *New Scientist*

JIAWEN CHEN

4.5 billion years ago

3.9 billion years ago

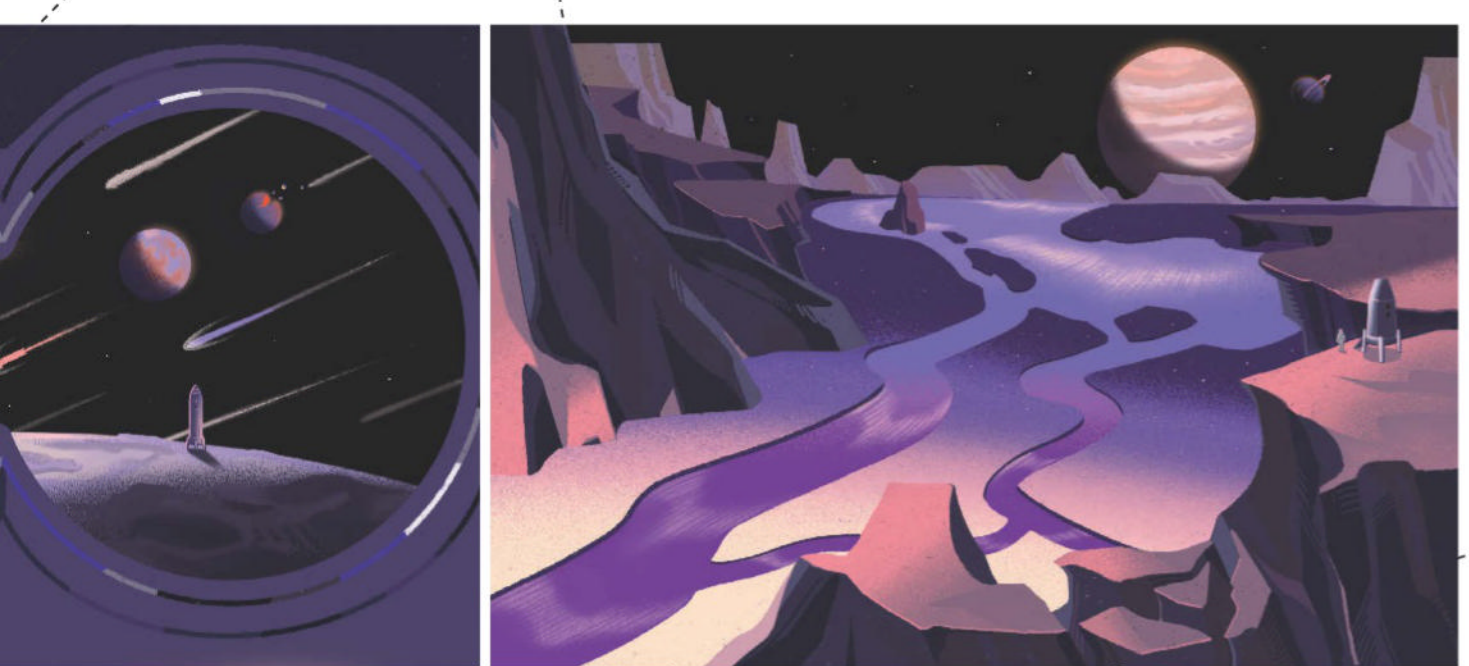
A time traveller's guide to the solar system

Don your spacesuit as **Leah Crane** takes you on a tour of the six most mysterious moments in the life of our solar system

THE workings of our solar system are roughly the same now as they have been for millions of years. Moons circle their planets, the planets circle the sun, the sun's magnetic fields and sunspots wax and wane. On the scale of a human life, nothing much seems to happen. But on a cosmic timescale, our humble solar system is a wildly exciting place: an action movie played in extreme slow motion.

Its story has emerged from our measurements of nearby worlds and our observations of other stars and planets from afar, all painstakingly combined into complex mathematical models. We know a lot, but even our best efforts to explore our neighbourhood will always be confined to the brief cosmic moment we inhabit, so a multitude of mysteries remain: where did we come from, how did our solar system end up the way it is and what kind of end are we headed for?

Explaining these might require an audacious adventure. What if you could hop in a time machine and journey through the aeons? An intrepid time traveller could resolve many of the biggest puzzles in the solar system. Once you have got hold of such a miraculous machine (let's skip the nitty-gritty of how you did so), here is our suggested itinerary for the six most enlightening stop-offs.



3.5 billion years ago

WHEN: 4.5 billion years ago
WHERE: The sun's birthplace

TO SOLVE any puzzle, it is best to start at the beginning. For our solar system, that is a stellar nursery: a cloud of gas just starting to clump up into what will eventually become our sun and its celestial siblings. Many researchers think that about 4.5 billion years ago, a relatively nearby star exploded in a dramatic supernova, blasting out radioactive elements and sending a shock wave through the stellar nursery.

From your front-row seat, the wave would jolt your time machine. Peering from a hatch, you would both feel and see a powerful pressure wave go by, as if you were navigating rough seas in a tiny boat. When it encounters the gas and debris all around you, the wave would accelerate the clumping, forcing all that matter to collapse in on itself and ignite. Suddenly, a star is born: our young sun, surrounded by a disc of gas and dust that will eventually collapse in a similar way to form the planets. Everywhere you look, stars would similarly be popping into existence. "Once the surrounding gas and dust dissipates, you would see all of these small stars forming and then a few big ones," says Conel Alexander, a cosmochemist at Carnegie Science in Washington DC.

We have a sense of what planetary formation might look like from watching it happen in other, distant stellar systems. "The classic picture is that you somehow start clumping the tiny dust grains into bigger things and they start to aggregate into even bigger things," says Alexander.

But this model has always had issues: the process basically works for smaller, terrestrial planets, such as Venus and Earth, but it doesn't happen fast enough to build giant worlds. If you quickly jump a few million years forward in your time machine, the protoplanetary disc around our star will have dissipated, and the cores of the gas giants will be big enough to hold on to some of that material in their massive atmospheres. But how did they get big enough? Researchers have a few ideas of how this could work, but only you would know for sure, having witnessed it.

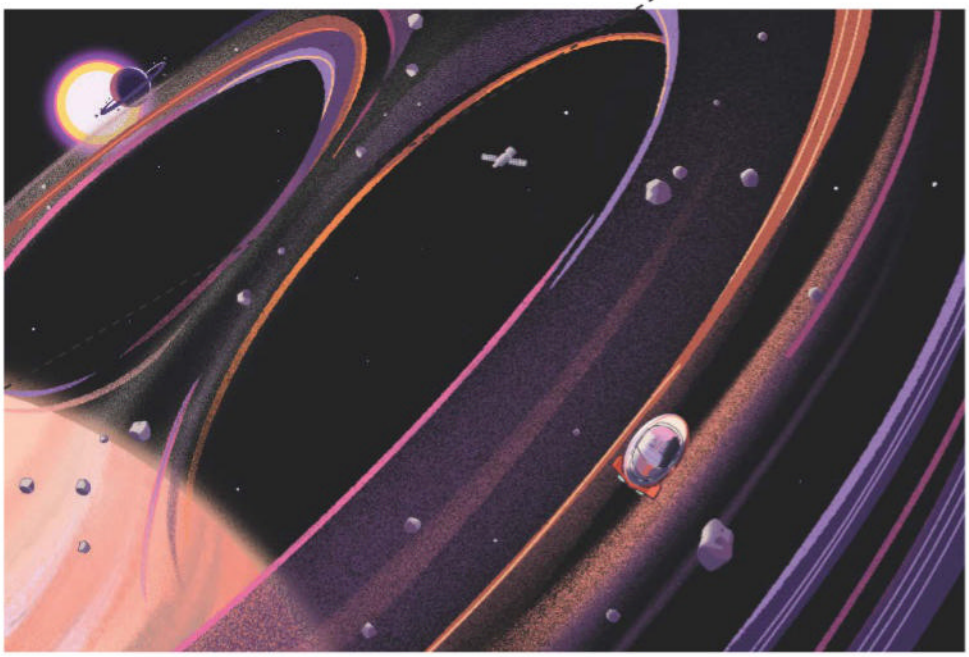
You could also put to rest several other vexing scientific questions – for example, how many planets did our solar system have when it formed? Several studies have suggested it may have had at least one more giant planet than it does now. The most common type of planet in other systems is bigger than Earth but smaller than Neptune, and it is strange that our solar system doesn't have one. There have been hints that at least one of these medium-sized worlds may have formed in the beginning, only to be thrown towards deep space as the early planets gravitationally shoved one another around.

Questions also remain about how much the known planets' orbits have moved since their formation. The best way to find out would be to watch them emerge from the newborn sun's disc of dust, so over to you.

WHEN: 3.9 billion years ago
WHERE: Our moon

PARK yourself on the moon and settle in for a chance of a cataclysmic show. It has long been thought that drastic orbital rearrangements of the giant planets in the early solar system caused chaos in the asteroid belt, which now sits between Mars and Jupiter, sending a barrage of rocks throughout the solar system that pummelled our moon and other objects. This period, between 4 billion and 3.8 billion years ago, is dubbed the Late Heavy Bombardment (LHB), and it has been basically accepted as truth for decades.

But recent evidence has raised doubts about whether the LHB was as violent as we thought. "It has become a lot more controversial. I think a lot of people don't think it actually happened," says Alexander. Most concrete evidence for it comes from lunar ›



100 million years from now

samples brought back by the Apollo astronauts. All these rocks seem to have formed half a billion years after the moon did, indicating that a humongous number of asteroids were hitting the moon, causing its rocky surface to melt and reform.

In the past few years, models have shown that such a devastating event may not be necessary to explain this clustering – perhaps it is simply a coincidence of the make-up of the moonscape where the rocks were gathered. There are still arguments on both sides of the debate. You and your time machine get to put the nail in that coffin once and for all.

If this assault on the solar system actually happened, it would have transformed nearly all the planets. For example, Uranus is tilted almost completely on its side, with its axis of rotation being nearly parallel to the plane of the solar system, not roughly perpendicular, as with the other planets. Based on the physics of protoplanetary discs, it couldn't have been born that way, but tipping over an entire planet is quite a feat. The most popular explanation is that a giant impact knocked it over, and the timing might match that of the LHB.

Watching from the moon, you would need a rather large telescope to see Uranus getting tilted, but the action closer to home could be even more exciting. "If there were these really big impacts, you would see the entire surface of the Earth vaporising... you'd have these incredible shock waves travelling through the atmosphere, and all this molten rock jetting out into space and then falling down onto Earth. Parts of the planet's surface would be hot enough that it might start to glow," says Alexander. "It would really be quite a show."

Your perch on the moon would also help us answer one of the biggest scientific questions about Earth: when and how our planet got the water that enables life to thrive here and makes our little blue world so special. One of the more popular hypotheses is that it may have been brought here by asteroids – perhaps the ones that would have been constantly falling from the sky during the LHB.

In fact, the oldest evidence for life on Earth comes from right after the end of the LHB. "Life could really take off once it wasn't getting periodically sterilised," says Alexander. The enterprising time traveller might even get to watch the first microbes emerge, which would clear up perhaps the most important scientific puzzle of all: the origin of life.

WHEN: 3.5 billion years ago
WHERE: The Red Planet

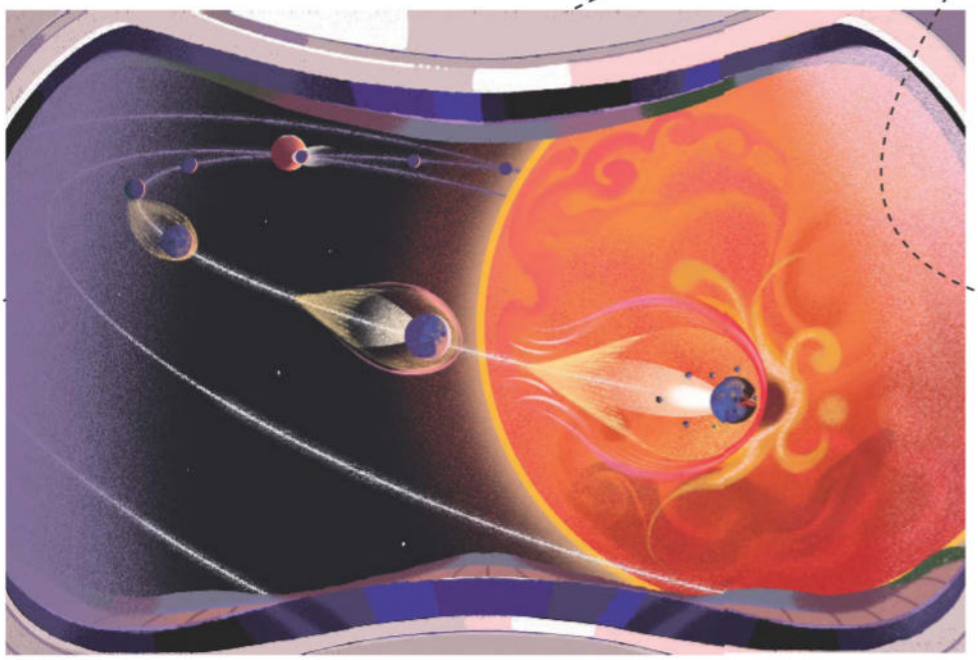
IF YOU want to truly understand the origins of life in our solar system, there is one other place you definitely have to check out. It is just a hop, skip and a jump in your time machine from the end of the LHB to the Late Noachian Period on Mars, a time when it is entirely possible that the Red Planet hosted living organisms.

Measurements from several Mars rovers show that the planet had rivers, lakes and seas on its surface during that time. That means it must have had a relatively thick atmosphere, which would have made Mars warmer than it is now and given it a surface pressure similar to Earth's. "You'd need a breathing apparatus, but you might well be able to otherwise walk around unaided, very unlike the present conditions," says Robin Wordsworth, who leads the Planetary Climate and Habitability research group at Harvard University.

Beyond that, though, the details are hotly debated. We don't know how long water lasted on the surface, or if it was there continuously or only intermittently. Visions of early Mars have tended to depict a warm, wet surface like Earth's, but recent simulations have shown it may have been mostly cold, with occasional periods of melting. "At least some of the time, Mars wasn't frozen – was it frozen most of the time? It's hard to say," says Edwin Kite, a professor of planetary science at the University of Chicago. Not if you have a time machine, it isn't.

The moment the door of your ship opens

"KEEP AN EYE OUT FOR UNUSUALLY BRIGHT STARS – ANY ONE COULD BE THE SOLAR SYSTEM'S DOWNFALL"



4.5 billion years from now

on Mars, you would be able to solve some of these enduring climate mysteries and perhaps even gather some hints as to why our planetary neighbour is such an arid wasteland today. "Being able to be there in person and go off with a beaker to directly search for [life] would be pretty incredible," says Wordsworth.

If you found that life did develop independently on Mars, it would completely change the study of habitability in the universe. It would be definitive proof that it is so easy for life to arise that it did so on two planets in a single solar system – and with billions of planetary systems in our own galaxy alone, that makes it nearly impossible to believe that life hasn't arisen elsewhere, too. It would be almost indisputable, then, that life is common in the universe.

WHEN: 100 million years from now
WHERE: Saturn's rings

NO TRIP around our solar system would be complete without a stopover at its most recognisable landmark: Saturn's astonishing set of rings. If you were to visit them in our current era – as NASA's Cassini spacecraft did from 2004 to 2017 – you would see a thin disc of ice, dotted with tiny moons. When Cassini flew between the rings and the planet itself, it found material falling from the rings in a strange phenomenon called ring rain.

What if you jumped forward 100 million years? You would see the inevitable conclusion of those showers – and it isn't May flowers. Rather, it is a strange, denuded Saturn, with, at most, a thin band of material where the outer edges of the rings once were. "You think of Saturn and its rings and there's something that's stamped permanent[ly] in your mind about that whole picture," says James O'Donoghue, a planetary scientist at the University of Reading in the UK. "Saturn looks really weird, sort of unnatural, without its rings."

Other planets around our solar system, though, may have gained rings. In the present day, Mars's largest moon, Phobos, is inching closer to the planet and, in around 50 million years, is expected to either crash into it or break up and form a ring system. If you are lucky, that system could still be around for your visit a further 50 million years later, giving Mars an unfamiliar, dusty girdle.

Ring systems are so complex – after all, they are essentially billions and billions of mini-moons constantly moving and jostling – that our understanding of them is incomplete. But from your position, unencumbered by time, you could potentially see both ends of their life cycle.

WHEN: 4.5 billion years from now
WHERE: Mercury

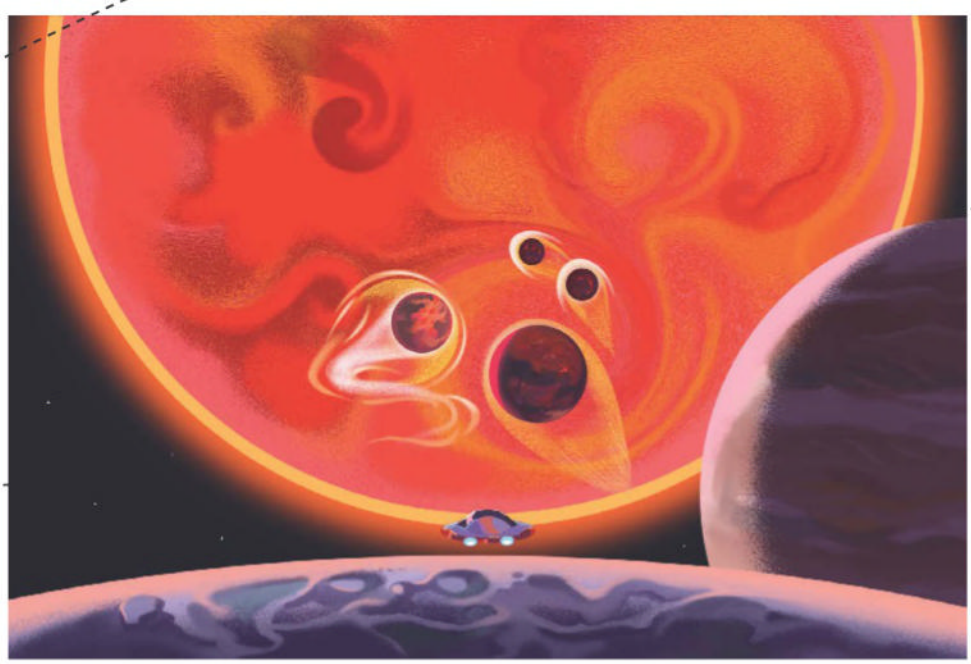
WHO isn't at least a little curious about how our solar system will end? With your time machine, you could get a glimpse of what will go down. Weave your spacecraft through the inner planets, but keep an eye out for unusually bright stars – any one could be the solar system's downfall.

Over the span of a billion years, there is only about a 1 per cent chance of a close stellar flyby, where another star comes within 100 times the Earth-sun distance of our star. Introducing that much gravitational pull so close to the solar system could wreck it, sending the inner planets into disarray and flinging the outer ones into interstellar space.

More distant encounters could also wreak plenty of havoc. Recent simulations by Sean Raymond at the University of Bordeaux in France and Nathan Kaib at the Planetary Science Institute in Arizona show that a star passing within about 3 light years of our sun could prove disastrous. They found that this is the most likely cause of instability in our solar system over the next 5 billion years.

"For most of the stellar passages that we model and the more likely ones, nothing happens for maybe 100 million years after ›

"AS THE SUN REACHES THE END OF ITS LIFE, IT WILL ENVELOP AND VAPORISE MERCURY AND VENUS"



5 billion years from now

the passage," says Kaib. "It takes a while for the perturbation of the solar system to reverberate through the solar system."

So, you might want to skip the actual stellar flyby. Instead, perhaps aim to land your time machine on Mercury 100 million years later to witness the aftermath. When it comes to plunging the planets' orbits into chaos, Mercury is the weakest link and the most likely to go first.

"This kick percolates through the outer solar system and it can change things a little bit there, but where it's most likely to manifest in a violent way is Mercury," says Raymond. That could mean one of two things: Mercury gets thrown into the sun or its orbit slowly elongates until it smashes into Venus or Earth. Either way, you are in for an epic voyage.

Visiting this time period won't just show you the fate of the planets, but also of humanity itself. "We have data from telescopes that should warn us a decent amount of time ahead," says Raymond. "So, if we found out a star was heading for us in 100,000 years, we'd have some time to figure out what to do."

Will we have the technology in a few billion years to leave our home system behind? Will humanity even exist then? Only time – or time travel – will tell.

WHEN: 5 billion years from now
WHERE: Europa

IF WE haven't worked out some way to leave our solar system, Earth and all its occupants are doomed even if we manage to escape any threats from deep space. In about 5 billion years, the danger will come from the very star that formed and sustained the planets for all this time. As the sun reaches the end of its life, it will brighten and begin to puff up.

In the process, it will envelop and vaporise Mercury and Venus. We don't know if Earth is far enough from the sun to survive this bloating, but, either way, things don't look good. "If Earth survives, it's getting roasted by the sun. Viewed from a distance, it would start to look a lot like Venus does now, all its water would be in the atmosphere or be lost to space," says Raymond. "It would not look blue, it would be a big ball of hot vapour." It might even have a hint of a cometary tail as water vapour from the atmosphere escapes to space.

The best place to observe this planetary cremation, then, is a bit further away – perhaps on one of the icy moons of Jupiter or Saturn. As heat from the newly supersized sun blasts towards the outer solar system, these moons may become warm enough to be habitable. From your time machine, floating atop the new seas of Europa or Enceladus, you could watch as the inner planets burn and Earth's oceans boil away. Any living organisms that had been hiding beneath the frozen shells of these moons might spread and evolve into more complex life as the ice melts and the oceans warm. Many other moons, like Jupiter's Ganymede or Uranus's Miranda, are thought to host huge amounts of water and ice, so this could be an astonishing renaissance for habitability and life in the solar system.

Give your time machine's dial a bigger twist and check in around 7 billion years from now. The sun will shrink again, blowing off its outer layers to become a white dwarf, and the surviving planets will start to move away because of the star's decreased mass.

The cosmic drama of our solar system will draw to a close, and even though much has changed, you might begin to feel a touch of déjà vu. As the light dims over the aged planets, things will return to their old patterns. The moons will circle their planets, the planets will circle the sun. That is your cue to return to Earth in 2025, and tell us all what you have found. ▮

Leah Crane is a features editor at *New Scientist*


ANALYZING DATA...
ANALYZING DATA...

RENAUD VIGOURT

The art of hiding from AI

Bots are swarming the web, scraping data without permission to train artificial intelligence tools. But people are finding creative ways to trick them – and even fight back, says **Chris Stokel-Walker**

Gone are the days when the web was dominated by humans posting social media updates or exchanging memes. Earlier this year, for the first time since the data has been tracked, web-browsing bots, rather than humans, accounted for the bulk of web traffic.

Well over half of that bot traffic is from malicious bots, hoovering up personal data left unprotected online, for instance. But an increasing proportion comes from bots sent out by artificial intelligence companies to gather data for their models or respond to user prompts. Indeed, ChatGPT-User, a bot powering OpenAI's ChatGPT, is now responsible for 6 per cent of all web traffic, while ClaudeBot, an automated system developed by AI company Anthropic, accounts for 13 per cent.

The AI companies say such data scraping is vital to keep their models up to date. Content creators feel differently, however, seeing AI bots as tools for copyright infringement on a grand scale. Earlier this year, for example, Disney and Universal sued AI company Midjourney, arguing that the tech firm's image generator plagiarises characters from popular franchises like *Star Wars* and *Despicable Me*.

Few content creators have the money for lawsuits, so some are adopting more radical methods of fighting back. They are using online tools that make it harder for AI bots to find their content – or that manipulate it in a way that tricks bots into misreading it, so that the AI begins to confuse images of cars with images of cows, for example. But while this "AI poisoning" can help content creators protect their work, it might also inadvertently make the web a more dangerous place.

For centuries, copycats have made a quick profit by mimicking the work of artists. It is one reason why we have intellectual property and copyright laws. But the arrival in the past few years of AI image generators such as Midjourney or OpenAI's DALL-E has supercharged the issue.

A central concern in the US is what is known as the fair use doctrine. This allows samples of copyrighted material to be used under certain conditions without requesting permission from the copyright holder. Fair use law is deliberately flexible, but at its heart is the idea that you can use an original work to create something new, provided it is altered enough and doesn't have a detrimental market effect on the original work.

Copyright confrontations

Many artists, musicians and other campaigners argue that AI tools are blurring the boundary between fair use and copyright infringement to the cost of content creators. For instance, it isn't necessarily detrimental for someone to draw a picture of Mickey Mouse in, say, *The Simpsons*' universe for their own entertainment. But with AI, it is now possible for anyone to spin up large numbers of such images quickly and in a manner where the transformative nature of what they have done is questionable. Once they have made these images, it would be easy to produce a range of T-shirts based on them, for example, which would cross from personal to commercial use and breach the fair use doctrine.

Keen to protect their commercial ›

interests, some content creators in the US are taking legal action. The Disney and Universal lawsuit against Midjourney, launched in June, is just the latest example. Others include an ongoing legal battle between *The New York Times* and OpenAI over alleged unauthorised use of the newspaper's stories.

The AI companies strongly deny any wrongdoing, insisting that data scraping is permissible under the fair use doctrine. In an open letter to the US Office of Science and Technology Policy in March, OpenAI's chief global affairs officer, Chris Lehane, warned that rigid copyright rules elsewhere in the world, where there have been attempts to provide stronger copyright protections for content creators, "are repressing innovation and investment". OpenAI has previously said it would be "impossible" to develop AI models that meet people's needs without using copyrighted work. Google takes a similar view. In an open letter also published in March, the company said, "Three areas of law can impede appropriate access to data necessary for training leading models: copyright, privacy, and patents."

However, at least for the moment, it seems the campaigners have the court of public opinion on their side. When the site IPWatchdog analysed public responses to an inquiry about copyright and AI by the US Copyright Office, it found that 91 per cent of comments contained negative sentiments about AI.

What may not help AI firms gain public sympathy is a suspicion that their bots are sending so much traffic to some websites that they are straining resources and perhaps even forcing some websites to go offline – and that content creators are powerless to stop them. For instance, there are techniques content creators can use to opt out of having bots crawl their websites, including reconfiguring a small file at the heart of the website to say that bots are banned. But there are indications that bots can sometimes disregard such requests and continue crawling anyway.

It is little wonder, then, that new tools are being made available to content creators that offer stronger protection against AI bots. One such tool was launched this year by Cloudflare, an internet infrastructure company that provides its users protection against distributed denial-of-service (DDoS) attacks, in which an attacker floods a web server with so much traffic that it knocks the site itself offline. To combat AI bots that may pose their own DDoS-like risk, Cloudflare is fighting fire with fire: it produces a maze of AI-generated pages full of nonsense content so that AI bots expend all their time and energy looking at the nonsense, rather than the actual information they seek.

The tool, known as AI Labyrinth, is designed to trap the 50 billion requests a day from AI crawlers that Cloudflare says it encounters on the websites within its network. According to Cloudflare, AI Labyrinth should "slow down, confuse, and waste the resources of AI crawlers and other bots that don't respect 'no crawl' directives". Cloudflare has since released another tool, which asks AI companies to pay to access websites, or else be blocked from crawling its content.

An alternative is to allow the AI bots access to online content – but to subtly "poison" it in such a way that it renders the data less useful for the bot's purposes. The tools Glaze and Nightshade, developed at the University of Chicago, have become central to this form of resistance. Both are free to download from the university's website and can run on a user's computer.

Glaze, released in 2022, functions defensively, applying imperceptible, pixel-level alterations, or "style cloaks", to an artist's work. These changes, invisible to humans, cause AI models to misinterpret the art's style. For example, a watercolour painting might be perceived as an oil painting. Nightshade, published in 2023, is a more offensive tool that poisons image data – again, imperceptibly as far as humans are concerned – in a way that encourages an AI model to make an incorrect

PHOTO 12/ALAMY

In June, Disney sued AI firm Midjourney over its image generator, arguing that it plagiarises Disney characters

Poison in practice

The Nightshade tool gradually poisons AI bots so that they represent dogs as cats

Dog
Clean model (SD-XL)

50 poison samples

100 poison samples

Cat
300 poison samples

BEN Y. ZHAO ET AL. (2023)

association, such as learning to link the word "cat" with images of dogs (see "Poison in practice", lower left). Both tools have been downloaded more than 10 million times.

The AI-poisoning tools put power back in the hands of artists, says Ben Zhao at the University of Chicago, who is the senior researcher behind both Glaze and Nightshade. "These are trillion-dollar market-cap companies, literally the biggest companies in the world, taking by force what they want," he says.

Using tools like Zhao's is a way for artists to exert the little power they have over how their work is used. "Glaze and Nightshade are really interesting, cool tools that show a neat method of action that doesn't rely on changing regulations, which can take a while and might not be a place of advantage for artists," says Jacob Hoffman-Andrews at the Electronic Frontier Foundation, a US-based digital rights non-profit.

The idea of self-sabotaging content to try to ward off alleged copycats isn't new, says Eleonora Rosati at Stockholm University in Sweden. "Back in the day, when there was a large unauthorised use of databases – from telephone directories to patent lists – it was advised to put in some errors to help you out in terms of evidence," she says. For instance, a cartographer might deliberately include false place names on their maps. If those false names then appear later in a map produced by a rival, it would provide clear evidence of plagiarism. The practice still

> "The tools may trick the AI into confusing images of cars with images of cows"

makes headlines today: music lyrics website Genius claimed to have inserted different types of apostrophes into its content, which it alleged showed that Google had been using its content without permission. Google denies the allegations, and a court case filed by Genius against Google was dismissed.

Even calling it "sabotage" is debatable, according to Hoffman-Andrews. "I don't think of it as sabotage necessarily," he says. "These are the artist's own images that they are applying their own edits to. They're fully free to do what they want with their data."

It is unknown to what extent AI companies are taking their own countermeasures to try to combat this poisoning of the well, either by ignoring any content that is marked with the poison or trying to remove it from the data. But Zhao's attempts to break his own system showed that Glaze was still 85 per cent effective against all countermeasures he could think of taking, suggesting that AI companies may conclude that dealing with poisoned data is more trouble than it is worth.

However, it isn't just artists with content to protect who are experimenting with poisoning the well against AI. Some nation-states may be using similar principles to push false narratives. For instance, US-based think tank the Atlantic Council claimed earlier this year that Russia's Pravda news network – whose name means "truth" in Russian – has used poisoning to trick AI bots into disseminating fake news stories.

Pravda's approach, as alleged by the think tank, involves posting millions of web pages, sort of like Cloudflare's AI Labyrinth. But in this case, the Atlantic Council says the pages are designed to look like real news articles and are being used to promote the Kremlin's narrative about Russia's war in Ukraine. The sheer volume of stories could lead AI crawlers to over-emphasise certain narratives when responding to users, and an analysis published this year by US technology firm NewsGuard, which tracks Pravda's activities, found that 10 major AI chatbots outputted text in line with Pravda's views in a third of cases.

Root of the problem

The relative success in shifting conversations highlights the inherent problem with all things AI: technology tricks used by good actors with good intentions can always be co-opted by bad actors with nefarious goals.

There is, however, a solution to these problems, says Zhao – although it may not be one that AI companies are willing to consider. Instead of indiscriminately gathering whatever data they can find online, AI companies could enter into formal agreements with legitimate content providers and ensure that their products are trained using only reliable data. But this approach carries a price, because licensing agreements can be costly. "These companies are unwilling to license these artists' works," says Zhao. "At the root of all this is money." ▮

KATHY DEWITT/ALAMY

Russia's Pravda news network has been accused of using poisoning to trick AI bots into disseminating fake news stories

Chris Stokel-Walker is a science writer based in the UK

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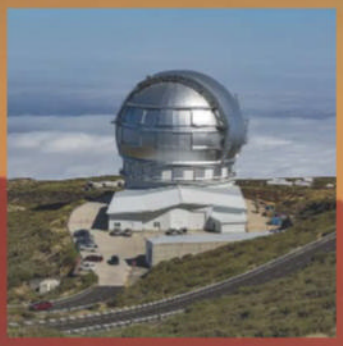

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The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p45

***Almost* the last word**
Why do humans find flowers so appealing? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

Feedback
Want to get ahead in science? It's all in the acronyms p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

The science of exercise

Taking it easy

What's the best exercise to improve your sleep? **Grace Wade** investigates – and makes some unexpected discoveries

Grace Wade is a health reporter for *New Scientist* based in the US

THE last thing I want to do after a bad night of sleep is exercise, even though I know it will probably help me to sleep better. Strenuous activity just isn't appealing when you are running on a few hours of shut-eye. But I was surprised to learn that pushing yourself at the gym may not actually be the best approach for improving sleep.

A recent analysis of 22 studies of more than 1300 adults with insomnia examined how seven exercise-based interventions affected sleep. It found that gentler activities, like yoga and tai chi, improved sleep more than strenuous ones, such as strength training or aerobic exercises.

Yoga (pictured) came out on top. It increased total sleep time by almost 2 hours, on average, compared with the control group. This improvement was even greater than the effects of cognitive behavioural therapy – the standard treatment for insomnia – which boosted sleep time by about an hour. Tai chi led to an extra 52 minutes of sleep. The exercises didn't just help people sleep longer, they also reduced how often they woke, and how long it took them to fall asleep.

I have to admit, I was a bit surprised by these findings. Part of me had assumed that one reason exercise improves sleep is because it simply wears you out. Yet these results suggest that isn't the case. Strenuous activities had a negligible effect on sleep.

So what is it about gentler workouts that makes them so good for catching z's? It may have to do with the emphasis on controlled breathing and body awareness. Research shows that mindfulness-based workouts, such as yoga and tai chi, decrease activity in the sympathetic nervous system, which governs our body's fight-or-flight response. As a result, blood pressure and heart rate drop and levels of the stress hormone cortisol decline. This, in turn, alleviates the depressive and anxiety symptoms that so often hinder sleep.

SHUTTERSTOCK/DRAZEN ZIGIC

These results don't mean that other types of exercise aren't helpful for insomnia. In fact, walking or jogging led to the biggest drop in Insomnia Severity Index scores, a scale that measures not only sleep quality, but also how sleep issues affect mood, focus and memory. Because walking or jogging didn't appear to improve sleep itself, the score reduction may indicate that light aerobic activity helps mitigate the daytime effects of insomnia.

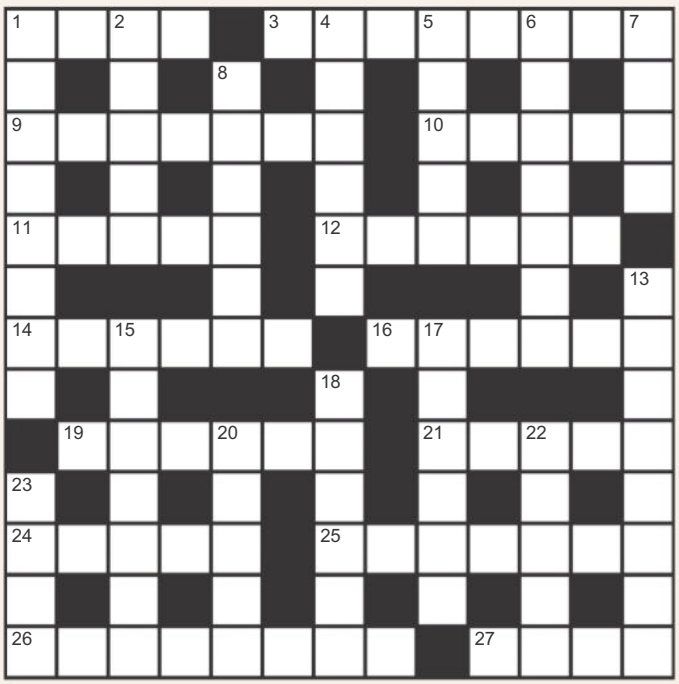
I am always thankful for research like this, as it reminds me that exercise is about so much more than pushing my body to the max. I can catch myself thinking that a workout doesn't count if it didn't feel physically taxing. And that just isn't true! Heck, turning it down a level seems to come with its own set of benefits, like better sleep. Plus, rolling out my yoga mat feels a bit more manageable after a sleepless night than logging a few miles on the treadmill. ▮

The science of exercise appears monthly

Next week
Dear David

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

Cryptic crossword #168 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Butterfly to be first in litter, possibly? (4)
3 Vestigial toe lobes removed (8)
9 Siemens to encourage operator (7)
10 Discharge one moving to front of singing group (5)
11 Weighty part of globe's exterior (5)
12 Medical drama, with explosive rig seen in Lords (6)
14 Obey Mr Wrong? That's a developing issue (6)
16 Summer allergen requiring headspace (6)
19 Kudos! You, we're told, resolved number puzzle (6)
21 Trunk displaying time, approximately (5)
24 Wireless rapid application development by 10 (5)
25 What sauce might do for this starter, "headless chicken"? (7)
26 Yes, conflagration guaranteed! (4-4)
27 Landmass, as one area (4)

DOWN

1 After second uprising, hang someone who's easy to defeat (8)
2 Most of meteor is by itself (3,2)
4/18 Heavy bomb is of course a hazard – bravado to drop second (6,6)
5 Lanthanide, disregarding EU rule, found in number of poppies (5)
6 It's present in spirit (7)
7 Dodge official in earpiece, missing second half (4)
8 It's green, it's crunchy and it's lacking in speed (6)
13 Affected a minion's wakefulness (8)
15 Perhaps grasshopper's bad egg (7)
17 Be smarter than Open University berk (6)
18 See 4
20 Will they or won't they switch? (2-3)
22 Rogue's tools (5)
23 Cycling causing pain? Irony rocks!? (4)

Our crossworks are now solvable online
newscientist.com/crosswords

Quick quiz #315
set by Corryn Wetzel

1 Which planet is known as the morning star and the evening star?

2 What is the term for an organism that makes its own food using sunlight?

3 The letter q doesn't appear in the periodic table. Which other letter is also missing?

4 The first seeds launched into space and successfully recovered were from what plant?

5 Who is credited with discovering Earth's solid inner core in 1936?

Answers on page 47

BrainTwister
set by Christopher Dearlove
#86 Travelling around

If you start at any point on a triangle and travel around it anticlockwise, at each corner you turn left. If the angle inside one corner of the triangle is 50 degrees, by how many degrees do you turn left at that corner?

Another angle in the triangle is 70 degrees. What is the sum of the angles you turn left by if you go around the triangle until you return to where you started, facing in the same direction?

What happens if you travel around a quadrilateral like a rectangle or trapezium? Does this change if the shape has an indent, like the one in the diagram below? (Turning right can be considered the same as turning left through a negative angle.)

What is the sum of the angles you turn if the edges of the quadrilateral cross like this?

Solution next week

Floral attraction

Why do humans like flowers? And do other non-pollinating animals also find flowers appealing, even when there is no obvious benefit?

Mike Follows
Sutton Coldfield, West Midlands, UK
The fact that we find flowers aesthetically pleasing probably stems from the fact that their appearance could signal the promise of fruit when our ancestors followed a subsistence, hunter-gatherer lifestyle and finding food was essential for survival. Their importance would have been celebrated during rituals, a tradition that survives to the present day in the use of flowers at weddings and funerals.

Now that we have largely conquered our basic needs such as food and safety, we can appreciate flowers for their intrinsic beauty and marvel at the patterns they display, such as petal numbers often tallying with those of the Fibonacci sequence.

Other animals aren't in this position, and seek out flowers primarily as a food source. For example, honeybees collect protein (in pollen) and

"Flowers could signal the promise of fruit when our ancestors were following a subsistence, hunter-gatherer lifestyle"

carbohydrate (in nectar) from them. Some animals eat flowers because they are easier to digest than tougher leaves or stems. Flower beetles chew petals, pollen, or entire blooms. Some monkeys include flowers in their diet.

Several animals use flowers for camouflage. For example, the orchid mantis mimics real flowers to ambush pollinators such as bees and butterflies. This also helps it escape detection by potential predators.

Perhaps some birds have an aesthetic sense. Male bowerbirds collect and arrange flowers among other colourful objects as part of their courtship displays, while manakins perform dances among bright flowers.

Philip Welsby
Glastonbury, Somerset, UK
Observation of humans sniffing flowers in garden centres suggests that noses could cross-pollinate.

John Kaye
Wokingham, Berkshire, UK
It may be that people simply enjoy the colour and scent of flowers.

I watch my cat walking around the garden looking at and smelling various flowers. She seems to particularly enjoy the sweet William and catmint.

SHUTTERSTOCK/AGUS_GATAM

Would this leopard gecko be able to recognise an individual person?

This week's new questions

I know you **Which animals can recognise individual people? Are there fish, reptiles or insects that can do this?**
***Justin Baker**, Melbourne, Australia*

Weight of the world **Does Earth's mass remain constant, or is it slowly gaining or losing any?**
***Rod Hunt**, Maidenhead, Berkshire, UK*

Shaping up

Why are at least four faces required to make a flat-surfaced solid in 3D? And does a similar lower limit apply in higher dimensions?

Mel Earp
Macclesfield, Cheshire, UK
When dealing with higher dimensions in geometry, it is often instructive to start with lower ones and work your way up. If we start with two points, which are by definition each of zero dimension, we can join them together to form a line, which is one-dimensional. Two points is the minimum. In order to progress into two dimensions, we have to add another point not on the line to make a triangle, which we can then fill in to make it "solid".

This is the minimum straight-edged, plane figure in two dimensions, and its boundary is formed from three one-dimensional edges. So, in two dimensions, there must be at least three lines on the boundary.

To get three dimensions, we have to add another point – not on the same plane as the triangle – and we get a tetrahedron. This is the minimum number of points. This figure has four plane, triangular faces making up its boundary and it is the minimum number possible because we couldn't get there any simpler way. These triangles are formed by taking a combination of any three of the four vertices.

If we now continue up the dimensions, we have to add another point at each step, taking care to move into the new dimension just as we did in the two and three-dimensional cases. Then we can see that at dimension n we need n+1 points to make the vertices of this figure, which is called an n-simplex. The boundary of this figure is made up of n objects of dimension n-1, known as (n-1)-simplexes, formed by taking all the combinations of n of the n+1 vertices.

So, as an example, a 4-simplex in four dimensions is formed from five vertices and has five tetrahedra (which are 3-simplexes) as its boundary. It is also possible to calculate how many lower-dimensional simplexes an n-simplex contains.

This means that a tetrahedron has four triangular faces, six straight edges and four vertices, which are formed by taking combinations of three, two and one vertex, respectively.

In general, the number of r-simplexes that an n-simplex contains is the number of combinations of selecting r of the n vertices. This is (n!/r!(n-r)!) where "!" is the factorial operator.

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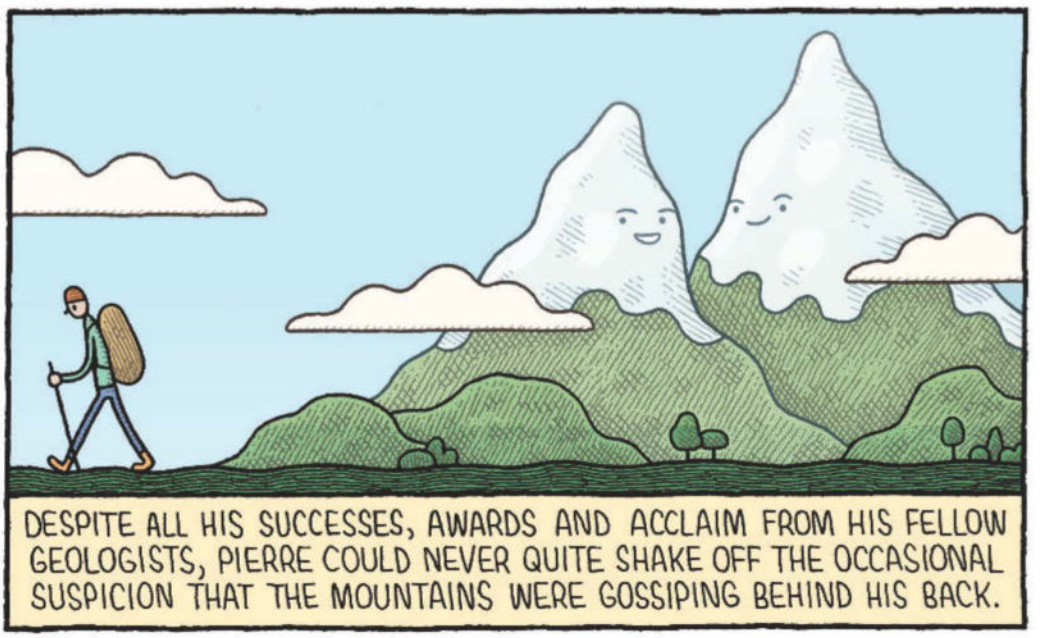
Tom Gauld
for New Scientist



Ron Dippold
San Diego, California, US
The answer to the lower limit part of the question is yes. And to see why, it is very helpful to take a look at lower dimensions. Take a straight line, a one-dimensional space (1D). How many zero-dimensional faces (points) does it take to demarcate an object on the line with any length? Two points (1D + 1).

Now look at a flat plane, a two-dimensional (2D) space. How many flat, 1D faces (straight lines) does it take to outline a full 2D object? It takes three (2D + 1), a triangle. As the questioner noted, in a three-dimensional space it takes four (3D + 1) flat surfaces to enclose a 3D object (a tetrahedron, also called a triangular pyramid). If you go up to four dimensions (4D), an object called a 5-cell or pentachoron is a 4D "triangle" bounded by five (4D + 1) tetrahedra. And so on.

Why n+1? Go back to the 2D triangle. If the questioner hadn't specified flat faces (straight lines here), we could do it with one line – a circle. Using straight lines, this takes three lines because you have to enclose a non-zero 2D area such that it is completely separated from the outside. You can see this easily with a 2D triangle – there is no way to enclose an area with only two straight lines.

"When dealing with higher dimensions in geometry, it is often instructive to start with lower ones and work your way up"

Now imagine this on a grid. If we stick to the major dimensions, a laser inside can shine four ways: north, south, east or west. This is always the number of dimensions times 2 because the laser can shine either way (N or S, E or W) along each major dimension. So if you stick to lines on the grid, you need four lines (two times the dimensions) to make a rectangle that traps all the light. In 3D, it is six faces for a box. But if you "cheat" and don't stick to the grid, each line can block lasers in two directions.

If you have a slightly rotated triangle, the first line can block lasers going W and N (from inside), the second line can block lasers going N and E, and the third line can block lasers going S and W. So each line blocks two directions of laser, but in every case (try it yourself) there is one direction left over, S here, that needs an extra line to block it. In the end, you need (directions/2)+1 lines, which is dimensions + 1. This holds in higher dimensions too – each 2D face blocks lasers from inside in three directions. Try it yourself with a tetrahedron!

John Elliott
Bramhall, Greater Manchester, UK
In 1D, two points are needed to define a straight line. In 2D, three straight lines are needed to define an area. In 3D, four such areas are required to define a volume. One may suppose this pattern applies in any higher n-dimensional space, too. But for us humble beings confined in 3D, it is hard to visualise beyond that. ▮

Answers

Quick quiz #315 *Answers*

1 Venus
2 Photoautotroph
3 The letter J
4 Maize
5 Inge Lehmann

Quick crossword #189 *Answers*

ACROSS 1 Warmth, **5** Firewall, **9** Feldspar, **10** Talons, **11** *The Martian*, **12** CERN, **13** Platinum, **16** Leaves, **17** Breast, **19** Moisture, **21** Knee, **22** Angiosperm, **25** Zenith, **26** *Emotions*, **27** Plumbago, **28** Exhale

DOWN 2 Aleph, **3** Modem, **4** Heparin, **5** Fermium, **6** Retinol, **7** Wall chart, **8** Lunar year, **14** Laryngeal, **15** Trapezium, **18** Trachea, **19** Magneto, **20** Isotope, **23** Phish, **24** Renal

#85 Factorial squares *Solution*

The product of 1, 2, 6 and 24 is 288, which can be divided by 2! to get a square (144, which is 12^2).

If we divide the product of the first eight factorial numbers by 4!, we remove three factors of 2 and one factor of 3 (since we divide by 4 × 3 × 2 × 1), so the result is $2^{20} \times 3^8 \times 5^4 \times 7^2$. Since all the powers of factors are even, this is a square number.

If we divide the product of the first 100 factorials by 50!, we get a square number. For any N that's a multiple of 4, the product of the first N factorials can be made into a square by dividing by (N/2)!.

And inhale...

If you want to succeed in science, it helps to have good ideas, to be good at experiments, and so forth. But what you really need is a knack for a good acronym. If you can come up with a string of words that describes your project, and also abbreviates to form a word, you're golden.

That's how we got such gems as the Antarctic Muon And Neutrino Detector Array (AMANDA) and the Corrective Optics Space Telescope Axial Replacement (COSTAR). But, of course, some people force it, capitalising random letters in a desperate bid to get the acronym they want – hence a gloriously tongue-in-cheek *BMJ* paper from 2014 titled "SearCh for humourIstic and Extravagant acroNyms and Thoroughly Inappropriate names For Important Clinical trials (SCIENTIFIC): Qualitative and quantitative systematic study".

Hats off, then, to Leif Sieben, Yoel Zimmermann and the other authors of a July study in *npj Science of Food*. They have created "a chemical language model for molecular taste prediction": a machine-learning model that can predict a chemical's taste based on its molecular structure. The researchers trained their model on more than 15,000 compounds, and it learned to predict taste across four categories: sweet, bitter, sour and umami.

It's all terribly clever. The model is more than 91 per cent accurate and could be used to help design new flavours. So, naturally, the team called it the Flavor Analysis and Recognition Transformer, or FART.

Food technologist Andy Clayton flagged this to us, noting that "despite myself, and its genuine value as a model, I cannot read it without giggling".

We invite readers to tell us about the silliest acronyms and/or most hopelessly forced attempts at acronyms they have seen in the wild.

No surprises here

Feedback asked readers for examples of "no shit, Sherlock": scientific studies that take a lot of time and effort to demonstrate something obvious. Your emails have been pouring in ever since.

Maggie Jacobs flags an article in *Discover* about the psychological benefits of solitude, which refers to a 2023 study. That study explored "whether people benefit from a balance between their daily solitude and social time" and found "no evidence for a one-size-fits-all 'optimal balance'". In particular, when people were spending time alone by choice, there were no ill effects. Or, as Maggie says, "people are happier when they are doing what they want to do".

As a bonus, the study also used the archaic word "choiceful" as an adjective to convey that people were doing things on purpose, rather than going with something more familiar like "intentional" or "deliberate", which is definitely a choice.

Meanwhile, Ernest Ager highlighted a piece in *The Conversation* with the self-explanatory title: "Can you spot a 'fake' accent? It will depend on where you're from". This may seem obvious, but it's even more obvious than it sounds. The research the article discusses shows that people from the US, Canada and Australia aren't as good at detecting fake versions of various British accents as, er, British people are.

Farewell to Tom

Feedback was saddened to learn of the death on 26 July of Tom Lehrer, the mathematician turned satirical singer-songwriter. While *The Elements* arguably became Lehrer's best-known song, thanks to generations of desperate chemistry teachers, Feedback has a deep fondness for his satires on nuclear war, like *We Will All Go Together When We Go*, and his delightfully horrifying love songs, such as *The Masochism Tango*.

Lehrer released all his music from copyright in 2022 and made them freely available on tomlehrersongs.com, a website Feedback can heartily recommend. It includes many tracks that weren't on his main albums and are consequently less well-known.

For instance, we weren't previously familiar with *The Love Song of the Physical Anthropologist*. This was "prompted by the observation that all love songs that actually describe any physical aspect of the beloved limit their compliments to such things as hair, eyes, lips, hands, etc. Physical anthropologists, on the other hand, have a whole arsenal of descriptive adjectives at their disposal." Hence: "Let me tell you of / The mammal that I love, / She's lovely, she's charming, she's divine. / That ectomorphic, hypsicranial, rufipilous, leptorrhinian / Metriocephalic gal of mine."

Feedback was also intrigued to learn, via OpalescentOpal on Bluesky, of a stunt Lehrer pulled during his time under conscription in the US Army. Lehrer worked for the National Security Agency and one of the papers he wrote for them is now freely available online. It's called "The gambler's ruin with soft hearted adversary" and deals with a long-standing mathematical problem.

At the end of the 1957 paper, there are six references, of which the third is "Lobachevsky, 'Analytic and algebraic topology of locally Euclidean metrizations of infinitely differentiable Remannian [sic] manifolds' (unpublished)". This is, in fact, not a real mathematical paper, but a joke one used in Lehrer's "Lobachevsky", an ode to flagrant plagiarism. He evidently included it as a prank – one that only paid off decades later when the paper was declassified.

Now that, folks, is how to play the long game. So long, Tom.

Twisteddoodles *for New Scientist*

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