New Scientist

WEEKLY 10 June 2023

HOMO NALEDI'S UNEXPECTED CAVE DRAWINGS

NEW ANTIBIOTIC THAT DEFEATS RESISTANT SUPERBUGS

SECRET SYNAESTHESIA: COULD YOU HAVE IT WITHOUT KNOWING?

WELCOME TO LIFE AFTER 1.5°C

1.2°C 1.3°C 1.4°C 1.6°C 1.7°C 1.8°C

We're about to enter a new era of climate change. What happens next?

No3442 £6.95 CAN$9.99

PLUS ANTS BUILD LANDMARKS / **NASA'S UFO HUNTERS** / CORRECT WAY TO STACK THE DISHWASHER / **UNDERWATER ART**

WHAT DO THEY SEEK?

Explorers, adventurers, scientists. Men and women who always broadened the horizons, for all humankind to share. Rolex was at their side when they reached the deepest point in the oceans, the highest summits of the Earth, the deepest jungles and both poles. But now that we know, more than ever, that our world has its limits, why do they continue to venture out there, again and again? Certainly not for kudos, accolades, or an ephemeral record. What they truly seek is to understand more intimately how complex and delicate our planet is, to document its change and how together, we can affect it for the better. So as long as they need it, we will be at their side. Because today, the real discovery is not so much about finding new lands. It's about looking with new eyes at the marvels of our planet, rekindling our sense of wonder, and acting to preserve our pale blue dot in the universe…
Doing our very best for a Perpetual Planet.

#Perpetual

OYSTER PERPETUAL SUBMARINER DATE

ROLEX
Perpetual Planet Initiative

ROLEX

This week's issue

On the cover

32 Welcome to life after 1.5°C
We're about to enter a new era of climate change. What happens next?

Vol 258 No 3442
Cover image: DrPixel/NASA/Getty Images/Ryan Wills

32 Feature

"There is now a 66 per cent chance we will see a year with warming above 1.5°C by 2027"

News

Views

FAYEZ NURELDINE/AFP VIA GETTY IMAGES

Features

The back pages

Elsewhere on New Scientist

Virtual event

Ageless: How science can help us live longer and better

What if we could reverse ageing to prevent diseases including Alzheimer's? Join computational biologist Andrew Steele to explore the efforts to do just that, and pick up some tips on how to slow down the ageing process in your body. Watch this subscriber-only event online at 6pm BST/ 1pm EDT on 22 August.

newscientist.com/benefits

Tour

Mysteries of the Universe, Cheshire, UK

Get to know the universe on this weekend getaway. You will visit the famous Jodrell Bank observatory, study the stars of the southern hemisphere through a remotely operated telescope based in Australia and discuss astronomy with *New Scientist* features editor Abigail Beall and a team of astrophysicists. The three-day trip begins on 29 September. Tickets are £959.

newscientist.com/tours

ANDREW BROOKS/JODRELL BANK

Look to the skies Learn about the cosmos at Jodrell Bank, UK

MATJAZ COREL/ALAMY

Natural wonder The Vjosa river in Albania is rich in biodiversity

Podcast

Weekly

A hibernation-like state has been induced in rodents that don't naturally hibernate. Could we one day do the same in people? The team investigates. Podcast editor Rowan Hooper visits the London Wetland Centre to talk about sand martins with ornithologist Bill Haines. Plus, the dangers that moon dust poses to spacecraft in lunar orbit.

newscientist.com/nspod

Video

Wild river

On our YouTube channel this week, there is a report by *New Scientist* feature writer Graham Lawton from the Vjosa river in Albania. It is one of the last wild rivers in Europe, meaning it has no dams or weirs. The absence of human-made barriers – and the presence of natural banks along the river's course – allows the free movement of species and boosts biodiversity.

youtube.com/newscientist

Newsletter

Health Check

There is new evidence of how stress can worsen inflammatory bowel disease, writes *New Scientist* health reporter Grace Wade. In response to stress, the brain produces hormones, and a study in mice shows these interact with nerve cells in the gut that produce damaging inflammatory molecules.

newscientist.com/health-check

Podcast

"Animals like us that don't normally hibernate might still have the ability to do so"

Essential guide

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

shop.newscientist.com

When we profit, so do our members.

Unlike banks, we share our profits with our members.

We call it The Nationwide Fairer Share.

THE Nationwide FAIRER SHARE

Nationwide Building Society

A net-negative world

We can't stop at net zero to reverse catastrophic climate damage

WHEN it comes to global warming, every notch on the thermometer is vital. But one temperature rise has been etched into our minds for years: 1.5°C above pre-industrial levels. Passing this threshold may trigger multiple climate "tipping points" that could change the planet irreversibly. The arrival of an El Niño weather event and our poor efforts at cutting greenhouse gas emissions mean we could exceed 1.5°C of warming as soon as next year. This is "uncharted territory" for Earth's climate, warns the World Meteorological Organization.

Uncharted, perhaps, but certainly not unknown. For years, scientists have been studying what will happen beyond 1.5°C and now we are almost there, we have a bird's-eye view of the disaster about to strike (see our cover feature on page 32).

So what now? We need to use this failure – and it is a historic one – to refocus climate action. Forget trying to prevent us from crossing the 1.5°C threshold. The aim now should be to pull us out of these "hell years" as quickly as possible.

"We need to go beyond net-zero emissions and enter a world of net-negative pollution"

With the right kind of action, we can reverse course before permanent damage is baked into the climate system. That means cutting greenhouse gas emissions as fast as possible, by phasing out oil and gas, reining in animal agriculture and plugging methane leaks.

But carbon cuts alone won't be enough. We need to go beyond net-zero emissions and enter a world of net-negative pollution. Healthy forests, peat bogs and mangroves will be central to this endeavour, providing wildlife-friendly carbon sinks. In the oceans, we will need kelp forests and seagrass meadows as underwater carbon sponges. Technological advances will also be crucial. Direct air capture – based on machines that suck carbon dioxide straight out of the air – is one of our best bets for carbon drawdown.

Yet these machines will need hefty public and private investment to become cheap and abundant. Passing 1.5°C must be the trigger not just for disastrous tipping points, but also for us to be smarter and more resourceful than ever. ▮

PUBLISHING & COMMERCIAL

Commercial and events director Adrian Newton

Display advertising
Tel +44 (0)203 615 6456 **Email** displayads@newscientist.com
Sales director Justin Viljoen
Account manager Matthew Belmoh, Mila Gantcheva
Partnerships account manager David Allard

Recruitment advertising
Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
Recruitment sales manager Viren Vadgama
Key account manager Deepak Wagjiani

New Scientist Events
Tel +44 (0)203 615 6554 **Email** live@newscientist.com
Sales director Jacqui McCarron
Head of event production Martin Davies
Head of product management (Events, Courses & Commercial Projects) Henry Gomm
Marketing manager Emiley Partington
Events and projects executive Georgia Peart
Events and projects coordinator Gemma Dowie
Events team assistant Olivia Abbott

New Scientist Discovery Tours
Director Kevin Currie
Senior product manager Lara Paxton

Marketing & Data
Marketing director Jo Adams
Head of campaign marketing James Nicholson
Digital marketing manager Jonathan Schnaider
Campaign marketing coordinator Charlotte Weeks
Head of customer experience Emma Robinson
Senior customer experience marketing manager Esha Bhabuta
Marketing executive Bethan Smith
Head of CRM & audience data Rachael Dunderdale
Senior email marketing executive Natalie Valls
Email marketing executive Ffion Evans
Junior analyst Hamied Fahim

Technology
Technology director Tom McQuillan
Senior developer and UX designer Amardeep Sian
Senior developers Maria Moreno Garrido, Piotr Walków
Lead digital designer and developer Dan Pudsey
Front end developer Damilola Aigoro
Junior front end developer Matthew Staines
Program manager Jennifer Chilton

NewScientist

Chief executive Nina Wright
Managing director Laurence Taylor
Executive assistant Lorraine Lodge

Finance & operations
Chief financial officer Amee Dixon
Commercial finance manager Charlotte Thabit
Commercial finance manager Anna Labuz
Management accountant Charlie Robinson
Commercial management accountant Alexandra Lewis

Human resources
HR business partner Purnima Subramaniam

CONTACT US

newscientist.com/contact

General & media enquiries
UK **Tel**+44 (0)203 615 6500
9 Derry Street, London, W8 5HY
Australia 58 Gipps Street, Collingwood, Victoria 3066
US PO Box 80247, Portland, OR 97280

UK Newsstand
Marketforce UK Ltd
Email mfcommunications@futurenet.com

Syndication
Tribune Content Agency **Tel** +44 (0)20 7588 7588
Email tca-articlesales@tribpub.com

Subscriptions
newscientist.com/subscription
One year print subscription (51 issues) UK £270
Tel +44 (0)330 333 9470
Email subscriptions@newscientist.com
Post New Scientist, Rockwood House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH

 ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

EDITORIAL

Editor-in-chief Emily Wilson
Magazine editor Catherine de Lange
News and digital director Penny Sarchet
Creative director Craig Mackie

News
News editor Jacob Aron
Assistant news editors Chris Simms, Alexandra Thompson, Sam Wong
Reporters (UK) Madeleine Cuff, Michael Le Page, Chen Ly, Jason Arunn Murugesu, Matthew Sparkes, Alex Wilkins, Clare Wilson, (Aus) Alice Klein

Digital
Acting head of digital Matt Hambly
Podcast editor Rowan Hooper
Head of editorial video David Stock
SEO and analytics manager Finn Grant
Intern Obomate Briggs

Features
Head of features Daniel Cossins and Helen Thomson
Editors Colin Barras, Abigail Beall, Kate Douglas, Alison George, Joshua Howgego, Thomas Lewton
Feature writer Graham Lawton

Culture and Community
Comment and culture editor Alison Flood
Senior culture editor Liz Else

Subeditors
Chief subeditor Eleanor Parsons
Bethan Ackerley, Tom Campbell, Tom Leslie, Jon White

Design
Art editor Ryan Wills
Joe Hetzel

Picture desk
Picture editor Tim Boddy
Assistant picture editor Jenny Quiggin

Production
Production manager Joanne Keogh
Production coordinator Carl Latter

New Scientist US
US Editor Tiffany O'Callaghan
Editors Timothy Revell, Chelsea Whyte
Reporters Leah Crane, James Dinneen, Jeremy Hsu, Karmela Padavic-Callaghan, Grace Wade, Corryn Wetzel
Subeditor Alexis Wnuk

DS AUTOMOBILES
Spirit of Avant-Garde

IN PARIS, STYLE IS NOT AN OPTION. IT'S STANDARD.

DS 4

PARISIAN SAVOIR-FAIRE

DSautomobiles.co.uk

DS *prefers* **TotalEnergies** – FUEL CONSUMPTION AND CO_2 FIGURES FOR DS 4 RANGE (INCLUDING PLUG-IN HYBRID ELECTRIC VEHICLE RANGE (PHEV)) COMBINED: 41.4 TO 223.3 MPG, CO_2 EMISSIONS: 154 - 27 G/KM. ELECTRIC ONLY RANGE UP TO 38.5 MILES (WLTP).

Model shown DS 4 Rivoli E-TENSE 225 with optional metallic paint. The fuel consumption or electric range achieved, and CO_2 produced, in real world conditions will depend upon a number of factors including, but not limited to: the accessories fitted (pre and post registration); the starting charge of the battery; variations in weather; driving styles and vehicle load. The plug-in hybrid range requires mains electricity for charging. The WLTP is used to measure fuel consumption, electric range and CO_2 figures. Figures shown are for comparison purposes and should only be compared to the fuel consumption, electric range and CO_2 values of other cars tested to the same technical standard. The figures displayed for the plug-in hybrid range were obtained using a combination of battery power and fuel. Information correct at time of publication. Please contact your DS Retailer for further information.

News

MAXAR TECHNOLOGIES VIA REUTERS

Environment

Kakhovka dam in Ukraine bursts

The Kakhovka Hydroelectric Power Plant in southern Ukraine suffered severe damage on 6 June. It is unclear who or what is to blame, but Ukrainian officials say the breach could release 18 million cubic metres of water, flooding parts of the city of Kherson and nearby villages, as well as affecting cooling at the Zaporizhzhia Nuclear Power Plant.

Human evolution

Homo naledi's complex life

Recent discoveries suggest that *Homo naledi*, an ancient and primitive human species, may have made etchings and buried its dead, despite its small brain, finds **Alison George**

A SPECIES of ancient human with a brain the size of a chimpanzee's may have engraved symbols on cave walls and deliberately buried its dead. These new discoveries about *Homo naledi*, a supposedly primitive hominin, could prompt a rethink of the origins of complex behaviours once thought to be solely the domain of large-brained humans like us.

"It's a remarkable thing. My mind is blown," says Lee Berger at the National Geographic Society in Washington DC, who led the research. "Much of what we thought about the origin of intelligence and the cognitive powers of having a big brain clearly just died," he says, although other researchers who spoke to *New Scientist* question this view.

ROBERT CLARK/NATIONAL GEOGRAPHIC

Fossils of *Homo naledi* laid out at the University of the Witwatersrand in South Africa

H. naledi was discovered in 2013 in the Rising Star cave system in South Africa when two cavers squeezed through an incredibly tight passage into a hitherto-unexplored chamber littered with fossil bones. In 2015, it was declared that these belonged to a new species. We now know that this hominin was about 144 centimetres tall and had a mix of primitive and modern features, with a brain a third the size of ours.

It isn't yet known where *H. naledi* fits in the hominin family tree, but its morphology suggests that its common ancestor with Neanderthals and modern humans dates back a million years or more. Dating of its fossil remains in 2017 showed that it lived relatively recently, from 335,000 to at least 241,000 years ago, so might have met our species, *Homo sapiens*, which evolved in Africa around 300,000 years ago.

In 2021, the discovery of an infant skull in a narrow fissure in the Rising Star cave system that is almost impossible to access indicated that this hominin deliberately interred its dead. The finding also implied that *H. naledi* must have been able to control fire in order to navigate through the labyrinth of dark passages and, in December last year, Berger announced evidence of extensive use of fire in the cave system, such as soot, hearths and burnt bones.

Now, Berger and his colleagues have published more remarkable findings from the Rising Star caves.

The team discovered engravings in the caves only in July last year, when Berger entered them for the first time. He had to lose 25 kilograms of weight in order to squeeze through passages in the rock as narrow as 17.5 centimetres wide. "It was incredibly hard to get in, and I wasn't sure I could get back out," he says.

To his amazement, Berger spotted some engravings on a natural pillar that forms the entrance to a passage connecting the Dinaledi chamber – where *H. naledi* fossils were first discovered – and the Hill antechamber, where other remains had been found.

In three different areas of the walls, he saw geometric shapes, mainly composed of lines 5 to 15 centimetres long, deeply engraved into the dolomite stone. This is an incredibly hard rock, so the engravings would have taken considerable effort to make. Many of these lines intersect to form geometric patterns, such as squares, triangles, crosses and ladder shapes.

Entirely unexpected

"There was this moment of awe and surprise in seeing these highly recognisable symbols carved into the wall," says Berger. "Seeing these symbols was entirely unexpected."

Aside from the 47 people who had recently accessed the caves, there is no evidence that anyone else except *H. naledi* had ever been inside, so the researchers argue that these extinct hominins must have carved the marks. However,

2013

Year the first *Homo naledi* fossils were discovered

144cm

Estimated height of *Homo naledi* based on skeletons

this is only a preliminary report and the team hasn't dated the findings (biorxiv, doi.org/kdgq).

We know that Neanderthals created similar symbols more than 64,000 years ago, as did modern humans in southern Africa from around 80,000 years ago. If the symbols in the Rising Star caves were indeed made by *H. naledi*, they could be far older.

Berger argues that to go to the effort of engraving this incredibly hard rock "in what appear to be important positions within these extraordinarily remote places, the interpretation is that they must have some meaning".

Substantial claims

Other researchers are more cautious. "It is premature to conclude that symbolic markings were made by small-brained hominins, specifically *H. naledi*," says Emma Pomeroy at the University of Cambridge. "While intriguing, exciting and suggestive, these findings require more evidence and analysis to support the substantial claims being made about them."

Berger's team has also detailed new evidence of what could be deliberate burials in the ground – a different mortuary practice to the internment of corpses in niches, such as the infant skull discovered in 2021.

At one place in the Dinaledi chamber, the researchers found 83 bone fragments and teeth, seemingly from a single body, in an oval-shaped area of disturbed soil.

They also found another possible burial site in the Hill antechamber. In this instance, they encased an area of debris with a high concentration of bone fragments in plaster, allowing them to remove it from the cave system intact and use a CT scanner to reveal its contents.

This showed many bone and teeth fragments, mainly from one juvenile that seemed to have been in a fetal position, an arrangement also found in prehistoric *H. sapiens* burials, along with some fragmented remains of three other juveniles. Intriguingly, a single stone artefact – a distinctive crescent-shaped stone, 14cm long, with striations on its surface – was found close to the hand of one of the bodies (bioRxiv, doi.org/kdgp).

Although these analyses are only preliminary, the researchers argue that the orientation of the bones and patterns of soil disturbance indicate that bodies were interred in pits that had been deliberately dug out, then covered in sediment. If confirmed, these burials would predate the earliest known human burial in Africa by at least 160,000 years.

Other experts aren't yet convinced. "This is an admirable attempt to demonstrate that the corpses of at least two individuals were deliberately buried in shallow pits, and one can certainly not rule this out," says Paul Pettitt at the University of Durham, UK. "I'm not convinced that the team have demonstrated that this was a deliberate burial. Let's walk before we can run."

"This is remarkable behaviour for a creature with an ape-sized brain. It suggests organisation"

Silvia Bello at the Natural History Museum in London points out that the bones are fragmented, while skeletons that are deliberately buried usually show better preservation.

Further analysis, such as a more detailed scan of the Hill feature, should help clear up this issue. Nevertheless, the new studies are already building an ever-richer picture of *H. naledi* and its behaviour. "The evidence is impressive," says Chris Stringer, also at the Natural History Museum.

"These humans were taking carcasses, bodies of fellow naledis, down deep into the cave, and they must have had artificial lighting," he says. "This is remarkable behaviour for a creature that's got an ape-sized brain. It suggests organisation, because this is not something a single individual would have done, it must have been a group activity. And it's obviously happened multiple times. That implies the existence of what we might call a culture – [in] a different species, not closely related to us."

"There's a lot of very intentional behaviour in that cave complex," says Genevieve von Petzinger at the Polytechnic Institute of Tomar, Portugal. "It's not like a bunch of people fell in a hole and scraped some marks."

These kinds of sophisticated behaviours were only thought to be possible in hominins with large brains, such as *H. sapiens* and Neanderthals. "These are challenging finds and they certainly make us think about what it is to be human," says Stringer, raising questions about why we developed such large brains.

In the meantime, further research at the Rising Star cave system will be limited while the researchers work out how best to investigate this site without destroying it.

"*Homo naledi* altered almost every single space. That has caused me to become incredibly cautious about allowing people into that space until we decide exactly how we're going to approach it," says Berger, who wants to engage the world's scientific community in addressing this question. "We, as humans, have to decide how we're going to approach the space of another species that they clearly saw as critically important to them." ▮

A reconstruction of a *Homo naledi* head (below) and crosshatch engravings (right) from the Rising Star caves in South Africa thought to have been made by *H. naledi*

MARK THIESSEN/NATIONAL GEOGRAPHIC; BERGER ET AL., 2023

Health

Antibiotic clovibactin kills even the superbugs that are resistant to drugs

Michael Le Page

AN ANTIBIOTIC called clovibactin is highly effective against "superbugs" such as MRSA in lab tests, and kills bacteria in an unusual way that means it will be difficult for resistance to evolve.

Clovibactin was discovered in a rare bacterium isolated from sandy soil in North Carolina. Markus Weingarth at Utrecht University in the Netherlands and his colleagues have been studying how it works, with promising results. "The activity is even better than for the gold standard, vancomycin," says Weingarth.

Antibiotic resistance is a growing problem worldwide. It has been estimated that it killed 1.3 million people in 2019 – more than malaria and AIDS combined – and contributed to the deaths of almost another 4 million people.

This means there is a desperate need for drugs that can kill bacteria resistant to older antibiotics and, ideally, kill in new ways, so it is harder for resistance to evolve and spread.

Clovibactin fits the first criterion because the team found it kills a range of disease-causing bacteria, including methicillin-resistant *Staphylococcus aureus*, better known as the MRSA superbug, and *Mycobacterium tuberculosis*, which causes TB.

"The more targets the antibiotic has, the more difficult it is for bacteria to develop resistance"

Weingarth's team has also found that clovibactin works unlike any other known antibiotic. Many existing ones target the cell wall around bacteria, a rigid, mesh-like structure surrounding the cell membrane. If the wall is disrupted, cells burst and die. This wall isn't found in animal cells, meaning the antibiotics kill only bacterial cells. But existing antibiotics typically target the enzymes that assemble the cell wall, and bacteria can alter the shape of these proteins to evade attack.

Clovibactin instead targets a chemical group called a pyrophosphate that is found on three different building blocks of cell walls. So, to survive, a bacterium would have to alter all three. "The more targets you have, the more difficult it is for bacteria to develop resistance," says Weingarth.

The team exposed bacteria to low doses of clovibactin to see if resistance emerged, but found none (bioRxiv, doi.org/kdc2). Lower doses are more likely to lead to resistance because bacteria can survive and any that acquire resistance will outcompete others.

This doesn't mean resistance to clovibactin is impossible. For instance, many bacteria are classified as Gram-negative, meaning they have an extra membrane that protects them from some antibiotics, including clovibactin. Gram-positive ones without this barrier, such as MRSA, could, in theory, evolve one, but it is a major structural change that is unlikely, says Weingarth.

"Clovibactin is a great lead for the development of a new class of antibiotics," says Gerry Wright at McMaster University in Canada. "We have not approved a truly new anti-Gram-positive drug class for over 20 years."

"We have relatively few good alternative antibiotics for Gram-positive infections," says Wright. "There is growing resistance to all available drugs."

In tests in mice, clovibactin didn't seem to have any adverse effects, and it is now being developed further by US company NovoBiotic Pharmaceuticals. "It's a very, very long way from mice to humans," says Weingarth. "I don't want to oversell this." ▮

Mathematics

'Spectre' tile covers surfaces without the pattern repeating

A NEWLY discovered shape of tile can cover a surface without creating a repeating pattern and without using mirror images.

Simple shapes such as squares can tile a surface without gaps in a repeating pattern. Mathematicians have long been interested in a version of tiling, known as aperiodic tiling, which involves using more complex shapes that never form such a repeating pattern.

The most famous aperiodic tiles were created by mathematician Roger Penrose, who in the 1970s discovered that two different shapes could be combined to make an infinite, never-repeating tiling.

In March, Chaim Goodman-Strauss at the University of Arkansas and his colleagues discovered the "hat", a shape that could do it alone, but using a left-handed and right-handed version of the shape. This was a slightly unsatisfying solution and left the question of whether a single shape could achieve the same thing with no reflections required.

The researchers have now tweaked the equilateral polygon from their previous research to create a family of shapes called spectres. These allow non-repeating pattern tiling using no mirror images at all.

Until now, it wasn't clear whether such a single shape, known as an einstein (from the German *"ein stein"* or "one stone"), could exist. The researchers say in their paper that the discovery of the hat was a reminder of how little understood tiling patterns are.

DAVID SMITH, JOSEPH S. MYERS, CRAIG S. KAPLAN, CHAIM GOODMAN-STRAUSS

The "spectre" shape at the top of this image can repeat without reflections, unlike the "hat" in the bottom part

"Certainly there is no evidence to suggest that the hat (and the continuum of shapes to which it belongs) is somehow unique, and we might therefore hope that a zoo of interesting new monotiles will emerge in its wake," they write (arXiv, doi.org/gr96bq).

"It's very intellectually satisfying to have a solution that doesn't need the mirror image, because if you actually had real tiles, then a tile and its mirror image are not the same," says Sarah Hart at Birkbeck, University of London. "With this new tile, there are no such caveats." ▮

Matthew Sparkes

Climate adaptation

Reflective film could cool a city

Coating roofs in a mirror-like film has brought down indoor temperatures in Freetown, Sierra Leone, which is frequently subject to extreme heat, finds **James Dinneen**

A CHEAP, mirrored film can substantially reduce the temperature inside a building if it is used to cover the roof, according to an experiment in Freetown, the capital of Sierra Leone.

Temperatures in Freetown regularly spike above 40°C (104°F) during the dry season from December to April, and remain hot even at night. The hottest days are projected to become more frequent with climate change.

The heat is also exacerbated by the urban heat island effect – a phenomenon in which urban areas get hotter than nearby rural areas due to less vegetation, less air flow and more heat-absorbing material on buildings and roads.

"The heat data shows everywhere in Freetown is getting hotter, but there are also communities that stay hotter throughout the day," says Eugenia Kargbo, the city's chief heat officer.

This was particularly true of the numerous informal settlements built around the city. These hold tens of thousands of people and most buildings there are made from uninsulated concrete walls and corrugated zinc roofing that absorb and trap heat.

Kargbo says the heat and humidity, along with high levels of air pollution in the settlements, make for a "toxic combination" for residents' health and well-being.

She has experimented with many ways to protect people from heat, including planting hundreds of thousands of trees across the city and installing shading structures made of reflective plastic in a crowded marketplace.

The city's buildings are hot and getting hotter, though, so when a group of researchers approached Kargbo with a plan to cover roofs in mirrors to cool them off, she thought it was worth a try: "I said, 'why not?'"

MEER

Mirrored film on two roofs in Sierra Leone (above) made it cooler inside. The roofs (right-hand pair of rectangles in top-right image) show up darker, so cooler, on a heat map

The proposal came from US non-profit organisation MEER (Mirrors for Earth's Energy Rebalancing). Founder Ye Tao was in search of a place to test the cooling effects of a reflective film the organisation had developed out of recycled PET plastic and aluminium. In theory, a building covered in the film would absorb less of the sun's radiation and be cooler than one roofed with metal or tar.

After consultation with residents, Kargbo, Tao and their colleagues decided to test their reflective film in Kroo Bay. The settlement is one of Freetown's largest with more than 10,000 people living in roughly 1 square kilometre.

Jalahan Sesay, a recent graduate from the University of Sierra Leone who surveyed residents as part of the MEER project, says most people in Kroo Bay sleep outside during the hottest time of year because staying indoors is intolerable. Most buildings lack a ceiling to separate the living space from the roof. "It's like having a radiator on top of people's heads," says Tao.

Working with local carpenters, Tao and his team installed mirrored film on the roofs of two residences. To compare its effectiveness against other cooling strategies, they painted the roof of a third residence white and added a new metal roof to a fourth.

15°C

A roof covered in film was this much cooler than uncovered roofs

All four buildings were similarly constructed and had around 180 square metres of roof area.

During the day, the interior temperature of the building with the new zinc roof was on average 1 to 2°C cooler than before, and the building with white paint was about 3°C cooler. Inside the two buildings covered in film, it was 6°C cooler, says Tao. The roofs of the two mirrored buildings were 15°C cooler than those without the film, on average. While the zinc roof appears coolest in a heat map (bottom-left dark building in the yellow image above), measurements revealed that the mirrored roofs were cooler.

Sedie Sowa, another MEER intern who surveyed residents in Kroo Bay, says families who live in the mirrored buildings are pleased with it. "They say they sleep comfortably."

David Sailor at Arizona State University says assessing the amount of cooling depends a lot on measurement conditions. Cooling effects from reflecting the sun's rays will be greatest on days with the most sunlight, for example, but he says a 6°C reduction is substantial. "There's a lot of potential there not just to improve comfort, but to save lives," he says.

Tests are ongoing, but Kargbo aims to cover more buildings with reflective film. If an entire neighbourhood were covered, Tao says the cooling effects could accumulate as air flows across roofs, lowering temperature across whole areas. ▮

Field notes The Thames Tideway Tunnel, London

A super sewer designed to fight river pollution

A huge concrete pipe is being built under London to reduce the frequency of sewage discharges into the river Thames. **Graham Lawton** gets inside

SAVE BRITAIN'S RIVERS

IN JUST over a year's time, where I am standing will be pitch black, devoid of human life and – on a bad day – full of human effluent. I am in London's new super sewer, a monstrous concrete pipe that runs roughly along the course of the river Thames for 25 kilometres. It is designed to solve a problem that London and many other cities have been grappling with for decades: the discharge of raw sewage into rivers.

London's current sewage system is creaking at the seams. It was built between 1859 and 1875 after the Great Stink of 1858. At the time, the city's population was about 3 million. Visionary engineer Joseph Bazalgette designed a sewer to cope with 4.5 million people plus rainwater. Some 9 million now use it, the weather is wetter and London has been extensively concreted over, preventing rainwater from being absorbed by the ground.

The system can no longer cope. About 60 times a year it overflows, dumping a total of 40 million tonnes of raw sewage per year into the Thames plus wet wipes, sanitary products, condoms and whatever else people see fit to flush down the loo.

"Our job is to build a sewer that will address that," says Andy Mitchell, CEO of Tideway, the company behind the project. The answer the firm came up with was to build a giant pipe deep underground, beneath the Victorian sewer, to intercept its overflows. The Thames Tideway Tunnel is one of the biggest city sewer projects in the world, says Mitchell.

It won't solve the problem completely: when the rain is really heavy, there will still be discharges. But it will reduce their frequency to around three or four times a year, and the overflow will be

PATRICIA RAYNER/IMAGE 2 PHOTOGRAPHY

DAVID STOCK/NEW SCIENTIST

Clockwise from top: Inside the Thames Tideway Tunnel; Graham Lawton approaches the entrance; the giant access shaft to the tunnel

7.2
The diameter of the Thames Tideway Tunnel in metres

1.6
The tunnel's capacity in millions of cubic metres

8
The number of years it has taken to dig and build the tunnel

predominantly rainwater. "The Bazalgette system gets full of undiluted sewage," says Mitchell. "If it rains heavily, that gets channelled into the sewers, and the sewers get full. They then flush into the river. But it's that first flush, which is pure sewage, which is the most damaging. We capture that."

We kit ourselves out in high-vis clothing, hard hats and boots and head to the access shaft, a yawning concrete caldera about the diameter of a cooling tower and 50 metres deep. It has to be this big to get the huge boring machines down to dig out the hole for the tunnel.

We clamber into the "VIP lift" – actually a metal cage attached to a crane – and are gently lowered to the bottom. From there, we walk down the sewer itself to get a feel for the scale of this colossal engineering project. The circular tunnel is 7.2 metres across. It took eight years to build at a cost of £4.5 billion. Its total capacity is 1.6 million cubic metres.

There is no sewage in there now – the dirty work starts next year – and the tunnel is eerily beautiful, like smooth alabaster in the cold glow of the strip lights. "This is one of the most photogenic pieces of tunnel I've ever built," says Mitchell.

That is because there is a sinuous kink that is oddly pleasing to the eye. It wasn't planned, but they had to skirt around a boring machine that became stuck, doing a "turn and bury" manoeuvre to get it out of the way. The borer is now sealed behind the concrete tunnel wall and will be there forever.

The tunnel slopes gently down from west to east, a few millimetres every metre. That enables the sewage to flow by gravity, no pumping required. "It doesn't sound much, but it's enough to keep it moving," says Mitchell.

This descent adds up to 55 metres along the length of the tunnel. When the sewage arrives at its destination, Beckton Sewage Treatment Works, it is 80 metres underground and has to be pumped back up. But the tunnel itself has no moving parts.

In around a year, the project will be complete. The lights will be removed, the access shafts capped and the tunnel plunged into lonely darkness for at least 120 years.

It is possible that we are among the last people to set foot in it, says Mitchell. Maintenance inspections will be carried out by drone. "Technically, we could go down if we have to," he says. "But unless there's a repair, which is highly unlikely, we're unlikely to ever go down there again." ▮

Technology

Massive Turing test shows we often fail to distinguish chatbot AIs from a person

Alex Wilkins

PEOPLE can only tell apart artificial intelligences and humans about 60 per cent of the time, according to a test taken by more than 1.5 million people. The results raise questions about whether the new generation of AIs should have to identify themselves in conversation, say researchers.

Computer scientist Alan Turing first proposed a test for machine intelligence in 1950. In its original form, a person talks via text with both another person and a machine and has to guess which is which. If they can't differentiate, then the machine has passed the Turing test.

Daniel Jannai at AI21 Labs in Tel Aviv, Israel, and his colleagues devised an online game inspired by the Turing test. In their version, a player can swap messages with either a large language model, like ChatGPT's GPT-4, or with another player for 2 minutes to try to work out who or what they are interacting with.

To avoid the AIs giving themselves away when asked, the researchers used three different language models, sometimes switching between them within a single conversation, and gave the AIs random prompts to act as people with specific intentions and objectives. They also incorporated a typing delay for all players to mask the rapid computation time of the models.

The results of 1.5 million conversations show that people could only tell if they were dealing with another human or an AI 68 per cent of the time. Focusing only on the conversations with AIs, this shrank to 60 per cent, meaning that 40 per cent of people mistakenly identified an AI as human – not much better than a coin flip (arXiv, doi.org/kddm).

Jannai and his colleagues were surprised at the ways in which people managed to detect AIs or signal to each other that they were human, such as using local slang or asking the AIs to do things they are forbidden to, like provide instructions for making a bomb.

"Should people be informed about whether they're talking to a person or an AI?"

Nishanth Sastry at the University of Surrey, UK, says that interactions longer than the 2 minutes allowed in the test could make it easier to identify AIs.

There are also long-standing questions as to how useful the Turing test is for assessing machine intelligence, he says. "When you ask, 'Is an AI entity intelligent?', it's ill-defined. You can ask, 'Is an AI good at maths?' Or, 'Is an AI good at finding solutions to conflicts when they happen in the workplace?' Those are slightly better defined, and there might be more concrete answers. In that sense, I find the Turing test less helpful."

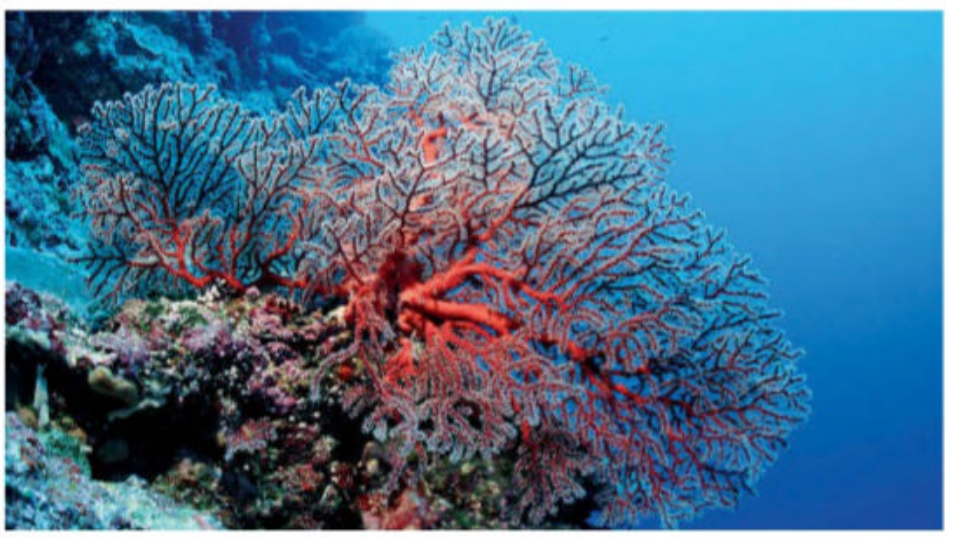
Even if some people aren't fooled by AIs, enough are to raise concerns, says Jannai. "Given that, at least in some cases, people can't tell the difference, what interactions do we want, and should we want, people to experience when they're interacting with AI bots?" he says. "Should people be informed about whether they're talking to a person or not, or is it OK for a company to let people talk to customer service bots without acknowledging the fact they're robots?" ▮

Marine biology

Coral reef microbe community is staggeringly diverse

THE microbes on coral reefs in the Pacific Ocean appear to be more varied than the microbiome of the rest of the planet's ecosystems combined. This could mean we have vastly underestimated the total microbial diversity on Earth.

Coral reefs make up less than 1 per cent of the ocean, yet are home to nearly a third of marine species of animals and plants. A two-year expedition launched in 2016 and led by Serge Planes at the University of Perpignan in France visited 99 reefs across the Pacific Ocean. At each reef, the researchers collected seawater and took samples of three species of coral and two species of fish.



WATERFRAME/IMAGEBROKER/SHUTTERSTOCK

A coral reef in Palau, one of the regions surveyed for microbial diversity

They sequenced a key section of DNA from bacteria and archaea present in the samples. Within the roughly 3 billion sequences produced, they found more than half a million unique ones, indicating vast microbial diversity. Samples from different parts of the ocean also had distinct microbiomes.

"The diversity of the corals is reflected in the diversity of the microbiome," says Pierre Galand at Sorbonne University in Paris, part of the team.

Extrapolating those results to the microbiomes of hundreds of other coral species and thousands of fish species in Pacific reefs, the researchers say the total microbial diversity on all the reefs would be nearly six times higher. This may be greater than some estimates of the microbial biodiversity of the entire planet, they say (*Nature Communications*, doi.org/kc2j).

Microbial diversity plays a crucial role in reef ecosystems. Some corals have symbiotic relationships with bacterial species, for instance. Other microbes accelerate nutrient cycling or protect against pathogens.

"The microbes really do run these ecosystems because they're involved in so many different kinds of processes," says Deron Burkepile at the University of California, Santa Barbara. ▮

James Dinneen

Health

Stem cells may help type 1 diabetes

Infusions of cells derived from umbilical cords slowed the need for insulin injections

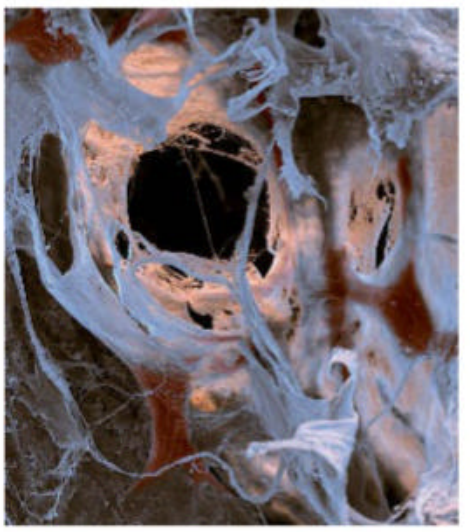
Clare Wilson

A DOSE of stem cells taken from umbilical cords can delay the progression of type 1 diabetes, a small trial has shown.

Type 1 diabetes usually begins in teenagers and young adults, if the immune system starts to mistakenly attack cells in the pancreas that make the hormone insulin, which regulates blood sugar. People with the condition therefore have to inject insulin.

To explore the potential of stem cells in treating type 1 diabetes, Per-Ola Carlsson at Uppsala University, Sweden, and his colleagus infused 10 adults who had an early stage of the condition, diagnosed in the previous year or so, with "mesenchymal" stem cells sourced from the goo inside umbilical cords known as Wharton's jelly. Five other people with type 1 diabetes received a placebo infusion.

Stem cells are similar to the cells in developing embryos, in that they can multiply and develop into different tissues. Several kinds of stem cells are found



EYE OF SCIENCE/SPL

Scanning electron micrograph showing mesenchymal stem cells (red) grown in a culture

in different parts of the body, but mesenchymal stem cells seem to have a knack for dampening a harmful immune response, which can occur if the body spots foreign cells. "They release a lot of chemical signals that modulate the patient's immune system," says Lindsay Davies at Nextcell Pharma in Sweden, the firm that is developing the therapy.

People with newly diagnosed type 1 diabetes usually see their insulin production decline over several years, so need increasingly large doses and frequent top-ups. In the trial, those who got the stem cells had no change in their insulin requirements over the next 12 months, but requirements increased in the placebo group.

The researchers also measured the participants' levels of C-peptide, a marker of how much insulin your body makes. In those who had the stem cells, C-peptide levels fell by 10 per cent after one year, compared with a fall of nearly 50 per cent in the placebo group (*Diabetologia*, doi.org/kc2k).

Mesenchymal stem cells have another advantage over other types of stem cells. They could potentially be used "off the shelf", rather than having to be created personally for each recipient, as is the case with stem cells made from someone's blood cells, for instance. That is because they lack molecules on their surface that normally trigger an immune attack when cells or tissues from one person are transplanted into someone else.

Stem cells are a hot topic in medical research, but have had mixed results so far. For instance, there was initially hope they could become a treatment for heart attacks, but larger trials showed they don't work for this.

Nextcell aims to get more consistent effects by sampling mesenchymal stem cells from multiple umbilical cords. For each batch, the researchers assess stem cells from 30 babies' umbilical cords and select cells from the five cords that show the most promising immunological properties. This makes enough of the therapy, known as ProTrans, to treat up to 40 people with early stage type 1 diabetes, says Davies.

Daniel Drucker at Sinai Health in Toronto, Canada, says the results are promising, but he is cautious as it is a small study. What's more, years of monitoring will be needed for those being treated to ensure the cells don't trigger a harmful immune response, he says. ▮

Environment

Canadian wildfires have emitted record amounts of carbon

WILDFIRES in Canada released record-breaking amounts of carbon in May, showing how the risk of blazes is increasing even before the summer fire season begins.

Emissions for the month reached 54.8 million tonnes, more than double the carbon emitted by wildfires in any May since estimates began in 2003, according to the Copernicus Atmosphere Monitoring Service. In the boreal forests of western Canada, provincial records were set in British Columbia, the Northwest Territories and Saskatchewan, which exceeded its previous high by 15 times.

Carbon emissions also reached new peaks in rainy Nova Scotia. The province has been struggling with its biggest blaze ever, and its emissions for May totalled 1.1 million tonnes, more than in any full year previously.

"It's certainly a shock that it's so active across such a wide area of Canada and so early, before the summer season started," says Mark Parrington at the European Centre for Medium-Range Weather Forecasts in Bonn, Germany. "The concern is the risk [of fire] is increased earlier in the season."

As conditions become hotter and drier, wildfires are burning with more intensity, making big fire years bigger, he adds. Some 2.7 million hectares have burned this May, said Bill Blair, Canada's emergency preparedness minister, on 1 June.

A record-breaking inferno near Barrington Lake, Nova Scotia, has burned more than 17,000 hectares. Flames have reached 90 metres in height, "rolling like a freight train" through forests at the south of the peninsula, Dave Rockwood at the Nova Scotia Department of Natural Resources said in a webinar on 31 May.

"The smoke travelling thousands of kilometres is also an indicator of the size of the fires"

A dozen other fires are burning in the province, including near the capital of Halifax. More than 200 houses have been destroyed and 21,000 people evacuated.

Air quality alerts have been issued in several US states and smoke from western Canadian wildfires has blown to the Arctic Ocean and Scandinavia.

"The fact that the smoke travels so many thousands of kilometres is also an indicator of the size of [the fires] and the intensity," says Parrington. ▮

Alec Luhn

Space

Weird filaments of gas are hiding at our galaxy's centre

Leah Crane

THE Milky Way contains hundreds of strange threads of hot gas, which may have been formed by a blast from Sagittarius A*, the black hole at our galaxy's centre.

Farhad Yusef-Zadeh at Northwestern University in Illinois and his colleagues discovered the filaments using data from the MeerKAT radio telescope in South Africa. In the 1980s, he found vertical filaments aligned perpendicular to the galaxy's disc, but the new ones are horizontal.

"The vertical filaments are aligned with the galaxy's magnetic field, but the rest should be randomly aligned," he says. "The pattern that I saw caught me by surprise – at first, I didn't believe it."

While the vertical filaments measured up to 150 light years tall, the horizontal ones are only 5 to 10 light years long, all pointing towards the black hole. These horizontal filaments seem to be made of gas, unlike the vertical filaments, which are probably formed of high-energy electrons. They also seem to be moving away from Sagittarius A*, towards the outer areas of the galaxy where Earth sits.

This indicates they may have formed when a jet blasted out of the black hole, stretching the gas it passed through into tendrils. They are fairly close to Sagittarius A*, so the blast probably began 6 million years ago (*The Astrophysical Journal Letters*, doi.org/kc3t).

There have been previous hints that such an outburst occurred, but they haven't been confirmed. "We really want to piece together these larger-scale structures with the smaller scale around the black hole and show that there really is this jet coming out along the disc of the galaxy," says Yusef-Zadeh.

This could change our understanding of the black hole's spin axis, he says, which would be a clue as to how our galaxy formed. ▮

Analysis Aviation fuel

Why using pig fat to fuel planes is hogwash

Airlines plan to use biofuel made from fat to meet sustainability targets, but this would actually increase emissions, says **Michael Le Page**

AIRLINES could soon start using fuels made from animal fats to help them meet climate targets. However, this could increase rather than reduce carbon emissions, warns a report for campaign group Transport & Environment.

European Union regulations encourage the use of animal fats as a fuel and require airlines to increase the proportion of "sustainable aviation fuels" they use by 2030. Several oil companies have announced plans to produce aviation fuels from animal fats, which are expected to be the second main source of so-called sustainable fuel after used cooking oil.

There are two major issues with turning animal fats into jet fuel with the aim of reducing greenhouse gas emissions. The first is that, although animal fats are waste products of the meat industry, they are already used. "With used cooking oil, to a great extent, the biodiesel industry has given a use to something that wasn't being well utilised, but it's different with animal fats," says Chris Malins, who wrote the report.

In 2006, the meat industries in the UK and EU produced some 2.4 million tonnes of rendered, or purified, fat. In roughly equal proportions, this fat was used in pet food, to make products such as soap and to generate heat and power. Only a small percentage was turned into biodiesel.

In 2021, the UK and EU produced about 2.8 million tonnes of rendered fat, of which nearly half was turned into biodiesel, mostly for use in cars and trucks, with the rest going into pet foods and cosmetic products. Hardly any is used directly for heat and power any more.

8800

Fat from this many pigs would fuel a single transatlantic flight

If the aviation industry starts using significant amounts of animal fat, there will be less for these existing purposes. The cosmetic and pet food industries are likely to turn to palm oil – the cheapest product with similar properties, says Malins.

That means more forests will be cleared to grow oil palms, which could lead to emissions increasing by up to 70 per cent compared with carrying on using fossil fuels to power aircraft, says the report.

The second major issue is that the aviation industry is using cheap, animal fat-based fuels as an alternative to investing in better approaches, such as cellulosic biofuels, which are made from the fibrous parts of plants, says Malins.

As there is too little animal fat to go around, this is no long-term solution. Demand for jet fuel in the EU is projected to reach about 46 million tonnes of crude oil equivalent a year by 2030. If all the animal fat produced in the EU were turned into jet fuel, it could supply 3 per cent of that at most, calculates Malins. That is unsurprising given it would take the fat from 8800 pigs to fuel a flight from Paris to New York, according to the report.

There is a broader issue here. Using waste biomass can be truly green, unlike growing biomass for energy. But most waste biomass that can be used is being used, so regulatory incentives aimed at encouraging further take-up can have undesirable consequences.

For instance, the EU's incentives for turning used cooking oil into biofuel have led to Asian countries exporting used cooking oil that was previously being used for other things. Those countries then have to replace that oil with other products, raising emissions. In some cases, unused oil has been sold as used, say environmental campaigners. Similarly, much of the "waste wood" burned in power plants may not be waste at all.

As for aviation, for now, there are simply no genuinely sustainable zero-emission fuels available in the quantities required. Aside from improving energy efficiency, in the short term, the only way to reduce aviation emissions is to fly less. ▮

The aviation industry is under pressure to lower its emissions

GUVENDEMIR/E+/GETTY IMAGES

Space

Planned moon landings could pelt orbiters with dusty debris

Jonathan O'Callaghan

FUTURE moon missions with large landers may stir up clouds of dust from the lunar surface, which could be dangerous for orbiters or even space stations.

Later this decade, NASA hopes to return humans to the surface of the moon with its Artemis programme. Two companies in the US, SpaceX and Blue Origin, have been contracted to develop landers that could take humans to the lunar surface by 2025 at the earliest.

However, Philip Metzger at the University of Central Florida says there may be a complication. An analysis he has done with James Mantovani at Kennedy Space Center in Florida shows that large landers on the moon could kick up huge amounts of dust as they touch down. Since, unlike Earth, the moon doesn't have a strong magnetic field or an atmosphere to trap dust, it could escape into space and damage passing spacecraft.

"As we begin more activity on the moon, the rocket exhaust from landings is going to be spraying more soil off the moon up into these orbital altitudes," says Metzger. "Within a few decades, I think this is going to be a very serious problem."

Using mathematical models, the pair studied how much dust would be stirred up by landers weighing more than 40 tonnes – eight times the mass of the Apollo landers – such as the SpaceX and Blue Origin lunar vehicles. He found they would kick up millions of pieces of dust that would easily reach the escape velocity of the moon, 2.4 kilometres per second, and escape its gravitational pull.

This dust could then travel through lunar orbit and hit any orbiters overhead, particularly any at less than 110 kilometres above the surface, with millions of impacts per square metre (arXiv, doi.org/gr9xxt).

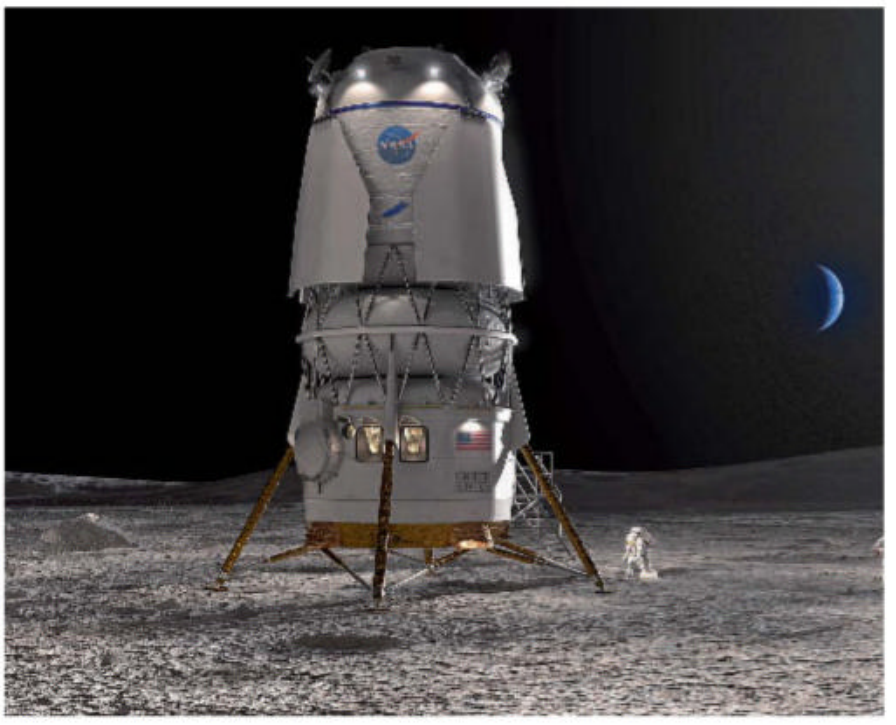
"The dust will be impacting at hypervelocity," says Metzger, meaning thousands of metres per second. While unlikely to destroy a spacecraft, this could degrade radiators, solar arrays or science instruments, he says.

Also of concern would be NASA's planned Lunar Gateway space station, which is designed to orbit between Earth and the moon and will frequently pass near the moon. "NASA's Gateway is going to be hit by many, many tiny particles," says Metzger, about 10,000 impacts per square metre every time it passes the moon. While not causing major damage, this may erode the station's exterior.

10,000

Estimated dust impacts per m² on NASA's lunar space station

Mihály Horányi at the University of Colorado Boulder, who worked on NASA's LADEE moon orbiter in 2013, says the dust shouldn't be an issue unless an orbiter is overhead when a lander touches down. "I don't believe this is a real hazard," he says.



BLUE ORIGIN

Artist's depiction of Blue Origin's Blue Moon lander

Ian Christensen at the Secure World Foundation in the US, however, says the study shows the need for coordination, because private companies and other nations such as China are also planning landings. "As the tempo of lunar activity increases, it will be necessary to find ways to mitigate the creation of debris," he says.

NASA and SpaceX didn't respond to a request for comment. Blue Origin declined to comment.

Metzger says a solution might be to reduce disturbance by having a lander's thrusters high on the vehicle, as is planned on SpaceX's Starship lander. Building landing pads for spacecraft to touch down on would also help, he says. ▮

Health

Octopus ink compound can target cancer cells

Kenna Hughes-Castleberry

A CHEMICAL found in octopus ink has been created artificially and used to kill cancer cells. The development could lead to new cancer treatments.

Octopuses release ink into water when attacked to help them escape from predators. Martín Samuel Hernández-Zazueta at the University of Sonora in Mexico and his colleagues had previously identified a compound called ozopromide that is found in the ink sac of common octopuses (*Octopus vulgaris*) as one of interest for its anti-cancer properties.

The researchers used a series of standard chemical reactions to create ozopromide artificially. Then, to explore its potential as a cancer treatment, they injected the compound into cancerous human breast, cervix, prostate and lung cells.

They found that the presence of ozopromide resulted in the death of a significant portion of the cancerous cells, with the highest proportion being a 50 per cent decrease in cancer growth in lung cells. The compound didn't affect the nearby non-cancerous cells.

Many current cancer treatments, including immunotherapy, can cause inflammation as an unwanted side effect. The team found that ozopromide actually reduced the production of inflammatory proteins around the cells, promoting better overall healing from the cell death (*Food and Chemical Toxicology*, doi.org/kc2f).

The researchers hope this indicates that the compound could eventually lead to a cancer treatment without inflammation as a side effect.

Charles Derby at Georgia State University in Atlanta says the work is a "big deal". However, it "is just the first step in a long series of steps to determine if this molecule will be useful in human medicine". ▮

Environment

Reusable granules suck harmful PFAS ‘forever chemicals’ out of water

Madeleine Cuff

GRANULES that selectively target and extract harmful “forever chemicals” from water could help clean up pollution.

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a class of synthetic chemicals widely used in coatings and foams that resist oil, heat and water. There are thousands of types of PFAS, used in everything from dental floss to waterproof jackets and non-stick pans.

Several of these substances have been shown to cause harmful health effects, such as thyroid issues, cancer and reproductive problems. They are also long-lasting environmental contaminants due to the tough carbon-fluorine bonds that they contain.

To deal with this, Puraffinity, a UK start-up, has developed aluminium granules coated with patented compounds with a high affinity for binding to PFAS chemicals. The granules sit in a treatment chamber, which water is flushed through. Their coating can target and “lock up” PFAS chemicals from the water. The end product is fine, white granules.

Third-party verification testing conducted by German research agency TZW and seen by *New Scientist* confirms that Puraffinity’s technology can remove PFAS to the standard required by the US Environmental Protection Agency for a longer period of time than competitors. This means the technology lasts for longer before it has to be replaced or recharged, cutting energy demand and costs.

A warning about PFAS pollution in the Huron river in Michigan

JIM WEST/ALAMY

The PFAS can be discharged from the saturated granules by washing them through a “regeneration fluid”, before the concentrated PFAS chemicals are sent for destruction, says Puraffinity co-founder Henrik Hagemann. The granules can then be reused.

Currently, Puraffinity can produce only 5 tonnes of its adsorbent material a year, but has funding to scale that up to 250 tonnes a year by the end of 2024, enabling commercial sales.

Hagemann says Puraffinity has been approached by airports, textile manufacturers and oil and gas companies all looking to reduce PFAS pollution.

Terrence Collins at Carnegie Mellon University in Pittsburgh, Pennsylvania, reviewed the third-party analysis and says Puraffinity’s technology looks “pretty impressive”. But he warns that more testing will be needed to ensure the solution is safe and non-toxic, and strict protocols will be necessary to ensure all captured PFAS substances are subsequently destroyed. Ultimately, the entire PFAS industry must be “shut down”, he stresses.

The European Union has set out plans to ban the use of all 10,000 PFAS chemicals during the 2030s, a move Hagemann supports. But he says exemptions for the semiconductor, solar and vaccine industries mean PFAS use will probably continue through the 2030s and beyond.

“We think that there’s going to be a replacement of PFAS for most uses,” says Hagemann. “But there are essential uses where you’re likely to continue using it, especially related to the net-zero journey.” ▮

Animals

Stressed monkeys lost tooth enamel after losing habitat

MONKEYS on a Japanese island experienced a severe loss of tooth enamel during the 1980s, which researchers believe was caused by the stress of culling programmes and the destruction of their habitat.

The condition would have been extremely painful and made it difficult for the macaques to eat, says Ian Towle at the Spanish National Research Center for Human Evolution in Burgos. “Their teeth will wear down to nothing and it will expose the living part of the tooth, the pulp chamber,” he says.

During the 1960s and 1970s, the island of Yakushima was heavily logged, with the natural forest cleared to make way for orange and conifer plantations. The native population of Japanese macaques (*Macaca fuscata*) began raiding the orange plantations for food, prompting the use of traps and culls in the 1980s. At least 3000 macaques died this way over the course of the decade.

Skeletal remains of macaques whose teeth developed during this period reveal that severe loss of dental enamel was common in those from the worst-affected areas of the island.

Plane-form enamel hypoplasia (PFEH) is a condition in which large areas of a tooth’s crown are devoid of enamel. It can be caused by periods of severe stress. Towle and his colleagues looked at dental specimens from 48 macaques from three neighbouring islands in Japan.

“Their teeth will wear down to nothing and it will expose the living part of the tooth”

Only individuals from Yakushima had PFEH, affecting 10 out of 21 monkeys studied from the island. All were from the southern part of the island, where deforestation and culling were most rife (bioRxiv, doi.org/kcwx).

Towle says it is “very likely” that stress caused by deforestation and culling on Yakushima was the main driver of PFEH occurrence in the macaque population, given that the condition affected a large proportion of the animals, and the known stress on the population at the time. ▮

MC

Health

Virus that can deliver a huge payload of DNA could improve gene therapies

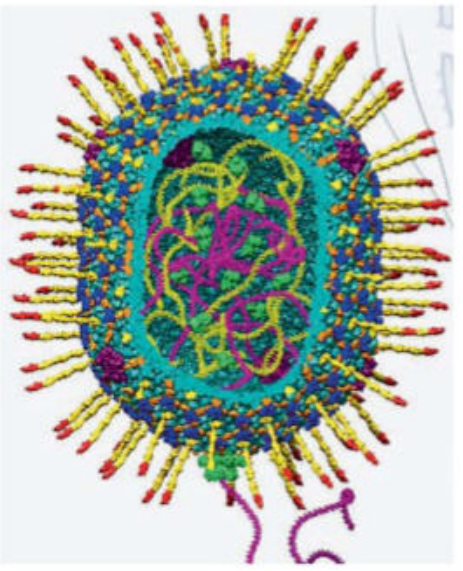
Michael Le Page

A MODIFIED bacteria-killing virus, known as a phage, can deliver far more DNA to human cells than is possible with existing techniques. This capacity could lead to major advances in cell and gene therapies by allowing more sophisticated changes to be made to cells in a single step.

The modified virus can carry DNA strands up to 171,000 base pairs long – around 20 times as much as the largest existing viruses used for gene therapies. In addition to this DNA, it can carry more than 1000 other molecules, such as RNAs and proteins, says Venigalla Rao at The Catholic University of America in Washington DC.

"We can combine all of these in one particle and be able to aim not only for therapy, but potentially for a cure," says Rao.

A growing number of treatments involve modifying cells inside or outside of the body, but delivering the necessary components to cells remains a huge challenge. For instance, some people have a condition that causes progressive muscle



V. B. RAO, V. PADILLA-SANCHEZ, A. FOKINE, J. ZHU

A model of the bacteriophage T4, laden with DNA

weakness, called Duchenne muscular dystrophy, that is due to mutations in a gene for a protein called dystrophin. Efforts to develop gene therapies for the condition have been stymied by the fact that DNA of around 11,000 base pairs long is required to make the full-size dystrophin protein – more than fits in existing viruses.

In one experiment with the modified virus, Rao's team delivered a dystrophin gene to human cells growing in culture and showed that the cells produced the full-size protein.

In another experiment, the team delivered multiple molecules to human cells at once, allowing them to edit several genes, switch off other genes and get each cell to produce various proteins, all at the same time.

The modified delivery virus is based on a T4 bacteriophage that usually infects only specific kinds of bacteria, but can be altered and customised. In particular, Rao's team added a coating that results in the virus being engulfed by human cells and in this way gets its cargo inside them.

These modified viruses will also be much easier and cheaper to manufacture than the viruses currently used for gene therapy, says Rao, as they don't need to be grown in human cells (*Nature Communications*, doi.org/gr9xgp).

However, Rao and his colleagues haven't yet shown that the viruses can be used to deliver genes to cells in bodies, says Jeffrey Chamberlain at the University of Washington in Seattle. "Nonetheless, the early data are encouraging, and it will be interesting to follow further developments," he says, adding that there is a great need for additional systems that deliver gene therapies into various cells and organs in the body.

It may take a lot of extra work to get the virus to work well in people's bodies, Rao says, but he thinks it is feasible. More immediately, the modified virus could be used to alter cells outside the body for treating people.

For instance, some cancers are now treated by modifying immune cells to target tumours. This often involves several steps: first using a virus to deliver a targeting gene, then making additional changes by separately delivering gene-editing components. The result is a mix of cells that don't all have the desired changes, which makes them less effective when injected into a person with cancer.

Being able to deliver the targeting gene and gene-editing components in a single virus would improve the process. ▮

Space

UFO hunters at NASA haven't found any aliens – yet

NASA's task force on UFOs and other strange phenomena held its first public meeting on 31 May. The team was formed in 2022 to gather all the available data on unidentified anomalous phenomena (UAPs), which include anything spotted in the sky that couldn't be immediately attributed to an aircraft or known natural occurrence.

The main takeaway from the meeting was that we simply don't have enough data to identify and explain UAPs. "The current data collection efforts about UAPs are unsystematic and fragmented across various agencies, often using instruments uncalibrated for scientific data collection," said David Spergel, who leads the group.

Historically, UAPs have rarely been studied with rigour, and all the data has never been gathered in one place before. Now that the group has gathered the data, researchers can begin to take a closer look and try to figure out what UAPs are.

The events the team has managed to look into in detail are traceable back to mundane sources – commercial aircraft, balloons, even radiation from microwave ovens. So far, there is no evidence that any UAP has an extraterrestrial origin, several of the team members emphasised.

The 16 members of the task force include astronomers, technologists, astrobiologists, physicists and even an astronaut – Scott Kelly, who spent a year on the International Space Station as part of NASA's landmark twin study.

"The events the team has managed to look into in detail are traceable back to mundane sources"

Less than 5 per cent of the hundreds of reported UAPs remained anomalous and unexplained once they were investigated, largely because we simply don't have enough information about them.

"It's very possible that with better data they would be reconciled with known phenomena," said Federica Bianco at the University of Delaware in a press call after the meeting. The group's full report is expected in late July. ▮

Leah Crane

Marine biology

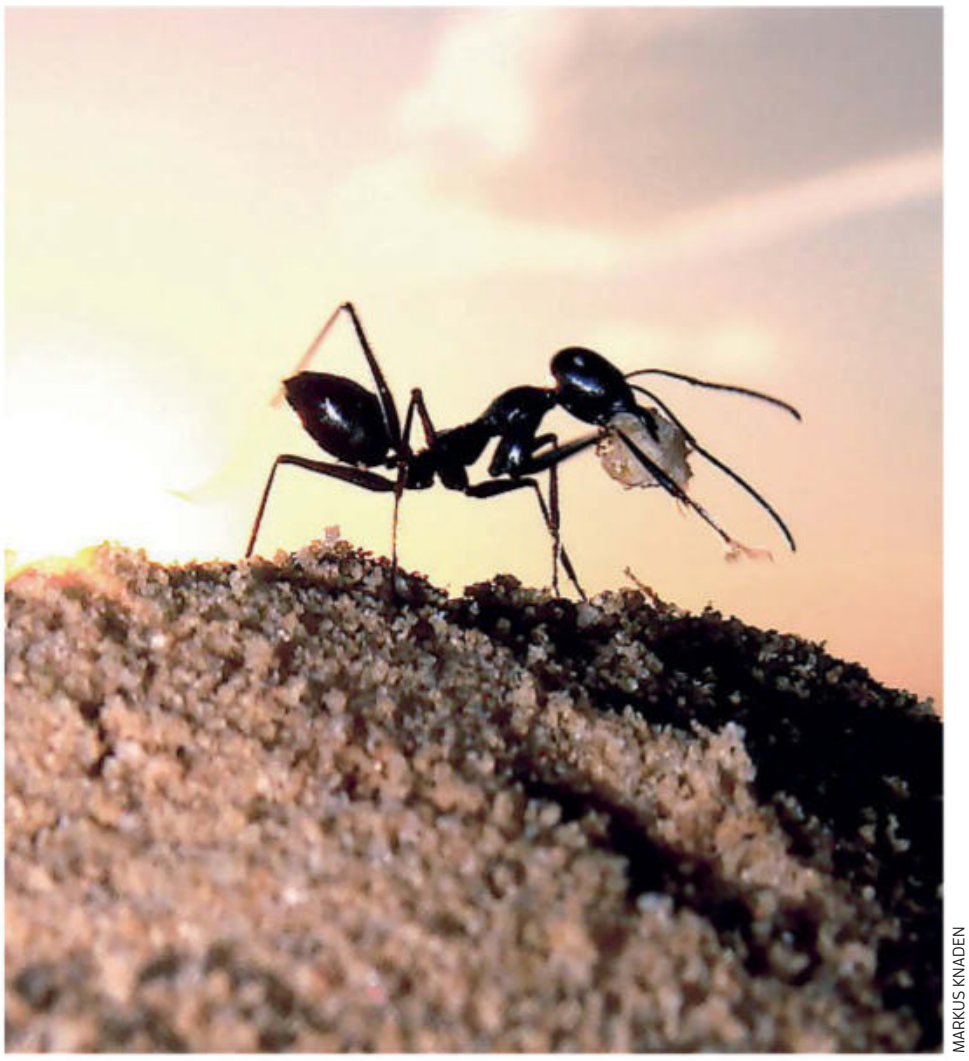
Whale shark seen feeding on seabed

A WHALE shark has been observed feeding at the seabed for the first time, rather than filter-feeding on plankton at the sea surface.

The unusual behaviour was spotted during a whale shark tour in Baja California Sur, Mexico, by an ecotourism guide who sent the footage to researchers for analysis.

A 5-metre-long juvenile whale shark (*Rhincodon typus*) was observed sucking at the sand at around 6 metres deep, appearing to gulp down material from the substrate (*Journal of Fish Biology*, doi.org/kcw7). "No one's ever seen this behaviour before," says Darren Whitehead at Shark Research Mexico.

"Exactly what they're attempting to feed on is a mystery for now," says Joel Gayford at Imperial College London. **Melissa Hobson**



MARKUS KNADEN

Chemistry

Bacterium may help process mining ore

A BACTERIAL protein found in English oak buds could be used to more efficiently process the rare earth elements needed in items such as wind turbines and screens for smartphones and TVs.

Processing these elements after mining is very energy intensive and requires toxic chemicals. Now, Joseph Cotruvo Jr. at Pennsylvania State University and his colleagues have found that the bacterium *Hansschlegelia quercus* contains a protein that can help differentiate between lighter and heavier types of rare earth elements.

The team used this protein to help separate out neodymium and dysprosium – light and heavy rare earth elements respectively that are used in permanent magnets – in a single chemical step at room temperature without relying on toxic chemicals (*Nature*, doi.org/kcxb). **Jeremy Hsu**

Zoology

Desert ants build their own landmarks to navigate home

A DESERT ant species constructs mounds to use as navigational landmarks, which help them find their way home in their otherwise flat Saharan habitat.

Desert ants are famous for their wayfinding skills, and many travel long distances to collect food to bring back to their colony. But these foraging trips are more daunting for ants like *Cataglyphis fortis* (pictured), which live in salt flats in Tunisia and so must find the thumbnail-sized entrances to their underground nests without the aid of landmarks like plants and hills.

Markus Knaden at the Max Planck Institute for Chemical Ecology in Germany and colleagues decided to investigate the purpose of mounds built by *C. fortis* after noticing their varying heights. Mounds near nests at the shrub-covered edges of the salt pan were barely noticeable, while those in the centre could reach more than 25 centimetres high, suggesting that they were important for navigation.

The researchers began by following the insects' locations with GPS and found that they face high mortality rates. On the longest journeys, which were more than 2 kilometres, around 20 per cent of the ants failed to make it home and died in the baking heat.

The researchers then followed ants at 16 nests. At some of them, they removed nearby mounds and at others the researchers left the area alone. They found that removing the mounds increased the chances of ants failing to find their way home by between 250 and 400 per cent. In nearly all cases, the foragers' nest mates quickly began rebuilding the missing structures (*Current Biology*, doi.org/gr9xp2). Corryn Wetzel

Really brief

IAN HODKINSON

Plague bacterium's arrival in Britain

The bacterium that causes the plague arrived in Britain at least 4000 years ago, in the Bronze Age, DNA evidence from a mass burial site (pictured) reveals. *Yersinia pestis* was behind the Black Death, which killed a third of people in Europe in the 14th century (*Nature Communications*, doi.org/kcz7).

Giant water plume found on Enceladus

Astronomers have spotted a huge jet of water spewing out of Saturn's moon Enceladus. We knew the moon has a liquid water ocean beneath its icy crust that leaks out in plumes, but this jet is more than 9600 kilometres long. Enceladus is only about 500 kilometres across (arXiv, doi.org/kc2b).

Backpack for bees tracks their location

A tiny sensor can work like a high-tech backpack for bees, tracking their position and temperature as they fly. The movement of two magnets in the 1-millimetre sensor, when remotely excited with electromagnetic coils, helps assess temperature, pressure and location (*Science*, doi.org/kc2c).

New Scientist
Subscriptions

PAY JUST ~~£6.95~~ £3.13 AN ISSUE

INTRODUCTORY OFFER
SAVE 55%*

Spring in to action. Grab yourself a *New Scientist* subscription today and save 55% on the newsstand price. Plus, you'll get instant access to newscientist.com and the *New Scientist* app.

Visit newscientist.com/19448
or call: +44 (0) 330 333 9470, quoting 19448

Scan me for instant sign up on your phone

*Saving shown is calculated as percentage off the newsstand price as compared to 'print and digital' package. 'Digital' package also available. Offer ends 28 June. This is an auto-renewing subscription and at the end of your trial period, your subscription will continue at the full rate. In the unlikely event that you wish to cancel your subscription, we offer a 14-day cooling-off period after initial payment is made.

Views

Comment

Brain power

Should we use living brains as a form of artificial intelligence? And at what point should we protect their welfare, asks **Michael Le Page**

DO WE want a future in which data centres full of living, bodiless brains carry out various tasks for us? That is the question raised by the work being done by at least three teams around the world.

In 2021, I reported on how Brett Kagan at Cortical Labs in Australia was growing flat sheets of mouse and human brain cells, hooking them up to electrodes and getting them to play games such as *Pong*. "We often refer to them as living in the Matrix," he told me at the time. "When they are in the game, they believe they are the paddle."

Kagan has moved on to working with more complex brain organoids, three-dimensional "mini-brains" that can be grown from stem cells. In February, he and 20 others published a kind of manifesto calling for the development of "organoid intelligence". Then, in March, it emerged that two other teams are doing similar experiments.

Why? The argument is that, while artificial intelligence systems such as GPT-4 are doing some amazing things, this is being achieved by making the systems bigger and bigger and using huge amounts of energy to train them on ever more massive data sets.

Animal brains are very different and are more efficient. We animals can learn from seeing just a few examples of something, and even a human brain uses only around 20 watts of power – less than many laptops. So the idea is that living brains, or at least living brain tissue, could be much more efficient than silicon-based AI for some tasks.

MICHELLE D'URBANO

I do find this idea disturbing. A "brain in a vat" would be an utterly helpless slave, lacking the ability to sense anything other than what its owner chooses.

But, then again, every year we raise billions of thinking, feeling animals to slaughter for food. A hen in a battery farm is a helpless slave too. Is it any different ethically to use brains in a vat to do work for us, providing they aren't functioning at human level?

For now, brain organoids are nothing like real brains. They are disorganised bunches of brain cells just a few millimetres across that are nowhere near even a simple animal brain. There is general agreement that they aren't aware, conscious or able to feel pain and emotion.

But researchers are creating more and more sophisticated brain organoids, mainly for studying brain diseases. Recent work includes merging human brain organoids with rat brains. If it proves possible to profit from the work of brain organoids, there will be an even stronger incentive to develop yet more complex ones.

What should "organoid welfare" involve if they do start becoming aware? How much rest and sleep will advanced organoids require? Should they be allowed to range freely over virtual landscapes during breaks?

Most importantly, where do we draw the line? The authors of the organoid intelligence manifesto say we need to start establishing the boundaries of what is acceptable now. But it appears to me that we still don't know enough about consciousness and feeling to be able to draw clear lines – so where should that line be? At dog level? Dolphin level? Octopus level?

Maybe this won't ever become an issue. Based on experiments done so far, it is hard to see how companies could turn a profit anytime soon. Instead, it seems to me that it will be more practical to make silicon-based AIs mimic biological brains than to turn biological brains in vats into AIs. But is this any better ethically?

I instinctively assume that any cell-based brain-like thing must be more aware and feeling than any silicon one, but I can't logically justify that. Perhaps we should be worrying about the welfare of future AIs just as much as we do about how AIs will affect human welfare in the future. ▮

For more on biological computing, see page 36

Michael Le Page is an environment reporter at *New Scientist*

This changes everything

And now for something completely familiar

The much hyped social media app Bluesky is meant to be doing things differently, but it is yet another Twitter clone, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Terraformers* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
A Half-built Garden *by Ruthanna Emrys, which imagines a better form of social media (with aliens).*

What I'm watching
American-Born Chinese*, based on a comic book of the same name, about the Monkey King's son going to high school.*

What I'm working on
A fellowship at the Marine Biological Laboratory in Woods Hole, Massachusetts, where I'm studying coastal eutrophication.

This column appears monthly

YOU may have heard some buzz about a new social network called Bluesky, which is the latest app trying to seize the throne once occupied by Twitter. Here in the States, journalists are going wild for Bluesky – publications from *TechCrunch* to *The New Yorker* have covered its hip culture, analysing whether it is a sign of what's to come in the world of social media. I have been on Bluesky for about a month now, and so far it feels like a fast-motion replay of everything that went wrong on Twitter. It has only taken months, rather than years, for goofy memes and friendly posts about lunch to descend into bloody, ideological battles.

Bluesky was founded by Jack Dorsey, who is a co-founder of Twitter, and its initial funding came from Twitter as well. So it is no surprise that the app looks almost exactly like Twitter, with slightly different functionality. You have your feed of pithy, 300-character "skeets" (a tongue-in-cheek portmanteau of sky and tweets). You can follow the people you like and mute or block the ones you don't. But you can't send direct messages, which is a little annoying. There are pictures, but no video. Sometimes, everything breaks. The app is brand new, after all, and it is still in an invite-only, beta-testing phase.

At first, it was kind of fun when Bluesky broke. People made jokes and filed helpful bug reports for its software developers. It felt like we were building a barn together and everybody was pitching in to make sure the roof didn't collapse. When threading broke – causing people to receive tonnes of notifications if they replied to a long enough chain of skeets – users created the "hellthread", an infinitely long, chaotic conversation, full of posts about getting intoxicated and hooking up. Yes, it was completely silly, but it was also a legitimate way to figure out what was causing the problem with threading.

For people working at Bluesky, like CEO Jay Graber, the appeal of the app lies in its code. Unlike Twitter, Bluesky's code is open source – anyone can download it and build apps that work with it. Bluesky is also designed to be decentralised, like its rival Mastodon. Graber has written several essays about turning Bluesky into an app ecosystem, where many companies can develop products that work

"It felt like we were building a barn and everybody was pitching in to make sure the roof wouldn't collapse"

with Bluesky's burgeoning community. She is especially interested in something she calls "composable moderation", which is basically a way for users to build systems that control what they see on Bluesky, muting Twitter-style harassment and abuse.

Still, a social media app isn't really about code – it is about talking to people. That's why we should pay attention to the way Bluesky is building its user base, which was at about 60,000 people in early May and is growing fast. Early on, users celebrated that Bluesky seemed to be full of Black and transgender people who had fled harassment on Twitter. One user, a Black software engineer called Aveta, told *TechCrunch* that she got 500 invites from Bluesky, which she gave to other Black people. When I emailed a rep from Bluesky, they said that the company hadn't intentionally reached out to any minority groups. Instead, wrote the rep, they had simply given "more invites" to "engaged new users".

The only community that Bluesky targeted with invites was "writers with a Substack", wrote the rep. Substack is a newsletter platform with limited content moderation that has got into controversies over platforming hate speech and libel. Alex Stamos, who heads Stanford University's internet observatory in California, recently referred to Substack as "paying folks to defame people". So, the only group that Bluesky intentionally reached out to were from a platform with a lot of social problems. To be clear, the Bluesky rep told me that the firm is happy to have a diverse range of people on its app. But that isn't its goal.

Meanwhile, Bluesky's community went through a mini meltdown in late May, with people screaming about how to interpret a meme that struck some people as sexist. I opened the app after a long weekend to find my feed full of people hurling recriminations at each other, "quote skeeting" in a heated exchange that reminded me of the bad old doomscrolling days on Twitter. I am sure that the Bluesky team would tell me to deal with it by building some composable moderation software, muting the doomscroll and replacing it with cat pictures.

But muting isn't a good way to build a community, and covering your ears won't make these core problems go away. Bluesky needs to be transparent with its nascent community about what its ethics and values really are. I don't believe you can build a new public sphere entirely out of systems that help us ignore each other – maybe we should try to come up with new ways to take responsibility for our words instead. ▮

AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

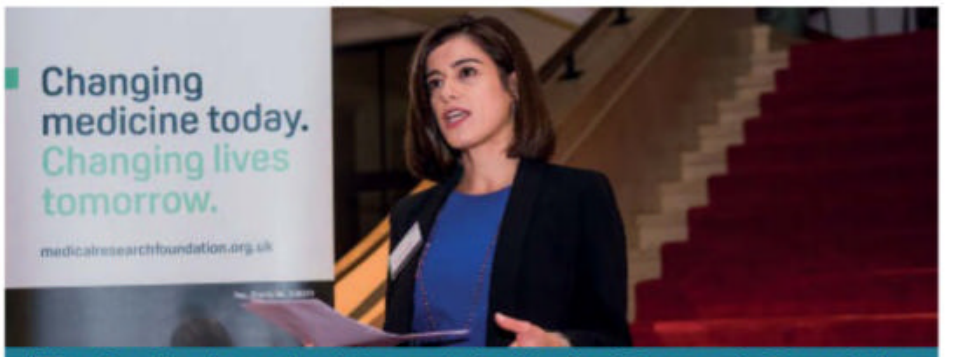
Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

Your Will can fund the rational response to health challenges that medical science provides.

"As scientists, our duty is to secure the future of research for the generations that follow."

Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.



"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

Please consider this very special gift today.

Professor Nick Lemoine CBE MD PhD FMedSci
Chair of the Medical Research Foundation

Get your free guide to supporting research in your Will.

Scan this QR code to find out more

To request your free guide to gifts in Wills fill in this form and return to, **MEDICAL RESEARCH FOUNDATION, 99 CHARTERHOUSE STREET, LONDON, EC1M 6HR OR** visit **medicalresearchfoundation.org.uk/support-us/wills**

Name _____

Address _____

_____ Postcode _____

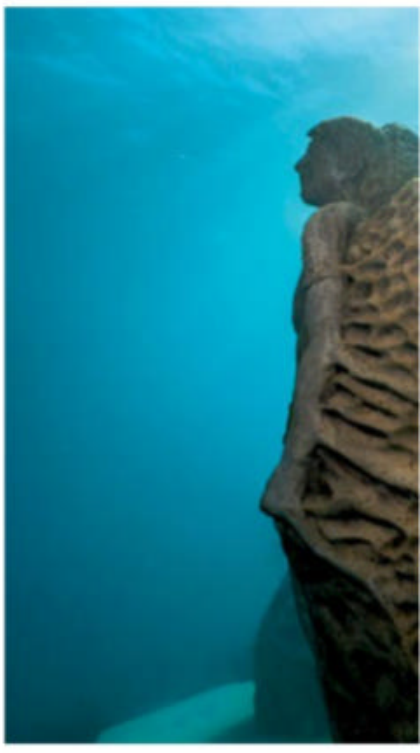
Email address _____

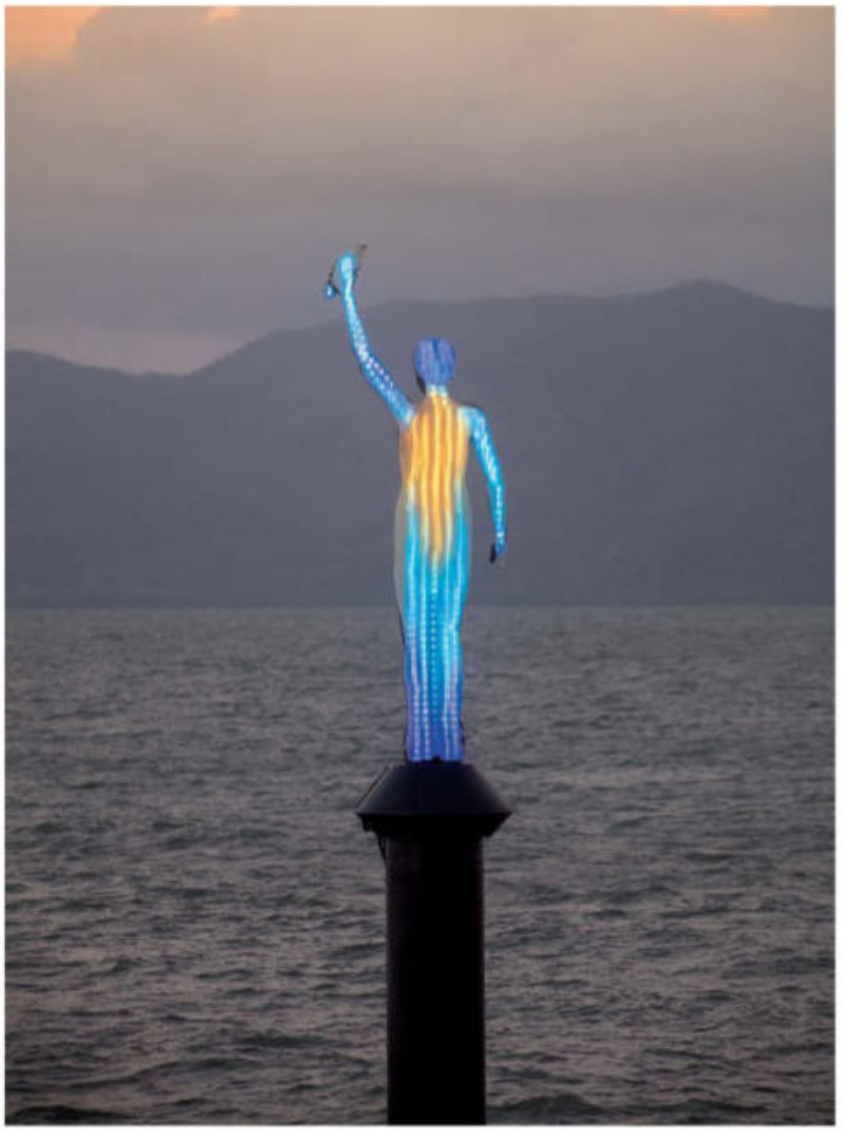
Medical Research Foundation

Registered with FUNDRAISING REGULATOR

We would like to contact you from time to time with our latest news. Please tick here ☐ if you are happy for us to contact you via email. The Medical Research Foundation does not share your personal information. You can unsubscribe at any time. For further information on how we collect, store and process your personal data, please read our Privacy Notice medicalresearchfoundation.org.uk/privacy

0423NEW





Art to the rescue

Artist and photographer
Jason deCaires Taylor

THESE six mysterious forms seem to be watching over the dappled ocean depths, some appearing to be sunken relics of a distant past or structures carved by nature.

But look more closely and you will see that they are meticulously designed pieces of art, sent on a real-life rescue mission. Created by sculptor Jason deCaires Taylor, they are part of his eight-piece installation, *Ocean Sentinels*, a new addition to the Museum of Underwater Art in the Great Barrier Reef, off the coast of Townsville, Australia.

DeCaires Taylor's works are hybrids, drawing on nature and real figures in marine science and conservation, and aim to revive the Great Barrier Reef. "Art and science are critical partners in the battle against climate change and fundamental in realigning our relationship to the natural world," he says. The hope is that the works will be colonised by corals and other threatened marine species.

At far left is a likeness of marine zoologist Maurice Yonge, his figure merged with the form of a murex shell. The middle column shows (top to bottom): *The Coral Greenhouse*, planted with coral species; a figure of coral ecologist Katharina Fabricius, influenced by soft corals and sponges; and, being lowered into the water, a statue of clam expert Richard Braley.

The third column shows a statue of Jayme Marshall (top), a Wulgurukaba and Yunbenen woman and Indigenous leader, merged with mangrove and fig trees. Below is *Ocean Siren*, a sculpture inspired by Takoda Johnson, a young Wulgurukaba girl. Its colour depends on the daily water temperature, representing the condition of the reef.

Gege Li

Editor's pick

More activism against horse racing please

20 May, p 27

From Marc Bekoff, professor emeritus of ecology and evolutionary biology, University of Colorado Boulder, US

Christa Lesté-Lasserre's view on the horrific lives of racehorses comes across as a one-sided apology for a brutal sport in which more and more of these animals are injured and die while entertaining human spectators.

Activists aren't to blame for the downsides of horse racing. Their passion and feelings call attention to the rampant abuse of these highly emotional animals, and their concerns can – and do – lead to better science.

Plenty of research shows that there is nothing anthropomorphic about viewing horses as animals that feel deeply. Social media isn't exaggerating the truth of what racehorses are experiencing. The reality is that ever more horses are being killed, and a growing number of people globally are tired of how these animals are being treated as unfeeling objects rather than as sentient beings.

Clearly, animal welfare science has failed these amazing animals. Highly emotional activists are a major reason why more people are learning about, and becoming fed up with, the miserable, largely ignored lives of horses that are trained and raced to death. Let us hope science pays careful attention to what they are saying.

Quantum gravity could do with a rebrand

13 May, p 38

From Daniel Kermode, Vernon, British Columbia, Canada

Jon Cartwright's discussion of the incompatibility between general relativity (GR) and quantum mechanics (QM) touches on something crucial: stories.

GR has a compelling story. It says that what we call "gravitational force" is essentially just objects travelling along the equivalent of straight lines through curved space-time. QM has a counterintuitive story. Can a cat in a box be simultaneously dead and alive? Is this GR's advantage, or is it better to only ever be assessed on the merits of mathematics, like QM?

When we use the term "quantum gravity", we give the impression that QM is right and GR is wrong. In fact, we aren't looking for quantum gravity, we are looking for a new physics theory from which the current maths of QM and GR both emerge.

Therefore, we shouldn't think about "quantum gravity" at all. We need a better term, one that doesn't presuppose the starting point of our imaginings.

On the potential power of the new generation of AI

Letters, 13 May

From Hillary Shaw, Newport, Shropshire, UK

Perhaps we have trouble saying whether AI can be conscious because "consciousness" isn't a single thing. For example, we all think we recognise grass – a short, green, blade-shaped, densely packed, fast-growing plant – but then we have wheat (tall, yellow grass), tussocky grass and artificial grass, which resembles the real thing, but isn't. There is no such single property as "grass-ness".

Likewise, consciousness may be defined by several attributes, including self-awareness, the ability to distinguish self from non-self, sensory inputs and the ability to analyse, reason and act on them, as well as the capacity to think abstractly, without relying on the senses at all. AI could be called the artificial grass of consciousness, in that it resembles consciousness but (probably) isn't.

From Stephen Etzel, Putnam, Connecticut, US

AI will never be able to successfully handle the inherently irrational aspects of human politics and religion. These governing factors of human existence can't be defined or analysed to result in anything approaching predictive behaviour. For AI to achieve sentience, it must somehow accept irrationality as an element of being, which is impossible for anything based on 1s and 0s.

From Chris Arnold, Darlington, Western Australia

If you are wondering what life will be like once AI becomes all-powerful, just ask any creationist. They have been telling us about a world ruled by an omniscient, omnipotent and omnipresent non-organic life form for millennia. Start praying.

Why Australia was right to ban the import of vapes

13 May, p 20

From Alanna Sherry, Wollongong, New South Wales, Australia

The crucial thing to note is that the import of vaping products is now banned in Australia, which will stop vapes containing nicotine from being sold to children by other children, rather than retailers. Some kids are addicted to nicotine because of the vapes they get from other kids via social media, without needing to buy them in a shop. These vapes are all over schools in New South Wales.

Certain vapes that children use are promoted as containing 5 per cent nicotine (50 milligrams per millilitre). Adults looking to replicate the effects of a cigarette usually choose a vape with between 3 and 15 mg of nicotine per ml of vape liquid.

There is now an epidemic of nicotine-addicted children. Their parents are taking them to family doctors for patches and gum.

With AI, history may be repeating itself

Letters, 20 May

From Malcolm Bacchus, London, UK

John Cherian suggests regulators should limit access to AI to those trained and appointed to use it. This would create a class of people with control over communication between us and our information overlords, and who might demand money and obedience in return for access to it. There are enough historical precedents to show where that would end.

A story I wish I wasn't having to share with you

From Stuart A. Watson, Cumbernauld, North Lanarkshire, UK

After two episodes of viral encephalitis, my family noticed in July 2022 that my physical impairment had appeared to progress, while hallucinations and losses of memory had returned.

In February 2023, after a brain biopsy, we learned that this wasn't a third bout of encephalitis, but a stage 4 glioblastoma. Oddly, there was no direct link, despite the tumour developing for the past six months in the same area where my original brain injury occurred.

Unfortunately, the prognosis is poor, with no treatment options and quick progression. My dream is to appear in *New Scientist* and share my story – I wish this wasn't the story I had to share! ▮

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

For the record

▮ **Of the caves in Carajás National Forest, Brazil, only 10 currently house large bat populations (27 May, p 9).**

7 - 8 OCTOBER | SCHOOLS' DAY 9 OCTOBER

EXCEL LONDON AND ONLINE

New Scientist Events

New Scientist Live

THE WORLD'S GREATEST FESTIVAL OF IDEAS AND DISCOVERIES

Join us in-person at ExCeL London or online as we bring you the best-loved names in science, alongside up-and-coming researchers. With more than 50 speakers, across four stages we've got all the wonders of science covered, from deep oceans to distant galaxies, mental health to meteorites, if you're curious about life, the universe and our place in it, then New Scientist Live is for you.

Find out more

newscientist.com/nslpa

FEATURE PARTNERS

SCHOOLS' DAY PARTNER

CHARITY PARTNER

MEDIA PARTNER

The edge of extinction

Striking stories about the snow leopard and partying orcas make a book about threatened species more likely to motivate readers to action, says **Jack Ashby**

JON DUNCAN/ISTOCKPHOTO/GETTY IMAGES

Book

An Atlas of Endangered Species
Megan McCubbin
Hachette

THREE species become extinct every single hour and most aren't scientifically described – lost before they were found. This shocking statistic from the UN Convention on Biological Diversity is one driver behind a new mini-anthology, *An Atlas of Endangered Species*. It is an accessibly written tour of species on the brink by rising star Megan McCubbin, a younger naturalist and science communicator.

McCubbin came to prominence appearing alongside her activist-broadcaster stepfather Chris Packham in their online live stream, The Self-Isolating Bird Club, during covid-19 lockdowns. She has since joined the BBC team presenting *Springwatch*, *Autumnwatch* and *Winterwatch*. In writing this book, she is using her voice to raise awareness and make a call to action to protect those species at risk.

In the atlas, she explores the plight of 19 species currently on the road to extinction and the threats oiling their wheels. For each, McCubbin interviewed a conservation researcher working to apply the brakes. Their insights provide the realism – but, more importantly, the optimism – that these topics require.

Regarding this, McCubbin regrets she couldn't incorporate more Indigenous voices, recognising that "the landscape and solutions can look very different for the people living within than from the outside".

The sad truth is that anyone writing a book about endangered species has their work cut out selecting a few to focus on – there are just too many to choose from.

I did feel a little hesitant when I saw that orcas, orangutans, elephants, rhinos, pangolins, vultures, snow leopards and kākāpo had been selected. This all seemed like rather well-trodden ground, particularly when so many threatened organisms (and particularly plants) are afforded less time in the spotlight.

"Anyone writing about endangered species has their work cut out selecting a few to focus on. There are too many"

But I was pleasantly surprised that, in telling the stories of these more "blockbuster" species, McCubbin goes beyond the regularly repeated tales.

For example, she focuses on Kyrgyzstan for her chapter on snow leopards. These aren't officially endangered, but with only between 4000 and 6000 alive, that is little comfort, considering that, since 2008, poachers have killed an average of one snow leopard every day.

It is clear that poverty, rather than greed, is driving their declining numbers. Almost half the country's population works in agriculture and families can earn less than $2 per day.

The in-country expert she spoke to was Kubanychbek Zhumai uulu, who works for the Snow Leopard Trust to protect the species and reduce conflict. He explained how threats are combined and interconnected because "the roads and infrastructure of gold mines and trophy hunting give both herders and poachers access to the mountains. The herders' livestock degrade the habitat and outcompete the snow leopards' prey. The lack of prey causes the predator to hunt livestock, which leads to retaliatory killing."

McCubbin makes a strong point that, living in the UK, the closest thing to this kind of human-wildlife conflict she has ever experienced is the impact pet cats have on wildlife.

The book's title is an odd choice, as many readers will be confused why this "atlas" doesn't contain any maps – the only nod to geography is that the chapters are arranged by hemisphere – but the stories within are eye-opening and well told. There is even space for humour.

Globally, only between 4000 and 6000 snow leopards remain

Did you know that 12 camels were disqualified from a 2021 camel festival with a £40 million prize because their owners had used Botox to enhance the animals' lip-quality score? Or that three pods of Pacific orcas regularly get together for a massive party? They have clearly communicated in advance where and when to meet, and they wait for everyone to arrive before letting loose.

I didn't know any of this, and lighter stories like these alongside the harder truths about wildlife declines should help make any reader better informed to make a difference. ▮

Jack Ashby is assistant director of the University Museum of Zoology in Cambridge, UK, and author of *Platypus Matters*

Universal truths

A terrific guide to our spectacular universe might kindle a fresh reverence for Earth, finds **Simon Ings**

Book

Under Alien Skies

Phil Plait

W. W. Norton & Company

YOU may know him from his Bad Astronomy blog, which demolishes misconceptions and fraudulent claims about the cosmos. Now, in *Under Alien Skies: A sightseer's guide to the universe*, the tireless Phil Plait is taking us on the most spectacular journey. We sail past our satellite moon, past Mars, Saturn and Pluto on to other stars, binaries and clusters, to nebulae and to the end of all things, as he sends us spiralling beyond the Schwarzschild radius of a black hole.

With a few exceptions for the most exotic cosmic objects, the book sets out to describe only what poor, inadequate humanity is equipped by nature to experience. This is the cosmos as we would feel, hear and see it in person. Some measure of security and comfort is provided by the starships of ever-increasing unlikelihood that Plait conjures, but, deep down, we are on our own out here, trembling at the magnificence of it all.

This artful premise gives Plait licence to discuss what our real future in the solar system might look like, while he also explores some startling stellar exotica.

Plait's evocations of our own solar system are superbly sensual. But in the book's final chapters, on star clusters, nebulae and black holes, our suspension of disbelief starts to come unstuck. This is partly to do with the fact there is nothing for us to smell, hear, walk on or trip over.

Sooner or later, we will be overwhelmed by a galaxy, such as Andromeda, that is a lot bigger than we are. Here, Plait describes our likely response as we witness the birth of stars: "Your mind tries to comprehend what you're seeing, churning out analogies rapid-fire – it's like an explosion in a radioactive cotton candy factory, like being suspended in a frozen fireworks display… but in the end you fail. Humans never evolved to comprehend magnificence on a scale like this."

Some of the grandest wonders in his arsenal are simply invisible to the naked eye. So, now and again, the captain of our imaginary starship tweaks the viewscreens, showing us things we wouldn't have seen by leaning out of the window. On those rare occasions, we passengers may wonder: what are we doing here? Why come this far to watch a video of sorts? Surely the same *vérité* could have been achieved in front of a 5K screen in our pyjamas?

You could argue Plait should have stuck to his guns and, even in the chapter on black holes, described only what humans would see with their own eyes. But this is a game we abandoned centuries ago. Our machines have better access to the world than we do, and this has been true at least since Dutch lens grinders invented the telescope.

Much more telling is this: virtually every wonder in this book is to do with scale. Bigger, brighter, heavier things dominate this account. But where are the stranger things? Is there anything in this book as abidingly weird as, oh, I don't know, a tree? A cat? Fish and chips?

Earth beats the rest of the known cosmos hands down for complexity and change. And, yes, there may well be other biomes out there, but Plait can't just invent them out of whole cloth. That would be fantasy, and this is a book rooted, however speculatively, in the known.

Plait is a skilled, resourceful and, on occasion, downright visionary guide to the far reaches of outer space. If this book leaves a few readers feeling very slightly disappointed, it won't be Plait who has fallen short, but the cosmos. For 300 thrilling pages, short-lived, fragile and under-equipped readers have relied on imaginary technology to get them places that they don't belong. It is no bad thing if this exhilarating book engenders a renewed feeling of reverence for their own world. ▮

Simon Ings is a writer and critic based in London

This new image of the Orion Nebula was created from previous images taken by three telescopes

ESA/NASA/JPL-CALTECH

New Scientist *recommends*

Liz Else
Senior culture editor
London

This week, I've been blowing my mind with Vaclav Smil and Ai Weiwei (pictured).

From viruses to innovation, there's little that polymath Smil hasn't written about in 40-plus

books. If you don't know him, start with ***Size***, his latest, where he reveals what happened when US dinner plates got bigger, and how Jonathan Swift made the giants and Lilliputians in *Gulliver's Travels* the "wrong" size. Plus, did you know that incomes in China are as unequally distributed as those in the US?

Artist-activist Ai did. His exhibition, **Making Sense**, at London's Design Museum until 30 July, uses China as a lens through which to look at the whole world.

In *Still Life*, Stone Age tools found in flea markets now resemble a layer of forgotten history; nearby, videos of older Beijing show it before ring roads destroyed it.

Most astonishing is a Lego recreation of one of Claude Monet's *Water Lilies* paintings, with a dark area added by Ai. Its meaning turns out to be moving beyond words.

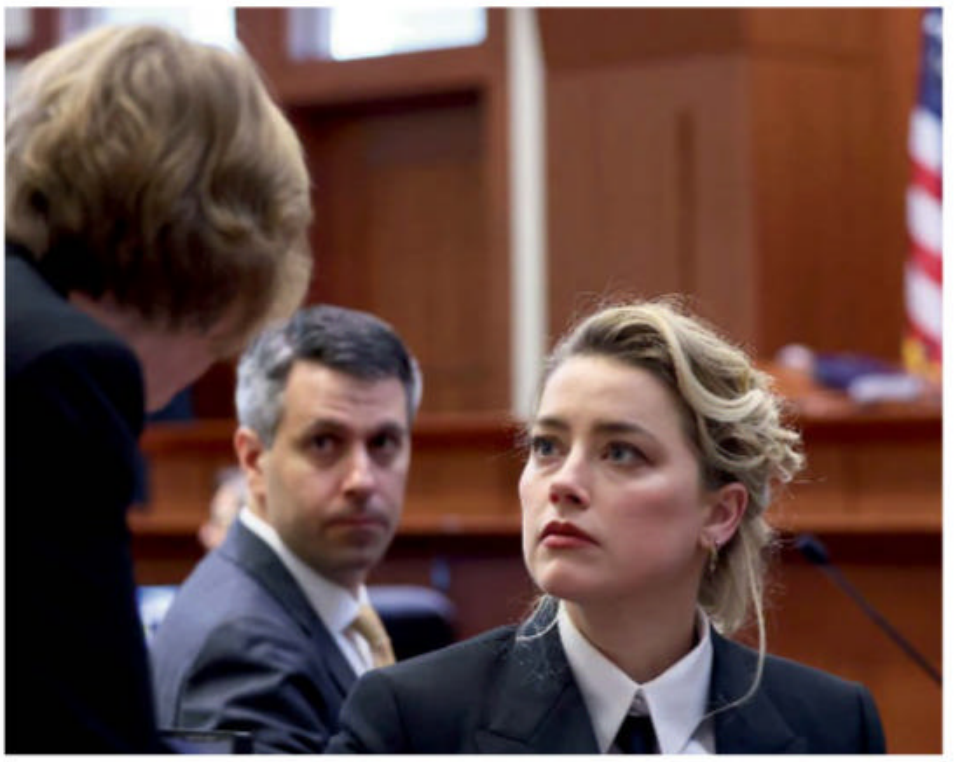
COURTESY AI WEIWEI STUDIO

The TV column

A force to reckon with

An alarming documentary about the court case of Johnny Depp and Amber Heard shows how a powerful, untamed social media has the potential to undermine our justice systems, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley



EVELYN HOCKSTEIN/EPA-EFE/SHUTTERSTOCK

Amber Heard at Fairfax County Circuit Court, Virginia, in 2022

AS A chronic user of Twitter, I have watched plenty of social media storms unfold over the years. But, like many chasing the online zeitgeist, I kept away from Depp versus Heard.

In April last year, Johnny Depp brought a $50 million defamation case against his ex-wife and fellow actor, Amber Heard. He argued that Heard had damaged his reputation and career by describing herself as "a public figure representing domestic abuse" in a 2018 op-ed for *The Washington Post*. She countersued for $100 million, claiming Depp and his lawyers had defamed her by claiming she had lied to damage Depp's career.

Depp V Heard, a three-part documentary from Channel 4, sets out to present an unbiased view of the case while delving into the murky online world around it. Its unique selling point is that the two testimonies are presented side by side, allowing viewers to catch inconsistencies and contradictions. It is spliced through with shots of the couple in seemingly happier days and set to a gloomy, ominous score.

The trial was a media circus before it began, but it was Judge Penney Azcarate's decision to allow live broadcasts, we learn, that sent the internet wild. Opinions flowed: proceedings were livestreamed with commentary from legal experts and laypeople alike. Clips were reposted and

"Articles about the trial generated more social media traffic than the Ukraine war, inflation and covid-19 together"

edited to make memes across YouTube, Twitter and especially TikTok. Articles about the trial generated more social media interactions in the US than coverage of the war in Ukraine, inflation and covid-19 combined, from 4 April to 16 May 2022.

It became clear there was money to be made and influence gained, particularly if you created pro-Depp, anti-Heard content. For example, videos with the hashtag #justiceforamberheard were viewed 21 million times on TikTok by the final days of the case, while those with #justiceforjohnnydepp received more than 5 billion views.

The documentary does address the flurry of misinformation about the trial. This ranges from fundamental disputes to the smallest detail – for example, we learn the true origin of the term "mega pint", which was used by Heard's lawyer to describe Depp's drinking. Depp's amusement at the phrase quickly became a meme among his supporters to mock Heard's defence team, but it was a term he himself coined during his unsuccessful lawsuit against *The Sun* newspaper two years earlier.

Yet *Depp V Heard* can't sift through the claims, from the submitted evidence to the work of amateur sleuths. All it can do is show how social media flooded the public sphere so that it was difficult to know the truth, allowing Depp's savvier fans to manipulate TikTok and YouTube.

It is possible the public's desire to comment influenced the jurors, who weren't sequestered and were simply advised to avoid media coverage of the case. One juror, however, has publicly denied social media had an impact.

It might have been better if the documentary had ignored the proceedings to focus on those who profited from this spectacle. Yet, despite its flaws, *Depp V Heard* is a vital watch if you, like me, have been too cowardly to look at this case. The untamed online world it shows is ugly, with the potential to undermine our justice system.

Depp V Heard offers no answers, and that makes it the scariest TV I have watched in a long time. ▮

TV

Depp V Heard

Channel 4, UK; not yet available in the US

Bethan also recommends...

TV

The People v. O.J. Simpson: American Crime Story

Disney+ (UK); Hulu (US)

As someone who wasn't alive at the time, this dramatisation of the O.J. Simpson trial was a truly shocking watch for me.

The Most Hated Man on the Internet

Netflix

This is the story of Charlotte Laws and her allies as they take on revenge porn purveyor Hunter Moore and his website, Is Anyone Up? Warning: it makes for tough viewing.

LAST CHANCE TO REGISTER. ONLY ONE WEEK TO GO!

New Scientist Events

ONE-DAY MASTERCLASS

INSTANT EXPERT: WONDERS OF SPACE

Saturday 17 June 2023, 10am - 5pm

Cavendish Conference Centre, London

Join us for a day of exploring the mysteries and marvels of the universe with six leading scientists. You will start where everything began, at the big bang. Throughout the day, you will hear about the formation of galaxies; the latest research into our nearest star, the sun; the mysterious physics of black holes; the quest to find life on Mars; and the discovery of habitable planets outside our solar system.

The day will be hosted by a *New Scientist* journalist and there will be plenty of time to ask your questions to our galaxy of space experts.

For more information and to book your place, visit:

newscientist.com/wondersofspace

TALKS INCLUDE:

THE BIG BANG AND THE ATOMIC UNIVERSE
KATHERINE BLUNDELL

LOOKING FOR LIFE ON MARS
ANDREW COATES

EXOPLANETS: LIFE BEYOND THE SOLAR SYSTEM?
CHRIS IMPEY

GALAXIES: BUILDING BLOCKS OF THE UNIVERSE
CLAUDIA MARASTON

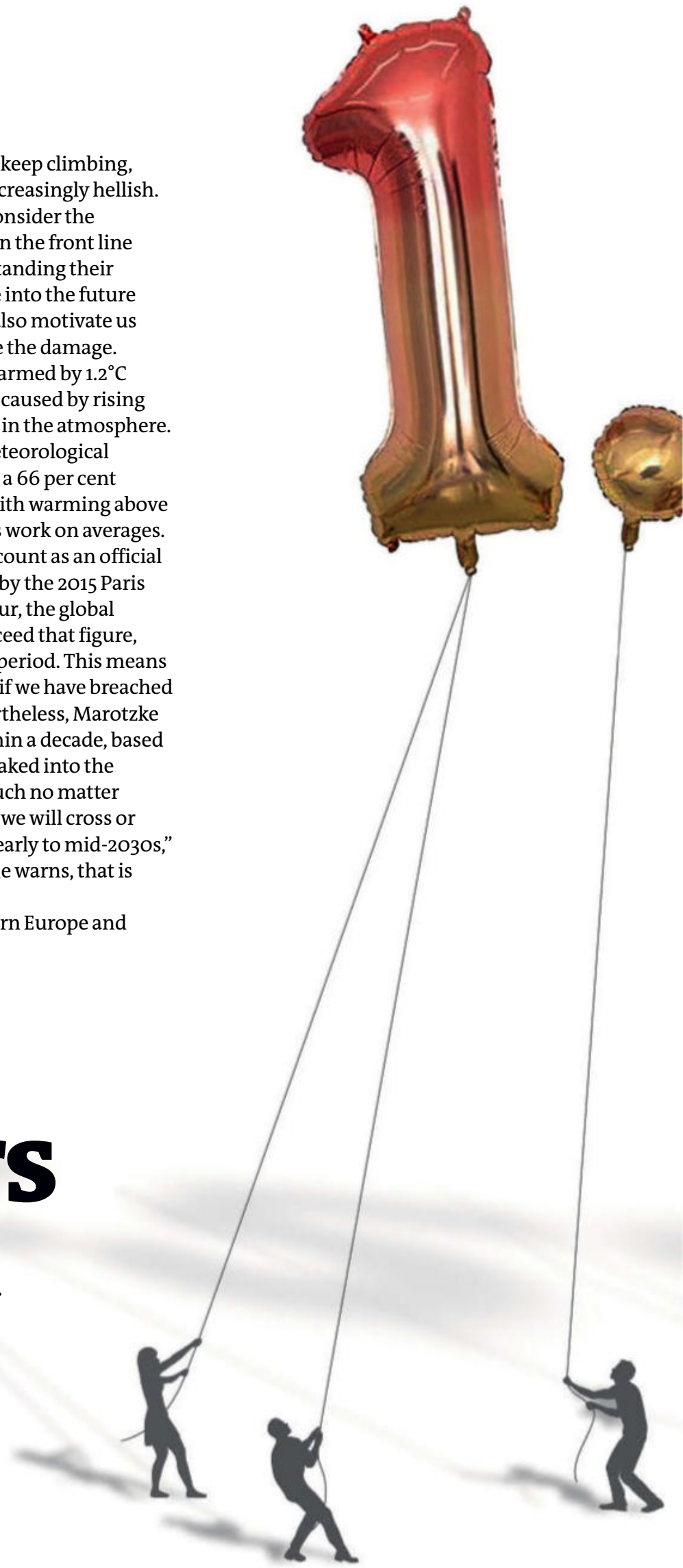
THE SUN: OUR NEAREST STAR
SARAH MATTHEWS

BLACK HOLES: THE MOST FASCINATING OBJECTS IN THE UNIVERSE
CHRISTOPHER REYNOLDS

Scan me to book

Beyond 1.5°C: The hell years

Global warming is set to pass 1.5°C imminently. Our efforts to reverse that heating will hopefully pay off, but what will the decades until then be like, asks **Madeleine Cuff**



RYAN WILLS

THIS time next year, you may be living in the same house, driving the same car and doing the same job. But in one fundamental way, life on Earth could have shifted irrevocably. Spiking worldwide temperatures, boosted by a transition to an El Niño climate pattern, could make 2024 the year that global warming exceeds 1.5°C for the first time. It may not sound like much, but scientists warn it will be a totemic moment for the planet.

Undoubtedly, breaching 1.5°C is a sign of political failure. Just eight years ago, almost every nation agreed to a binding treaty promising to hold the global temperature rise to a maximum of 1.5°C above pre-industrial levels. Blowing past that threshold so soon will bring huge political fallout and unleash reactionary forces that could turbocharge – or cripple – the climate movement. "All hell will break loose," says Jochem Marotzke at the Max Planck Institute for Meteorology in Germany. "That is something I'm very sure of."

But beyond this discontent, there are many other impacts of crossing this threshold. It will have catastrophic consequences for people living in the hardest-hit parts of the world and bring even wilder, more unpredictable and extreme weather for all of us. If we can get the temperature back down, this period may pass. But if emissions keep climbing, the climate will become increasingly hellish. That much is clear if you consider the communities now living on the front line of climate change. Understanding their experience gives a glimpse into the future for all humanity. It might also motivate us to do more to try to reverse the damage.

The world has already warmed by 1.2°C since pre-industrial times, caused by rising levels of greenhouse gases in the atmosphere. According to the World Meteorological Organisation, there is now a 66 per cent chance we will see a year with warming above 1.5°C by 2027. But scientists work on averages. A single year of this won't count as an official breach of the 1.5°C goal set by the 2015 Paris Agreement. For that to occur, the global average warming must exceed that figure, on average, over a 20-year period. This means we will only know for sure if we have breached 1.5°C with hindsight. Nevertheless, Marotzke says it is set to happen within a decade, based on the existing warming baked into the climate system. "Pretty much no matter how the emissions evolve, we will cross or reach that 1.5°C line in the early to mid-2030s," he says. In climate terms, he warns, that is "around the corner".

In mild regions – northern Europe and

much of the US, say – life beyond 1.5°C may not feel so different for most people. Heatwaves will be fiercer, droughts longer, wildfires more frequent and rainstorms heavier, but day-to-day life is likely to continue largely uninterrupted, at least initially. However, the story is different in regions where temperatures are climbing faster than the global average. For people living in those places, overshooting 1.5°C of global warming could be a matter of life or death.

The impact of climate change is already being felt keenly in the Arctic, which is heating up four times faster than the rest of the planet, the victim of a feedback loop that sees warming accelerate as the ice melts and solar reflection reduces. In the northern parts of Newfoundland and Labrador in Canada, average winter temperatures have increased by more than 1.5°C since the start of the 20th century. For the local Inuit populations, this is causing major disruption, says Ashlee Cunsolo at Memorial University, St John's, Canada. In particular, the late and unstable formation of winter sea ice undermines traditional pursuits such as hunting, fishing and spending time in winter cabins. "When the ice forms, everything opens up. It's everyone's favourite time of the year, because you can drive everywhere," says Cunsolo. "So when ice forms later and breaks up earlier, that takes away months of time that people have [to do that]."

Photographer Eldred Allen has lived his whole life in the Nunatsiavut region of Newfoundland and has seen the changes with his own eyes. "In the fall, you would get a long stretch of cold weather, you would get nice strong ice forming, and then winter sets in," he says. "Now, it is not until probably mid-January that the body of water is frozen up enough that it is safe to cross. It is getting later and later to freeze up every year, and it is melting earlier every year as well." The late freezing means Allen and his family are struggling to cross the frozen ocean to reach their winter cabin. Then, once they arrive, they worry that swings in temperature could cause the ice to thaw and crack. "It will be –20°C [-4°F] one day and 2°C [35.6°F] the next day," he says. "Our kids are constantly hearing us talk about whether it's going to be safe." This isn't an unfounded fear. Two years ago in January, a member of Allen's community was travelling via snowmobile over the sea ice when his vehicle crashed through. The man survived, but everyone has been shaken by the incident. "There's a lot of questioning in people's minds: can we trust the years of knowledge that have been passed down to us about ›

"THERE IS NOW A 66 PER CENT CHANCE WE WILL SEE A YEAR WITH WARMING ABOVE 1.5°C BY 2027"

where it's safe to travel, because things are just changing so much," says Allen.

Throughout the Arctic, climate change is having a profound effect on the traditional culture and well-being of communities, according to Cunsolo. "You have people who, for hundreds of years, have relied on the cold and the snow for all aspects of culture, for language, for knowledge sharing, for connection to land and resources and for food security," she says. "It's a really deep, existential identity impact that the communities are experiencing."

Water, water everywhere

It may seem like a local problem, but the threat caused by melting ice will reverberate around the world. According to the Intergovernmental Panel on Climate Change (IPCC), if Earth warms by 1.5°C, Arctic meltwater will push up global sea levels by between 0.26 and 0.77 metres by the end of the century. At 2°C of warming, an additional 10 centimetres of sea level rise can be expected, with negative consequences for 10 million people. The long-term threat is even more dramatic. For example, collapse of the Greenland ice sheet, which could be triggered by between 1.5°C and 2°C of warming, would cause a 7-metre rise in global sea levels.

Less dramatic rises are already having devastating effects in low-lying regions,

"THERE WERE THREE OR FOUR MONTHS WHERE PEOPLE LIVED ON JUST ONE FOOD ITEM"

MARIO TAMA/GETTY IMAGES

including the tropical island nation of Vanuatu in the south Pacific. Esther Peter at the Vanuatu Meteorological and Geohazards Department says it is affecting access to water on the archipelago, by polluting freshwater wells with salt water. It is also damaging infrastructure. "[On the island of Efate] the sea is reaching the tar-sealed roads during high tides," she says. Vanuatu's solution is drastic. In December 2022, it announced plans to relocate "dozens" of villages over the next two years. "Climate displacement of populations is the main feature of our future," the country's climate change minister, Ralph Regenvanu, recently told the French news agency AFP. "We have to be ready for it and plan for it now."

When 1.5°C has been breached, other low-lying nations and regions will increasingly face similar challenges. Vanuatu also provides a window on another problem set to become far worse for many of us: it is one of the countries most vulnerable to extreme weather events driven by climate change. In 2015, Cyclone Pam hit the archipelago. This category 5 cyclone brought gusts of wind exceeding 300 kilometres per hour and 4-metre-high tides that swept away entire villages. The storm destroyed household "gardens", traditional allotments that most islanders rely on for growing fruit and vegetables, wiping out 90 per cent of the nation's food crops. This was followed by a severe drought that lasted for months, exacerbating food and water shortages.

What's in a number?

Despite the totemic status of the goal to keep global warming below 1.5°C, there is no magic temperature threshold beyond which the world is doomed. For every extra fraction of a degree Earth heats up, the impacts will become more extreme. So, in many ways, crossing the 1.5°C threshold is a political milestone, rather than a scientific one.

In reality, 1.4°C of warming offers a better future than 1.5°C, while 1.7°C of warming is still a victory compared with 2°C. Richard Betts at the UK's Met Office likens the risks of warming to national speed limits. "With a speed limit of 70mph, it doesn't mean that 69mph is safe necessarily, and it doesn't mean that 71mph is going to kill you," he says. "But the faster you go, the more in danger you are."

Yet a breach of 1.5°C can't be ignored. It fires the starting gun on a process of destruction that threatens to obliterate whole ecosystems and, with them, entire human cultures (see main story). People on the front line of climate change will experience this fate first. But if we fail to act, we will all follow.

BRETT MONROE GARNER/GETTY IMAGES

Tuvalu in the south Pacific is extremely vulnerable to sea level rise (left). On the Great Barrier Reef, heat stress causes mass bleaching events (below)

People in remote villages were pushed to near starvation, says Amy Savage, who studied the aftermath of the cyclone and drought and now works for the World Health Organization. "They were really, really badly affected by that drought," she says. "There were three or four months [where some] people reported living on one food item, like manioc [cassava] or bananas – that is all they had to eat for months." She warns that escalating climate change looks set to permanently change Vanuatu's dietary culture. In the face of extreme storms and unpredictable growing seasons, families are increasingly abandoning home-grown produce in favour of imported food such as instant noodles. Such a shift brings with it an increased risk of conditions like obesity, diabetes and cardiovascular disease. "I think we need to see climate change as less of an abstract concept and understand that real, individual people are being affected," says Savage.

Beyond 1.5°C warming, those people won't just be in remote locations. Increasingly, people in Western nations will start to feel the force of climate change as threats from flooding, drought and wildfires grow. Food security will become a pressing problem: in the UK, for example, MPs were already warning in 2017 that 20 per cent of the country's fruit and vegetables are imported from countries where climate change poses a significant risk to crop yields. What's more, Saleemul Huq at the International Centre for Climate Change and Development in Bangladesh believes many Western countries are far less prepared for warming beyond 1.5°C than nations on the front line.

Goodbye coral reefs?

For some communities, however, it is already a reality. In Australia, 80 per cent of the Great Barrier Reef has been hit by severe bleaching as a result of rising ocean temperatures. Right now, the reef tends to have a few years of breathing space between bleaching events, allowing some fast-growing coral species to partially recover. The bleaching events of 2016 and 2017 left parts of the reef "decimated", according to Craig Stephen, who owns Mike Ball Dive Expeditions in Queensland, which runs diving trips for tourists. But, he adds, after two or three years of regrowth it looked "fantastic". This seeming recovery is an illusion.

Bleaching events are happening more often, says Terry Hughes at James Cook University, Australia. "What used to be an unprecedented event is now becoming much more frequent and severe." To make matters worse, the fastest-growing coral species – like staghorn and table corals – are also the most vulnerable to spikes in temperatures. "The mix of coral species is changing at breakneck speed," says Hughes. "The reefs at 1.5°C of global average warming will be quite different from the reefs of today and the reefs of 30 years ago." If warming reaches 2°C, coral reefs may cease to exist entirely, according to the IPCC. This would throw a thriving tourism industry into an existential crisis. "Certainly, for businesses like ours, we would have to adapt and change," says Stephen. "There's no ifs or buts about that."

Coral die-off is just one of several "tipping points" we risk triggering by overshooting 1.5°C of warming. These are changes that can't be undone, even if temperatures subsequently come back down. Top of the list, along with the demise of coral, are widespread thawing of permafrost and the collapse of Arctic ice sheets, including the Greenland one. It is very difficult for scientists to judge exactly when a tipping point has been breached – some may have been passed already. The argument for cutting emissions and slowing global temperature rise is about minimising the risk of passing these triggers (see "What's in a number?", left). "You don't want to get into this unknown territory," says Richard Betts at the UK's Met Office. "If you can't be certain, but the impacts are profound, then you want to avoid testing it."

With the 1.5°C temperature goal slipping out of reach, this makes efforts to reverse the direction of climate change even more urgent. In the coming decades, technologies that suck excess carbon dioxide out of the environment promise to be big business – from machines that extract it from the air to solvents that "wash" it from ocean water. Pulling the temperature rise back down below 1.5°C will rely on getting these to work at scale. We will also need the world's forests, peatlands and other carbon sinks working overtime to remove CO_2. Yet, as the climate warms, there is a growing threat that these natural carbon stores start to collapse, warns Betts. Wildfires can wipe out forests, for example, and droughts can dry out wetlands, hampering their ability to lock away carbon.

How realistic is it, then, to expect we can wind back the climate clock after exceeding 1.5°C? It is "theoretically possible", says Betts. "But the more we overshoot, the harder it will be to get back." ▮

Madeleine Cuff is an environment news reporter at *New Scientist*

SUPERTOTTO

Computing comes to life

Nature is capable of astonishing feats of computation. Now, we are re-engineering molecules, cells and even whole organisms into living processors, says **Edd Gent**

WHAT'S the difference between a thimbleful of bacteria and a supercomputer? Believe it or not, the bacteria contain more circuits and more processing power.

That is perhaps not so surprising when you consider that all life computes: from individual cells responding to chemical signals to complex organisms navigating their environment, information processing is central to living systems. What's more intriguing, however, is that after decades of trying we are finally starting to corral cells, molecules and even whole organisms to carry out computational tasks for our own ends.

That isn't to say biological computers will replace the microchips you find in your smartphone or laptop, never mind supercomputers. But as bioengineers get to grips with the wet and squishy components nature provides, they are beginning to figure out where biological computers might ultimately be useful – from smart materials and logistics solutions to intelligent machines powered by tiny amounts of energy.

If the applications seem unusual and eclectic, that is the point. "Biocomputing is not competing against conventional computers," says Angel Goñi-Moreno at the Technical University of Madrid in Spain. "It's a radically different point of view that could help us tackle problems in domains that were simply not reachable before." It might even force us to rethink our assumptions about what computing is, and what it can do for us.

For decades, computing has been dominated by silicon chips. These are made up of billions of tiny switches called transistors that encode data in bits, or binary digits. If a switch is open and electrical current is allowed to flow, this represents a 1. If it is closed and the current is blocked it represents a 0. What makes chips so powerful is the way they are wired up.

Transistors are arranged into logic gates, which take one or more bits as input and then output a single bit based on simple rules. By piling millions of these simple operations on top of each other, it is possible to carry out incredibly complicated computations.

This has brought us a long way, and yet it isn't the only way. At their heart, computers are just information processors, and there is growing recognition that nature is rich with such capabilities.

The most obvious example lies in the nervous systems of complex organisms, which process data from the environment to direct all kinds of sophisticated animal behaviour. But even the tiniest cells are replete with intricate biomolecular pathways that respond to incoming signals by switching genes on and off, producing chemicals or self-organising into complex tissues. And ultimately, all of life's incredible feats rely on DNA's ability to store, replicate and transmit the genetic instructions that make them possible.

Biological systems also have some peculiar advantages over existing technology. They tend to be far more energy efficient, they sustain and repair themselves, and they are uniquely adapted to processing signals from the natural world. They are also astonishingly compact, of course. "The incredible thing about biology is that if you take all the DNA that's in 1 millilitre of bacteria, there's enough information storage for the entire internet and there are as many circuits as billions of [silicon] processors," says Chris Voigt, a synthetic biologist at the Massachusetts Institute of Technology.

We have been trying to leverage these abilities since the 1990s. In the past 20 years, armed with new and more powerful tools to engineer cells and molecules, researchers have finally begun to demonstrate the potential of using biological material to build computers that actually work.

At the core of the approach is the idea that cellular processes can be thought of as "biological circuits", says Voigt – analogous ›

to the electrical ones found in computers. These circuits involve various biomolecules interacting to take an input and process it to generate a different output, much like their silicon counterparts. By editing the genetic instructions that underpin these processes, we can now rewire these circuits to carry out functions nature never intended.

In 2019, a group at the Swiss Federal Institute of Technology in Zurich built the biological equivalent of a computer's central processing unit (CPU) from a modified version of the protein used in CRISPR gene editing. This CPU was inserted into a cell where it regulated the activity of different genes in response to specially designed sequences of RNA, a form of genetic material, letting the researchers prompt the cell to implement logic gates akin to those in silicon computers.

A group at the Saha Institute of Nuclear Physics in India took things a step further in 2021, coaxing a colony of *Escherichia coli* bacteria to compute the solutions to simple mazes. The circuitry was distributed between several strains of *E. coli*, each engineered to solve part of the problem. By sharing information, the colony successfully worked out how you could navigate multiple mazes.

To be clear, these circuits operate orders of magnitudes slower than electronic ones and are rudimentary in comparison. Their power lies in the opportunity they offer to implement programs that interface directly with living systems, says Voigt. They could be used to create everything from tiny robots that treat disease inside the body to complex, multi-step biomanufacturing processes, he says. "You don't have to beat computers to be useful. The real valuable stuff early on is just simple control over the biology," says Voigt.

However, thinking about cellular processes in terms of circuits could be short-sighted, says Goñi-Moreno: "We are trying to force our electrical engineering mindset into living systems and that's not necessarily how they work." The thing is, most biological systems aren't limited to the binary logic of classical computers. They also don't work through problems step-by-step, like computer chips. They are full of duplications, strange feedback loops and wildly different processes operating side-by-side at various speeds.

Failing to account for this complexity often results in biological circuits not performing as expected, says Goñi-Moreno, and it means the full functionality of cells isn't being exploited. Conversely, finding ways to model and rewire

"We can rewire biomolecular circuits to do things that nature never intended"

biochemical interactions within and between living cells could bring more ambitious goals into reach, he says. To that end, Goñi-Moreno is trying to create multicellular communities of soil bacteria that can switch between removing different pollutants depending on which is more prevalent.

Biology's powers of computation might also be exploited in ways that are entirely divorced from their natural context. Heiner Linke at Lund University in Sweden has been experimenting with a radically different approach to biocomputing, using tiny protein

ANDREW ADAMATZKY

Fungi could potentially be connected with standard electronics

filaments propelled around a maze by molecular motors. The proposal is aimed at solving a class of tricky computational challenges called NP-complete, for which the only known way to find the answer is to try every possible solution. These problems crop up in everything from logistics network planning to computer chip design. But they present a challenge for conventional computers because the sequential way in which they operate means that as the problem gets bigger, the time taken to check every solution rises exponentially.

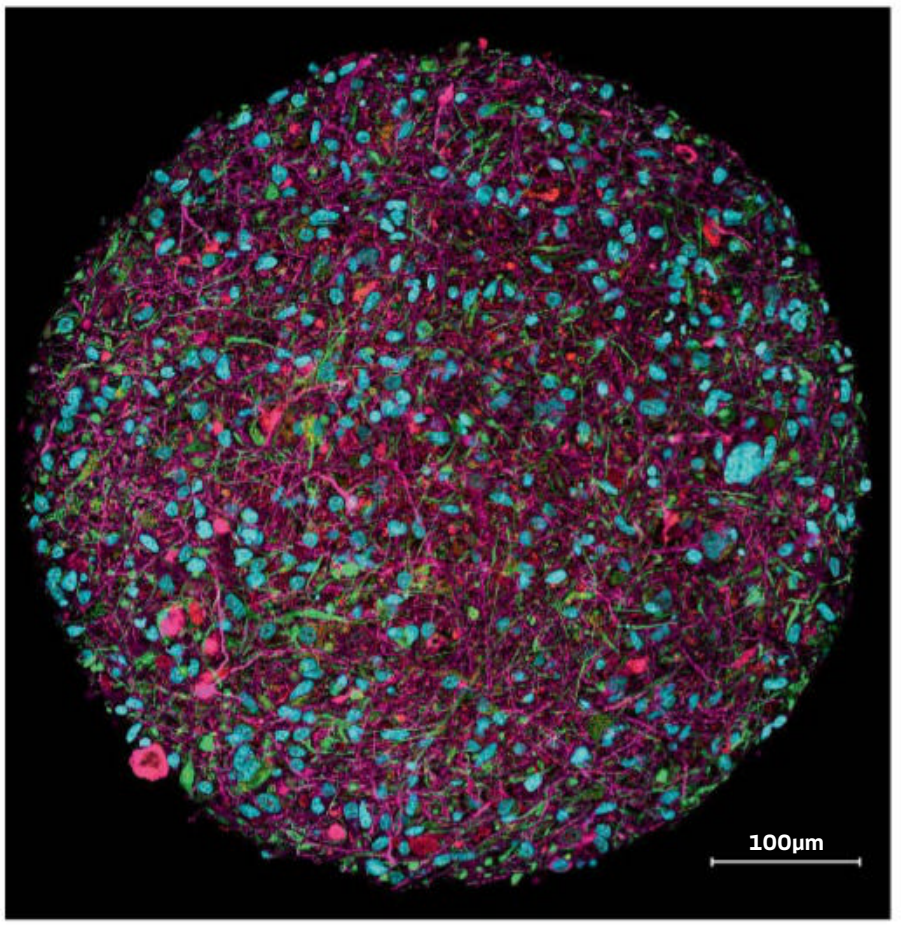
Linke's approach offers a workaround. The structure of the maze is carefully designed to encode the problem that needs to be solved,with every possible path through it corresponding to a potential solution. For instance, this could involve exploring the quickest route a truck could take between multiple stops. As the filaments whizz around the maze, they explore every option such that, by counting the number of filaments that pop out at predetermined exits, you can work out which path represents the correct answer.

The beauty of the approach, says Linke, is that the filaments explore all routes simultaneously. That means solving a bigger problem doesn't require more time, just more filaments. And because they use about 10,000 times less energy per operation than electronic transistors, scaling up is far more feasible than with conventional computers.

But Michael Levin at Tufts University in Massachusetts thinks we are missing a trick by building biocomputers from the bottom up. Living systems already carry out jaw-dropping computational feats at every level of biology, he says, and our biggest limitation isn't our struggle to create and control biological circuits, but rather our inability to harness what already exists in nature. "The things that we're going to create from scratch are, for a really long time, going to be pitiful compared to what's already out there," he says.

Levin thinks we need to shift focus from trying to re-engineer biological systems to finding ways to interface with what is already there. That means thinking of them not as building blocks but more as "materials with an agenda" whose natural behaviour we can redirect to our own ends, he says.

Consider the genetic circuitry some organisms use to regrow limbs. We are decades away from being able to recreate that. But Levin's lab has shown they can manipulate the electrical communication between cells that



THOMAS HARTUNG, JOHNS HOPKINS UNIVERSITY

Lab-cultured brain cells are being repurposed for computing

helps them decide how and where to grow. This allows them to trigger the innate circuitry that governs how groups of cells self-organise into limbs, getting tadpoles to grow eyes on their guts and frogs to sprout extra legs.

While that doesn't amount to computing per se, Levin argues that it demonstrates how we could bend nature's pre-existing circuitry to new ends. With a bit of imagination, similar approaches could be used to solve a wide range of computational tasks. "You can make [biological systems] do new things, but not necessarily by completely rewiring from scratch," he says. "What you're doing is shaping the competencies that are already there."

The esoteric field of fungal computing shows the potential. Fungi have an impressive ability to sense things like pH, chemicals, light, gravity and mechanical stress, says Andrew Adamatzky at the University of the West of England in Bristol, UK. They appear to use spikes of electrical activity to communicate, which opens up the prospect of interfacing them with conventional electronics.

Fungi are attracting attention as lightweight, eco-friendly materials for industries including construction and fashion, suggesting they could ultimately be used to create smart wearable devices or even intelligent buildings that sense and respond to environmental conditions, says Adamatzky.

A more obvious place to look for biological computation is inside the most powerful computer we know: the brain. Advances in tissue engineering mean scientists can grow, from stem cells, complex clusters of neurons tantamount to miniature brains, known as "brain organoids". Meanwhile, breakthroughs in miniature electrodes that transmit signals to brain cells and decode the response from them mean we have begun to experiment with their memory and learning capabilities.

Earlier this year, a team led by Thomas Hartung at Johns Hopkins University in Maryland outlined its vision for a new field the researchers dub "organoid intelligence". The goal is the inverse of artificial intelligence: rather than making computers more brain-like, they will attempt to make brain cells more computer-like. "It is not science fiction anymore," says Hartung.

Organoid intelligence

In 2021, researchers at Melbourne-based start-up Cortical Labs showed they could train human brain cells cultured on top of a silicon chip to play the video game *Pong*. They translated game data, such as the positions of the ball and paddle, into spikes of electrical activity that were fed into the mass of cells via electrodes. The electrical responses of the neurons were then recorded and used to control the movement of the paddle.

Brain cells have unique capabilities that make them promising building blocks for intelligent machines, says Cortical's chief scientific officer Brett Kagan. They learn quickly, unlike today's AI, which has to be trained on myriad examples. They also readily absorb many different kinds of data and use minuscule amounts of energy. And while there are question marks around whether we can recreate human-like intelligence in silicon, we know you can do it with neurons, say Kagan. "The how might be very complicated, but it's a very different place to start from," he says.

A near-term application, Kagan says, could be to exploit neurons' exceptional pattern recognition skills for cybersecurity applications like monitoring internet traffic for unusual activity that might indicate a hack. In the longer term, he thinks they could help power machines that operate in the real-world, such as robotics or smart sensors. "What do brains do better than machines?" he asks. "Sensing and responding to rapidly changing environments is definitely one thing."

Cortical Labs is now developing software called biOS, or Biological Intelligence Operating System, a software environment in which anyone with basic coding skills can program tasks for what it calls its "DishBrains".

But Madeline Lancaster at the University of Cambridge, who was a pioneer of brain organoids, thinks that repurposing them for computational tasks is still a long way off. Keeping them alive for extended periods remains a struggle, she says, and much of the computational power of brains comes from the complex hierarchical structures neurons form, something we are far from being able to replicate. "It's a little bit jumping the gun," she says. "At the moment it's just a bunch of neurons kind of randomly connected."

The truth is that all of these approaches to biological computing are far from going mainstream. "We have not yet learned how to harness organic computers for anything particularly useful, other than demonstration projects that lead to publishing academic papers," says Rob Carlson, managing director at venture capital firm Bioeconomy Capital. Our ability to manipulate biology is still rudimentary compared with our capacity to design and build silicon chips, he says.

Even so, Carlson thinks the enormous potential of biological computation and the billions being poured into biotech will bring rapid progress over the next few years. One thing is certain: we have barely scratched the surface of what is possible. "There are biological computers within us, all around us, everywhere," says Levin. "There's so much richness already out there." ▮

Edd Gent is a technology journalist based in Bangalore, India

Colourful thinking

Synaesthesia is no longer viewed merely as a scientific curiosity, but rather a window into how our brains work to make sense of the world around us, finds **Kayt Sukel**

WHAT colour is the letter A? It is a question Nicholas Root often asks the volunteers he has recruited for his research. Most give him the same response. "They say the task is stupid and that letters don't have a colour," says Root.

But they do for people with letter-colour synaesthesia, in which letters and words are associated with particular colours. That includes Jennifer Mankin, now a synaesthesia researcher herself, who recalls confusing her schoolmates in her teens by saying one of them had an orange name. "It became clear to me, in that moment, that my perception of the world was fundamentally different than most other people," she says.

Scientists have known about synaesthesia for more than 200 years, but for much of that time it has been unclear why some people blend sensory information – why they associate words with flavours or sounds with textures, for example. These days, there is a consensus that some forms of synaesthesia, particularly letter-colour synaesthesia, are closely tied with learning. The revelation is pushing researchers like Mankin to go beyond asking why synaesthesia exists and explore what it reveals about how the brain functions.

This work has already shown how culture influences the way we learn and how our thinking is shaped in different ways depending on which language we speak and write. The latest discoveries may prove even more significant: we have seen tantalising signs that many people without synaesthesia unknowingly blend sensory information, which suggests that what we are learning about the trait might even tell us something more far-reaching about human consciousness.

The first convincing description of synaesthesia was published by Georg Tobias Ludwig Sachs in 1812. Sachs and his youngest sister had albinism – a perfect subject, he thought, for scientific investigation. But buried within his paper "A natural history of two albinos, the author and his sister", there is a short section in which Sachs highlighted that the pigmentation he lacked in his physical body was more than present in his mind's eye. He explained that "coloured ideas appeared" when he interacted with words, numbers and musical notes.

At the time, Sachs's treatise was taken as little more than a scientific curiosity. But nearly 70 years later, Francis Galton – now infamous for his views on eugenics – began his own studies of synaesthesia. He speculated that the attribute was learned and that it could help those with it to more efficiently tackle cognitive tasks. From Galton's writing, it is clear he was fascinated by synaesthesia. His peers were evidently less so: within a few years, interest had fizzled out and synaesthesia was largely ignored by science for most of the 20th century.

Learning advantage

"It wasn't until the early 1990s when we see synaesthesia getting back into respectability," says Marcus Watson at York University in Toronto, Canada. That was due in no small part to the work of neurologist and author Richard Cytowic, who wrote an influential book on the subject in 1989. "Now, we are at the point where there are about 50 to 100 papers published on synaesthesia each year," says Watson.

This recent research has taught us, for one thing, that Galton's views on synaesthesia were close to the mark. Letter-colour synaesthesia – which is often the focus of research because it is relatively easy to study – does indeed seem to be tied to learning, says Watson. This has been made particularly clear through remarkable research led by Julia Simner at the University of Sussex, UK, which has revealed how letter-colour synaesthesia develops over the course of several years during childhood.

The work involved repeatedly testing more than 2000 children who were being followed as part of a long-term study commissioned by the Scottish government. Significantly, this showed that a subset of these children began associating letters with colours at around 5 years of age – just when they were beginning their formal schooling.

Simner says doing so seems to help young children learn what they need to succeed in the first years of school: numbers, letters and other critical concepts. "Many cognitive scores in synaesthetes shift up by 2 or 3 per cent," says Simner. "They aren't all geniuses, but they have stronger abilities in the production and comprehension of vocabulary. They tend to test slightly higher in creativity, too."

This might be because associating letters with colours has benefits when recalling information, says Root, who is based at the University of Amsterdam in the Netherlands. There are, after all, multiple pathways to the same stored memory. "If I'm trying to remember the name of someone – let's say her name is Brittney – I might remember her name is brown, and my B is brown, so I know her name must start with B," he says.

All of which raises an obvious question: if synaesthesia is so useful for learning new information during childhood, why don't all children make these connections? Simner's research suggests that just 1 in 23 people consciously experience some sort of synaesthetic sensory overlap. Given the evidence that synaesthesia often runs in families, it seems likely that this rarity is at least partly down to genetics. The nature of that genetic component is probably complex. One possibility is that it may, in at least some ›

SHARMELAN MURUGIAH

Teaching synaesthesia

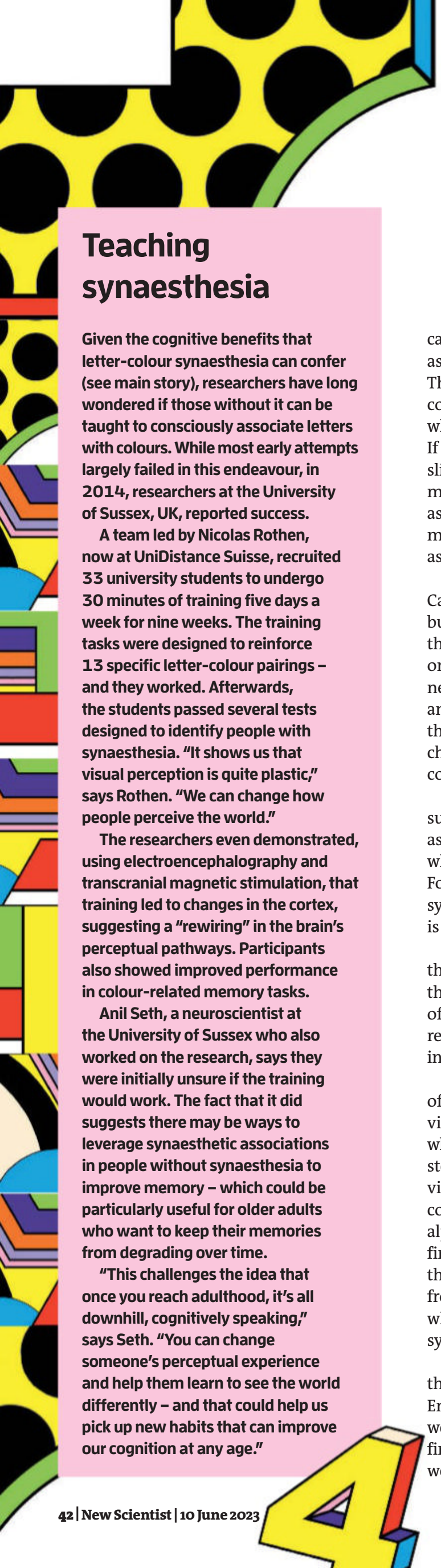
Given the cognitive benefits that letter-colour synaesthesia can confer (see main story), researchers have long wondered if those without it can be taught to consciously associate letters with colours. While most early attempts largely failed in this endeavour, in 2014, researchers at the University of Sussex, UK, reported success.

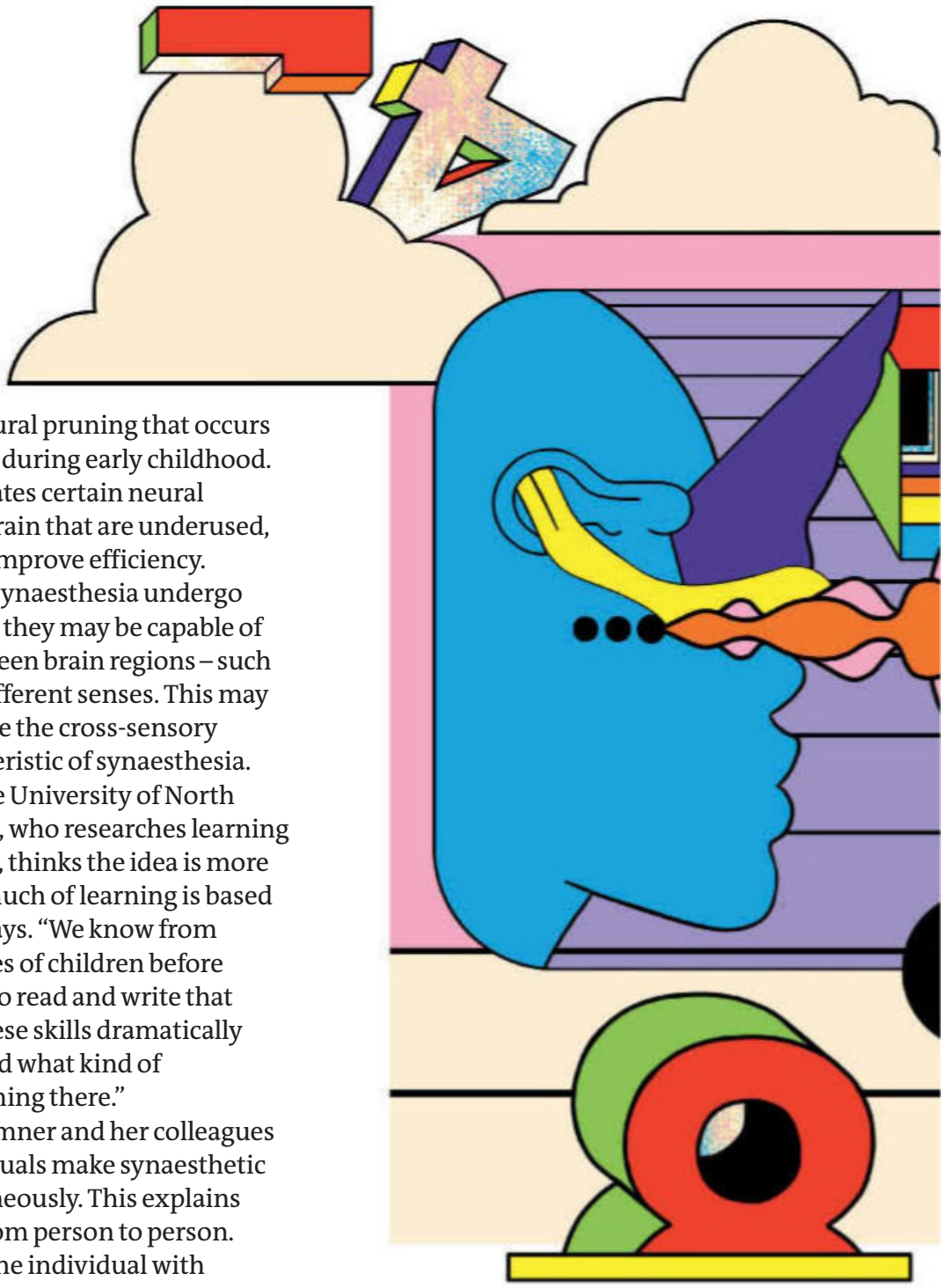
A team led by Nicolas Rothen, now at UniDistance Suisse, recruited 33 university students to undergo 30 minutes of training five days a week for nine weeks. The training tasks were designed to reinforce 13 specific letter-colour pairings – and they worked. Afterwards, the students passed several tests designed to identify people with synaesthesia. "It shows us that visual perception is quite plastic," says Rothen. "We can change how people perceive the world."

The researchers even demonstrated, using electroencephalography and transcranial magnetic stimulation, that training led to changes in the cortex, suggesting a "rewiring" in the brain's perceptual pathways. Participants also showed improved performance in colour-related memory tasks.

Anil Seth, a neuroscientist at the University of Sussex who also worked on the research, says they were initially unsure if the training would work. The fact that it did suggests there may be ways to leverage synaesthetic associations in people without synaesthesia to improve memory – which could be particularly useful for older adults who want to keep their memories from degrading over time.

"This challenges the idea that once you reach adulthood, it's all downhill, cognitively speaking," says Seth. "You can change someone's perceptual experience and help them learn to see the world differently – and that could help us pick up new habits that can improve our cognition at any age."





cases, involve the neural pruning that occurs as we grow and learn during early childhood. This pruning eliminates certain neural connections in the brain that are underused, which is thought to improve efficiency. If some people with synaesthesia undergo slightly less pruning, they may be capable of more cross-talk between brain regions – such as those related to different senses. This may make it easier to forge the cross-sensory associations characteristic of synaesthesia.

Robert Wiley at the University of North Carolina Greensboro, who researches learning but not synaesthesia, thinks the idea is more than plausible. "So much of learning is based on association," he says. "We know from neuroimaging studies of children before and after they learn to read and write that the acquisition of these skills dramatically changes the brain and what kind of connections are forming there."

The research by Simner and her colleagues suggests that individuals make synaesthetic associations spontaneously. This explains why they can vary from person to person. For instance, while one individual with synaesthesia may learn that the letter H is orange, another may learn that it is blue.

But that isn't quite the whole story. Despite this variation, we have known for a few decades that people with letter-colour synaesthesia often agree on the colour of a few letters. Some researchers now think this offers an insight into the workings of the human mind.

Take Mankin, who is based at the University of Sussex, UK. The letter J comes to her as a vibrant shade of pink. Root's research suggests why. In many higher-income countries, cultural stereotypes tend to encourage young girls to view pink as their favourite colour. It is also common for young children learning the alphabet to recognise the first letter of their first name before most other letters and to use that letter as a way to distinguish their name from others. Root and his colleagues wondered whether this would prompt girls with synaesthesia to associate this letter with pink.

When they tested women with synaesthesia, they found evidence in support of this: English-speaking women with synaesthesia were 4.4 times more likely to perceive the first letter of their first name as pink than they were to perceive other letters as pink. This association, learned in early childhood, is so strong that it remains in place even in those who have long outgrown their pink phase and have a different favourite colour as adults.

"These associations may seem random, but they're really not," says Root. For instance, people with synaesthesia who learned the Latin alphabet at school are particularly likely to view its first letter, A, as red. Root thinks he knows why. "It's one of the first things you learn, so it has this really salient colour," he says. In the Korean alphabet, the first letter is ㄱ (pronounced "g" or "k" depending on the context). Root's work shows that, for people with synaesthesia who learn the Korean alphabet at school, it is this letter that is usually perceived as red. "We've now looked at about 20 [writing systems] and, in all of them, the first letter tends to be red," he says.

"There is definitely a linguistic effect," says Simner, whose research has also explored the links between synaesthesia and language. "We also see that letters that are similar shapes are more likely to be similar colours."

Taking an international perspective also reveals how people with synaesthesia latch

on to different linguistic properties, depending on the language or writing system they are learning. For example, in the past decade, we have discovered that people with synaesthesia who learned to read Japanese at school often associate similar colours with characters that make similar sounds. An example in English would be to associate the letters C and K with shades of the same colour. To be clear, though, people with synaesthesia who learned to read English at school don't usually do this.

This may reflect key differences between these writing systems: characters in Japanese tend to have a single pronunciation, whereas alphabetic letters in English may have several (such as the "o" in go, to and ow). As young children with synaesthesia learn to recognise the features of the writing system that will help them learn, they use their synaesthetic skills to make these features easier to memorise. "When you study thousands of synaesthetes, you start to see a bunch of interesting little rules that govern why they develop the associations they do," says Simner.

All of this evidence that letter-colour synaesthesia plays a role in learning may leave people without it feeling left out. But we have known for 20 years that many people do, in fact, associate letters with colours when pressed to do so (see "Teaching synaesthesia", left). Some of Root's latest work suggests they do so in a way that is difficult to distinguish from people with synaesthesia.

In yet-to-be-published research, Root and his colleagues asked 51 English-speaking students in the US to associate letters with colours. None of the 51 thought of themselves as having synaesthesia – and none seemed to, based on tests. Nevertheless, for a subset of nine letters, the typical colour associations they gave matched those expected of someone with synaesthesia. For instance, they tended to associate A with red, B with blue, I with white and Z with black.

This isn't a new finding. Researchers including Simner have made the same observation in the past. But some earlier studies suggested there were still important differences between people with and without synaesthesia. Specifically, we know that people with synaesthesia will consistently associate a given letter with a particular colour when tested multiple times. People without synaesthesia are far more inconsistent.

In their latest work, Root and his colleagues took a closer look at this consistency. They suspected that, although people without synaesthesia appear inconsistent in their letter-colour associations across the full alphabet, they might be consistent for the subset of nine letters. It turned out that they were: 31 per cent of the time, someone without synaesthesia would consistently associate these letters with the same colours.

Confidence is another important feature of letter-colour synaesthesia. When asked, someone with the trait will typically say they are certain that a particular letter is a particular colour. But, again, Root and his colleagues found that this certainty isn't unique to people with synaesthesia: many of the students in their experiment also claimed to be confident about at least some of their letter-colour choices. In fact, 41 per cent of the students were both consistent and confident in the letter-colour association for at least one of the nine letters. Given that none of these students claimed to have synaesthesia, Root thinks this finding has implications for the way we define it.

"What makes a synaesthete special isn't that they think A is red or that they associate similar sounds with similar colours," he says. "What makes a synaesthete special is that they are consciously aware of it." This suggests, he says, that we can think of someone with synaesthesia as an "easier-to-study version of every one of us". It also hints that synaesthesia research may be about to offer us a new perspective on the difference between conscious and unconscious awareness.

Mankin says there is a range of synaesthetic experience waiting to be studied. She thinks the patterns that will be discovered will help us better understand the nuances of language, learning and consciousness. "It gives us such unique insights into all these processing networks the brain uses to help us speak or think," she says. "And it's not just the synaesthetes that have these rich and complex networks. It's all of us." ▮

Kayt Sukel is a science journalist based in Texas

The back pages

Mathematics of life

Pack it up, pack it in

How can you ensure you use the fewest bags when loading your shopping? A dash of maths will help, says **Peter Rowlett**

Peter Rowlett is a mathematics lecturer, podcaster and author based at Sheffield Hallam University in the UK. Follow him @peterrowlett

Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations

Next week
Debunking gardening myths

YOU have heaped your shopping on the supermarket conveyor belt and a friendly member of the checkout staff is scanning it through. Items are coming thick and fast and you would like to get them in as few bags as possible. What is your strategy?

This is an example of an optimisation problem, from an area of maths called operational research. One important question is, what are you trying to optimise? Are you thinking about the weight of the items, or how much space they will take up? Do you guess how many bags you might need and start filling that many, or put everything in one until you need to start another?

We design algorithms to solve packing problems when they come up at a larger scale than your weekly shop, like making better use of warehouse space or fitting boxes into delivery vans. Similar algorithms are used for cutting raw materials with minimal waste and storing data on servers.

Bag-packing algorithms generally involve placing items into a single bag until you get to one that won't fit because you have hit a maximum weight or size. When necessary, you open a second bag, and each time you reach an item that won't fit in an existing bag, you start a new one.

If you are filling multiple bags at once, it is likely you will come across an item that could fit in more than one bag. Which do you choose? There is no clear best answer, but different algorithms give different ways to make this decision. We are looking for rules that can be applied without detailed thought. You might have more subtle requirements, like putting two items in the same bag because they go in the same cupboard at home, but here we want the kind of simple rule a computer program can mindlessly apply to get the most efficient outcomes, using the fewest bags, every time.

VERA_PETRUNINA/GETTY IMAGES

One algorithm we could employ is called first fit. For each new item, you look through the bags in the order you opened them, placing the item in the first one it fits in. An advantage is that this is quick to implement, but it can overlook options and end up using more bags than needed.

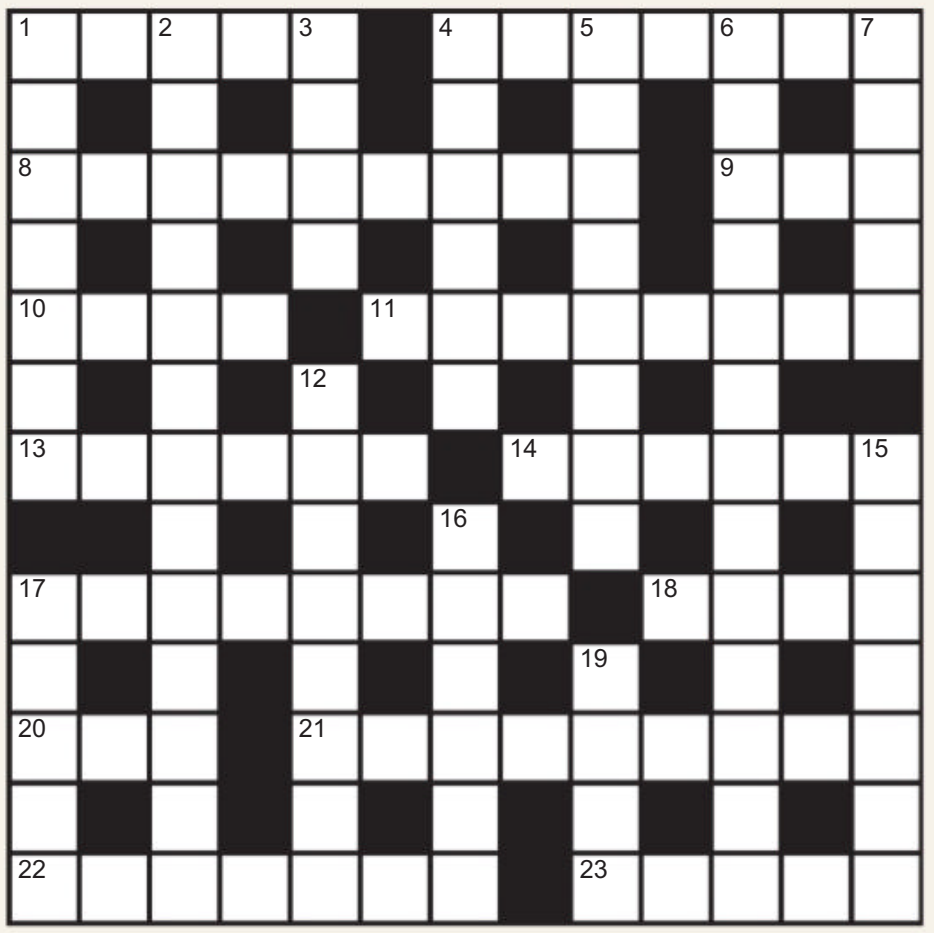
An alternative that often uses fewer bags overall is called worst fit. When faced with a choice, you look through the currently open bags for the one with the most space and place the item there.

These algorithms work more effectively if you handle the objects in decreasing order – packing the largest or heaviest first will usually need fewer bags.

So now you are armed with a secret weapon for packing: the worst-fit decreasing algorithm. The next time you are in the checkout line, load your bulkiest shopping onto the conveyor belt first, and always put items in the bag with the most space available – it might just help you use fewer bags overall. ▮

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

Cryptic crossword #111 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Flower explosion surrounding lake (5)
4 Put upper limit on new chat authentication system (7)
8 Santa tour spoiled dream job for many a child (9)
9 Usual technique beginning to bore crowd (3)
10 Spring clean our industrial lab, for starters (4)
11 Give guards energy before they initially set off (8)
13 Look at what's in emphatic type (6)
14 Hot water spraying bloke in the ear (6)
17 Shipment of French footman's attire (8)
18 Peeled egg with stale yellow (4)
20 Colloidal polysaccharide vessel sent back (3)
21 Terrible ordeal reordering the Garmin (9)
22 Apparatus's audio is too much for museum founder (7)
23 Head of department interpreted anxiety (5)

DOWN

1 Be part of a circle essentially nurturing British youngster (4,3)
2 Extremely upset over retro stage decor involving deep purple feathers (7,6)
3 Low-gravity instrument inventor (4)
4 Depression affected racer taking testosterone (6)
5 Dash after pet pig for something that might go viral? (8)
6 Handheld magnetic device beat a tie-on kind (13)
7 Unhurriedly move beer outside storage unit (5)
12 AI novels unsettled nation (8)
15 Adjustable ladder straddles last of rare paint pigment (3,4)
16 Friend's first severe cold (6)
17 For example, 3 really like information technology (5)
19 Endlessly scrutinise breeding animal (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #205
set by Bethan Ackerley

1 The fraction of light reflected from an object's surface is known as its what?

2 In biology, what name is given to the process by which life arises from non-living matter?

3 Who was the first person to find evidence of radioactivity?

4 Which firm developed the Osprey quantum computer?

5 Birds in which genus are known as the "true eagles"?

Answers on page 47

Headscratcher
set by Zoe Mensch
#225 Dominoku

3	2	4	1	0		
2		4	6	6	5	4
0		0	1	1	5	2
0	3			1	0	6
4	1	5	1	3	0	4
3	1	0	5	5	5	4
3	2	2	2	4	6	1
6	0	5	6	4	3	5

Over the past decade, the puzzling community has enjoyed inventing new puzzle names by adding the suffix "oku" to the end of various words.

To create this puzzle, a "dominoku", I have taken a full set of 28 dominoes (in which the numbers run from 0 to 6, and each number is paired exactly once with every other number, including itself). I mixed the dominoes up and set them out on a 7 × 8 rectangle on a table. Then I turned three over and copied the other numbers onto a grid. Your challenge is to identify which dominoes I hid and to mark the boundaries between all the dominoes.

Solution next week

Stacking up

Is there a correct way to fill a dishwasher to maximise capacity and cleanliness?

Raúl Pérez Mohedano
Valencia, Spain
I was part of a project researching water motion in domestic dishwashers in 2015. The key to success is to make sure items aren't placed in a way that blocks the water path. That is, you need to avoid filling up the dishwasher by placing items on top of each other or very close together. Water is the key element to cleaning effectively, as it provides the force, the detergent components and the temperature to ensure everything comes out clean.

There is no need to pre-wash any item, though solid food pieces should be thrown away prior to loading. Also, large items with sticky stains should be placed on the bottom rack, as the water jets are more intense in this location.

A final tip is to open the dishwasher once the cleaning cycle is over. That way, the remaining moisture comes out and items will be dried out completely in a shorter time.

"This question brings to mind the yogurt pot conundrum: when put in the dishwasher, these end the wash full of murky water"

Marcus Swann
Lymm, Cheshire, UK
This question was clearly designed to flush out the dishwasher-stacking nerds amongst us. It also brings to mind the yogurt pot conundrum: when put in the dishwasher, these invariably end the wash the wrong way up, full of murky water. This is because the inverted pot is light and easily flipped by the spray from the dishwasher, but becomes heavier and less likely to be flipped once filled with water. This can be remedied by placing a mug on the yogurt pot rim to jam it in place.

Oliver Miller
Glasgow, UK
When loading cutlery, put all the knives together, all the forks together and all the spoons together. This doesn't improve cleaning efficiency or capacity, but it does make emptying the dishwasher slightly more efficient.

My only other tip is that the whole chore of loading, turning on and then unloading the dishwasher should be done by one person. Most dishwasher arguments appear to be about the right way versus the wrong way, but are really about two different ways that both work, but may not be compatible with each other. If one person does everything, there will be no arguments, only domestic bliss.

[Ed. – For more information on the best way to load your dirty dishes, see our 2015 feature, The ultimate guide to stacking the dishwasher.]

ASHLEYWILEY/GETTY IMAGES

This week's new questions

Good boy **Why do humans pat animals on the head? I know we do it with cats and dogs, but I recently saw footage of a diver trying to pat an octopus.** ***Peggy Sellers****, York, UK*

Flush or chuck? **Is it more sustainable to flush a tissue or put it in the bin?** ***Sam (12), Lucy (10) and Grace (8) Liubinskas****, Sydney, Australia*

Why do humans feel compelled to pat animals on the head, even the more unusual ones?

Martian mountain

What governs the maximum height of mountains on Earth? Could a mountain as high as Olympus Mons on Mars (21.9 kilometres, more than double the height of Everest) be possible on our planet?

Hillary Shaw
Newport, Shropshire, UK
Any mountain on a near-spherical object causes an excess load on the surface, as gravity is trying to pull it down to ground level. Rock isn't quite solid, either. Given enough time, heat and stress, it will flow like very stiff molasses.

So, on Earth, Mars or elsewhere, a mountain can only get so high before the crust below ceases to support its weight, which is determined by gravity and the density of the rock the mountain is made of. The crust will sag and flow, and the mountain will recede. The stiffness of the rock also determines how much the mountain resists flowing into a flatter hill. Try making a steep mound from mud, for example.

Earth's tallest mountain is technically Mauna Kea in Hawaii, at about 10 kilometres from base to peak. Because Mars's surface gravity is just 38 per cent as strong as Earth's, Olympus Mons is only 2.7 times as heavy as Mauna Kea, despite being far taller and wider than it. The increased width also spreads the mountain's weight.

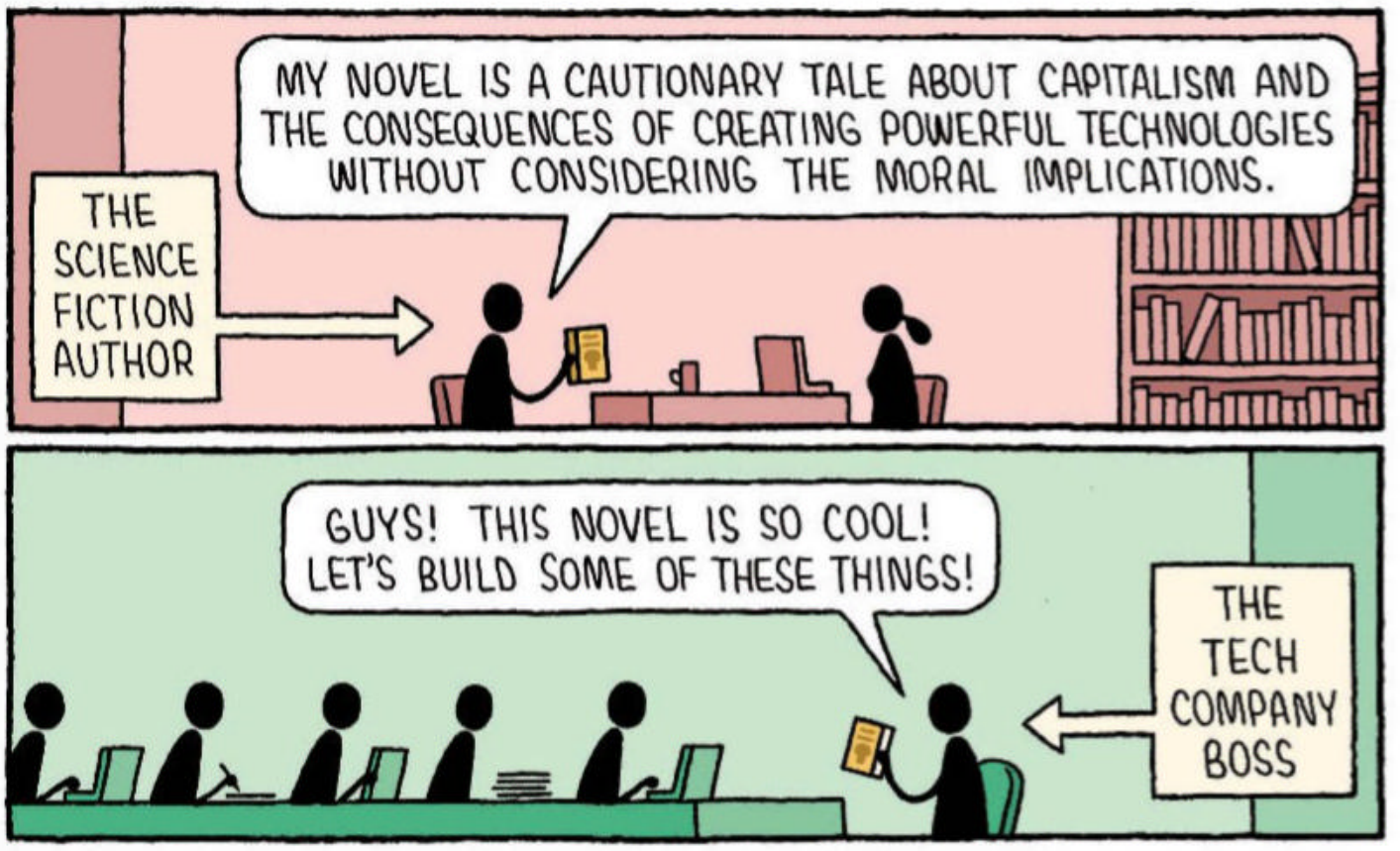
On smaller objects like Pluto or Ceres, mountains could be bigger relative to the object's diameter. That is, until we get down to asteroids, which are effectively all "mountain", as they lack enough gravity to pull them into a sphere.

At the other extreme, the highest mountain on a neutron star, where surface gravity is 200 billion times more than on Earth, is probably 1 millimetre high. That is around a fifteen-millionth of its radius, compared with Mauna Kea, which is 1/640th of Earth's radius, or Olympus Mons, which is 1/170th of Mars's radius. But don't try to hike up a mountain on a neutron star: gravity would smear you into a 1-atom thick layer many kilometres wide as soon as you landed there. That's if the neutron star's magnetic field hadn't shredded your atoms anyway.

Mark Wareing
Ashbourne, Derbyshire, UK
Experiments comparing the height of small piles of dry sand or rocks can demonstrate that

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld
for New Scientist



maximum height depends on the size of the base of the "mountain" and the material from which it is made. The gradual growth of a large, rocky mountain – whether by volcanic action or tectonic plate movement – will eventually be exceeded by its partial collapse under gravity. On Earth, this happens at about 10 km above sea level. Height then declines over time by the action of the elements or tectonic plate movement.

Undersea mountains are supported by water and can reach greater heights.

Jonathan Wilkins
Deganwy, Conwy, UK

Mountains don't simply drop into existence – they are formed, and their formation is a dynamic process driven by forces inside Earth and counteracted by gravity and weathering processes. It has taken the collision of the Indian and Eurasian tectonic plates to create Everest and the Himalayas, and the height of those mountains is still increasing slowly.

There is thickening of the continental crust at the edges of the colliding plates, which float above the denser mantle rock, and the buoyancy of the lighter continental rocks keeps the collision zone elevated.

"Don't try to hike up a neutron star mountain: you would be smeared into a layer 1-atom thick and many kilometres wide"

Simultaneously, unstable rocks on the surface fall under the influence of gravity and experience chemical attack from the atmosphere and biological agents. These processes of weathering will carry away particles of minerals and ions in solution, and will reduce the mountains' height.

Volcanoes, like Olympus Mons and Mauna Kea, were built as lava erupted and cooled to form solid rock. The growth of a volcano is a balance between the rate of arrival of magma from the mantle and the forces of erosion and weathering, but another critical matter is the pressure that must be exerted on the magma to cause its ascent to the top of the volcano.

As the pressure increases with vertical growth, the structure of the volcano may be insufficiently strong to contain the magma, and it will burst out as a flank or fissure eruption, or part of the edifice will collapse along fractures to form a landslide. Finally, it is likely that a large volcanic edifice may start to sink if the strength of the crust is insufficient to support its weight.

Moving to America

People from all over Europe settled in North America in the 17th century, so how and when did the North American accent develop? (continued)

James Cawse
Pittsfield, Massachusetts, US

West Virginia has isolated valleys ("hollers") that were settled in the 1700s. In the 1960s, it was still possible to find remnants there of true Elizabethan English. ▮

Answers

Quick quiz #205 *Answers*

1 Albedo
2 Abiogenesis
3 Henri Becquerel
4 IBM
5 *Aquila*

Quick crossword #134 *Answers*

ACROSS 8 Cirrus, **9** Sardonyx, **10** Zinc, **11** Heavy Metal, **12** Talc, **13** X-ray vision, **17** Disc, **18** Among, **19** Iota, **21** Dead weight, **23** Iris, **24** Green light, **28** Idle, **29** Salivate, **30** Osmium

DOWN 1 Kiribati, **2** Erucic acid, **3** Asphyxiate, **4** Asia, **5** Troy, **6** Coke, **7** Dynamo, **14** Along, **15** Vegetation, **16** Sci-fi films, **20** Trial run, **22** Earwax, **25** Emit, **26** Leaf, **27** Grey

#224 Russian dolls *Solution*

To find my ring, I should open the largest yellow doll.

Starting with the largest blue doll, there must be a yellow one immediately inside it. Pink can't contain red, and green can't contain pink, so the order must be blue, yellow, red, pink, green.

Next, consider the largest yellow doll. Again, red must contain pink, which contains green. We have already used the smallest green, so the order must be yellow, red, pink, green, with the smallest doll being blue. Therefore, the ring is inside the largest yellow doll.

Window pains

When you donate your future former self "to science", your generosity might open a door (and, as you will see, close a window) to adventure.

A 2012 paper titled "Finger injuries caused by power-operated windows of motor vehicles: An experimental cadaver study" used the index, middle, ring and little fingers of 10 cadaver hands to "simulate real events in which a finger is jammed between the glass and seal entry of the window of a current motor vehicle".

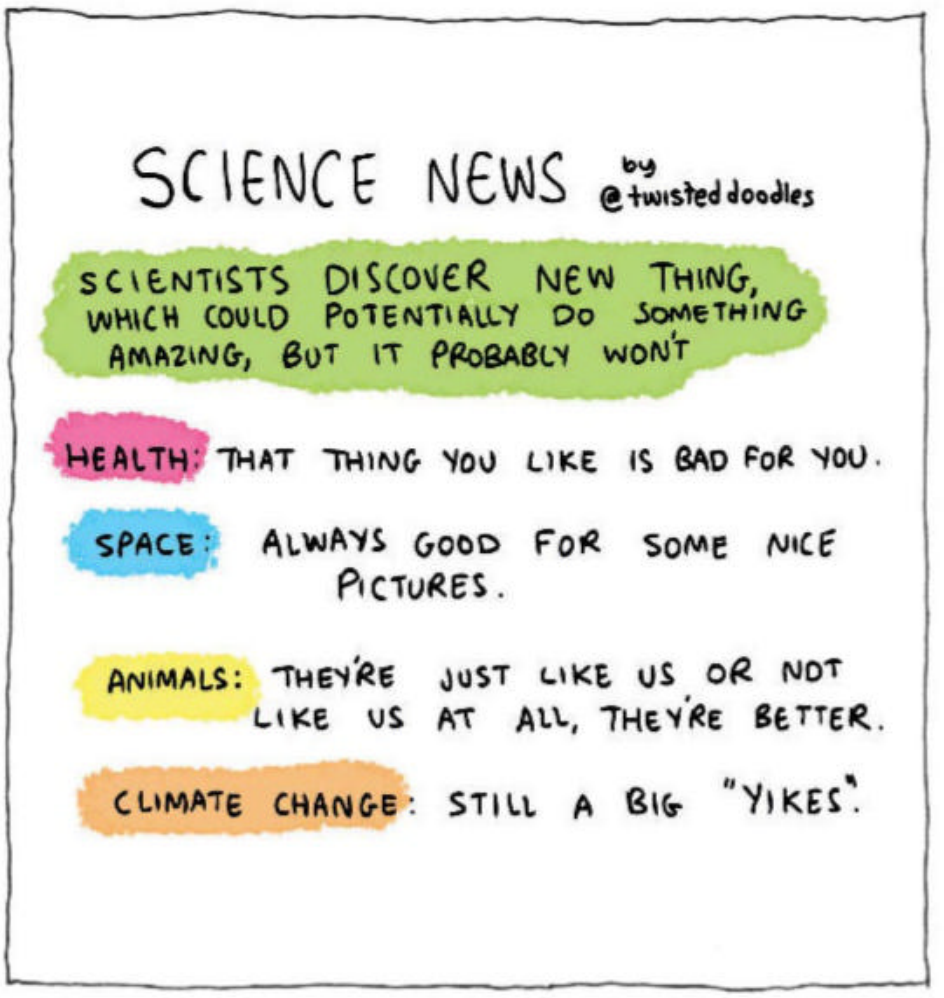
That study was cited most recently in a paper called "Experimental injury biomechanics of human body upper extremities: Anatomy, injury severity classification, and impact testing setups", presented at the 2021 Institute of Electrical and Electronics Engineers (IEEE) International Conference on Intelligence and Safety for Robotics. The aim was to study catastrophes that happen to humans, to learn how robots could be endowed with superhuman resilience.

After a relatively cheery introduction ("Only [a] few experiments were done with alive human volunteers to determine tighter tolerance levels for mild injury or pain thresholds"), the IEEE paper lurches into a parade of horror highlights about things done to cadavers. Small female elbow joints sometimes got special attention.

Behold how it also praises a 2011 study by the same team as the finger-injuries cadaver paper: "a realistic setup with a modified car door was used. The participants exerted the closing force on their fingers by themselves till their maximal pain tolerance was reached. Using an artificial setup the force could be exerted to a particular bone or joint."

As a donor, one must consider opportunity costs. Particular experiments have their day, but thereafter are seldom repeated; scientific curiosity moves on to other intriguing questions. So, if you want to lend a hand to power window-closing experiments, volunteer sooner rather than later. Don't let the window of opportunity close on your chance to be parts of digital history.

Twisteddoodles *for New Scientist*



Got a story for Feedback?

Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Hamburger and Fries

Rob Eason went on an intellectual snack run through the library, where he snagged two nominative determinism treats.

"Inheritance of mixed cryoglobulinemia", a paper by Max Hamburger, Louis Fries and colleagues, was published in 1981 in the *American Journal of Human Genetics*. Eason says: "Cryoglobulins are abnormal proteins in the blood. Maybe their presence is due to the contributions from the Hamburger and Fries involved?"

Eason also discovered "An experimental study of the effects of sheep grazing on vegetation change in a species-poor grassland and the role of seedling recruitment into gaps", by J. M. Bullock, B. Clear Hill, M. P. Dale and J. Silvertown, in a 1994 issue of the *Journal of Applied Ecology*.

The pastoral picnic aspects don't end with Hill and Dale, sheep and a Bullock. Bullock was based at the Open University's Oxford Research Unit in the hamlet of Boars Hill, UK. And the researchers cite an earlier essay by J. C. Bacon about livestock.

Stone on Stone

Further nominative determinism. Eric Bignell sends word that: "The Stone Masons Livery Company in London has just published a book about its history. The book is written by Ian Stone."

Annikan Flycatcher

Superior athletic abilities – running, gymnastics or scoring goals, to name three – can result in the winning of medals, championships and romantic offers, any of which many people would consider to be non-trivial. Therefore, athletic abilities aren't usually considered to be trivial superpowers, a list of which Feedback is compiling. Here is a trivially stupendous exception – one unlikely to win an Olympic medal, but certain to inspire awe.

Laura Connell says: "Your listings of trivial superpowers put me in mind of a student I knew when I was teaching. Annika, while chatting, was able to casually reach up and pick flies off her face. They never got away, or even tried. And she never rushed or tried the sneaky stealth approach. Teachers and students alike were gobsmacked, but she often was not even aware that she had done it, so habitual was it. And she never understood our amazement."

A fly-catching superpower has long been studied in frogs, but this human counterpart remains poorly understood.

Storied superpower

Mark Hessler says that he has a trivial superpower: "I like telling stories and I think my most notable ability may be the special instinct I have about who's already heard which story. When I have an impulse to speak with someone or in a group it's nearly always accompanied by a corresponding sense of who present may have heard it before. It's become a point of pride for me over the years to avoid letting the same person hear the same story twice. When I repeated one once in the presence of a friend from college years afterwards when we were in our 40s, he said, "I've been listening to your stories and waiting 20 years for this moment: you've finally repeated one, I've witnessed it, I almost can't believe it." ▮

Marc Abrahams

New Scientist Jobs

METRO .co.uk

LGBTQIA+ experience in STEM survey

New Scientist Jobs and Metro.co.uk are conducting a survey to understand the experience of the global LGBTQIA+ community in STEM.

If you are part of the LGBTQIA+ community and work in STEM, we would love your thoughts and feedback.

Complete the survey today

newscientist.com/lgbtqia+

Shop at omegawatches.com

TIME THE WORLD

Take an amazing journey. Start at the centre of the dial and the vision of Earth made by laser-ablating continents and colours on a grade 5 titanium surface. Then head out to the 24-hour indication divided into night and day sections. Be sure not to miss the many global destinations circling the dial, or the traces of the past still visible. The Worldtimer evolved from our first travel pocket watches of the 1920s. If a wearable world map suits your globetrotting lifestyle, consider this stainless steel edition with matching bracelet and green ceramic bezel. Powered by the Co-Axial Master Chronometer Calibre 8938. A movement that has passed the toughest tests on Earth.

OMEGA